Successful science

An evaluation of science education in England 2007–2010

The report evaluates the strengths and weaknesses of science in primary and secondary schools and colleges inspected between June 2007 and March 2010. There has been an improving trend in the provision of science education over the period of the report, especially in secondary schools, but there are areas that need further improvement, especially in primary schools. In schools that showed clear improvement in science subjects, more practical science lessons and the development of the skills of scientific enquiry were key factors in promoting pupils' engagement, learning and progress. This report identifies outstanding teaching and describes how to move from satisfactory to good or outstanding practice.

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Executive summary

This report draws on the results of visits by inspectors to 94 primary, 94 secondary schools and two special schools between June 2007 and March 2010. These schools were selected broadly to represent the profile of schools in England, but excluded schools in Ofsted's categories of concern. It also draws on the outcomes of subject conferences organised by Ofsted. During the past year, 2009–10, inspectors reported on post-16 science education in 31 colleges and their reports have also formed part of the evidence.

There has been an improving trend in the provision of science education over the period of this report, especially in secondary schools, but there are areas that need further improvement, particularly in primary schools. The most important focus for schools is to ensure that pupils are engaged and challenged by their work in science, particularly in scientific investigation and how science works. Students need access to relevant courses that provide them with clear, high-quality pathways through their education, allowing them to attain the highest standards possible, both in the short term and when they progress to further and higher education. The best schools are already doing this.

Achievement in science was either good or outstanding in just over two thirds of the schools visited. While this overall proportion of 'good or outstanding' was similar for primary and secondary schools, there was a larger proportion of secondary schools where achievement was judged to be outstanding. Overall levels of attainment in primary schools, as measured nationally by teacher assessment data, were broadly similar to those observed during the previous inspection cycle; however, attainment at the higher levels was slightly reduced. Over the same period, success rates for separate science subjects at GCSE level have increased significantly: in 2010 around 12,000 more students than in the previous year were awarded grades A* and A at GCSE in each of the three separate sciences of biology, chemistry and physics.

The highest-performing schools, both primary and secondary, had clear priorities for raising standards and had several features in common. These included rigorous monitoring and evaluation of performance, aligned with challenging target-setting for individual pupils. The schools focused strongly on improving the quality of teaching and learning, with staff within science departments planning together and sharing good practice. These characteristics are explored later in the report.

In both primary and secondary schools, teaching in science was at least good in around three quarters of the schools visited. This proportion is higher than for schools' overall performance in teaching and learning. Science, being a core subject, is a priority area for schools compared with the foundation subjects.

While the quality of teaching in the primary and secondary schools visited was similar overall, there was a slightly higher proportion of outstanding teaching in the secondary phase. Teaching was good when teachers had a clear understanding of what knowledge, understanding and skills were to be developed; understood how development in scientific enquiry promotes effective learning; understood the relationship between concepts and the cognitive demand they make; and were clear about what pupils already knew, understood and could do. The impact of good teaching was seen when pupils understood clearly the standards they had achieved; knew what they needed to do to improve and were involved in peer and self-evaluation; took part in decision-making, discussion, research and scientific enquiry; and were engaged in science that had relevance to their lives. In none of the schools visited was science teaching overall inadequate.

Primary teachers' take-up of science-specific continuing professional development was low in the schools surveyed. While much of the professional development they received overall was relevant to science, it was often generic, for example being focused on improving teaching and learning or assessment generally. In just under two thirds of the primary schools where science-specific continuing professional development was evaluated, it was no better than satisfactory. In the secondary schools where this provision was evaluated, the picture was better: nearly six out of 10 secondary schools had professional development for science that was good or outstanding.[1]

The curriculum in the best schools, both primary and secondary, engaged pupils' interest and enthusiasm and promoted good progress in knowledge, understanding and skills in science. Again, the curriculum was more often outstanding in the secondary schools visited than in the primary schools. This was achieved best through collaboration among teachers on planning for science and the effective sharing of good practice. In secondary schools, the introduction of a wider range of courses since September 2006 has been beneficial. In the last year covered by this report (2009–10), entries at GCSE for each of the three separate sciences increased by approximately 30,000. The entitlement of students achieving Level 6 in science at the end of Key Stage 3 to study the three separate sciences at GCSE has promoted recruitment to post-16 A-level science courses. Schools that entered students inappropriately for vocational courses such as BTEC limited their choice of pathways through post-16 education.

Post-16 science education has been inspected in both schools and colleges. Science provision was good or outstanding in 15 of the 31 colleges where science and mathematics were a focus for inspection and was inadequate in five. The proportion that was inadequate is a matter of concern, as is the proportion of good and outstanding provision which was lower than that earlier in secondary education. The strengths and weaknesses seen in science in these colleges were also often evident in school sixth forms. Since the last report, lessons where notes are simply dictated to students were seen less frequently. Good practices seen in Key Stage 3 and 4 have been transferred to sixth form teaching. These included more frequent assessment being used to inform planning and teaching, more rigorous target-setting and regular monitoring of progress.

[1] This refers to the 45 of the 78 secondary schools visited where a judgement on this aspect was made.

In the schools visited in 2007–10, assessment was better overall than it was for the schools featured in the last three-yearly report. It was good or outstanding in just over three quarters of the secondary schools and slightly under two thirds of the primary schools visited. In the secondary phase, there was a greater focus on the performance of individuals, with effective monitoring and tracking systems that allowed their progress to be identified. In a welcome development, a smaller proportion of schools in this survey compared only the performance of classes and cohorts rather than individuals. The increased focus on individuals' performance and that of different groups provided a good basis for intervention with them and promoted progress more effectively.

Overall, teachers used information and communication technology (ICT) effectively in their teaching. In both primary and secondary schools, ICT was used to present pupils with experiences that could not be provided first-hand. Teachers used ICT to build ideas pictorially and diagrammatically, using data from a range of sources, including the internet. Laptops were used to capture, manipulate and display data to enhance learning and promote the development of scientific skills. The use of ICT in the outstanding schools involved pupils in interactive presentations and independent research.

The removal of the requirement for statutory tests in science at the end of Key Stages 2 and 3 has helped schools to avoid an undue concentration on revision in Years 6 and 9 and freed teachers to be innovative in planning their teaching and in enriching the science curriculum. The increased range of courses for students at Key Stage 4, including the three separate sciences and vocational science, has also provided breadth in the science curriculum to meet the needs of a wider range of students, although not all the students surveyed have benefited from this yet.

Key findings

- In the schools which showed clear improvement in science subjects, key factors in promoting students' engagement, learning and progress were more practical science lessons and the development of the skills of scientific enquiry.
- Although pupils' progress in science was good or outstanding in 70% of the primary schools visited, a lack of specialist expertise limited the challenge for some more able pupils. Progress was outstanding in one in 10 of the primary schools visited, compared to one in six of the secondary schools. This is reflected in the slight decline since 2007 in the performance of higher-attaining pupils in teacher assessments in science at the end of Key Stages 1 and 2.
- Progress of students in science was good or outstanding in around two thirds of the secondary schools visited. Some improvements in achievement were observed in lessons during the course of visits, often associated with courses that were better matched to students' needs. National standards have increased slightly in Key Stage 3 over the period of the survey. The proportion of A* to C

grades awarded at Key Stage 4 has remained approximately the same but the proportion of students achieving grades A* and A has increased.[2]

- The removal of the requirement to carry out statutory tests in science at the end of Key Stages 2 and 3 has encouraged teachers to plan engaging schemes of work in science that avoid an undue focus on revision in Years 6 and 9. It has provided scope to vary the length of key stages appropriately and provide greater enrichment.
- Standards at A level in science subjects as seen in national data have shown a steady rise over the period of this report. In the schools visited, this improvement was associated with teaching which, increasingly, engaged students more actively in their learning. This development was less evident in the colleges visited.
- Science was good or outstanding in 15 of the 31 colleges where it was inspected; it was satisfactory in 11 and inadequate in five. No other post-16 curriculum area in colleges was judged to have such a high proportion of unsatisfactory provision.
- The introduction of the new science GCSEs in September 2006 resulted in a greater number of courses being provided to meet the needs of all students. In the schools surveyed, these have been successful, in the main, in allowing more higher-attaining pupils to study three separate sciences. This has contributed to the increased recruitment of students to A-level courses in the sciences.
- The availability of vocational courses had a positive impact on the motivation and achievement of students for whom academic programmes were less suitable. However, some schools had used these courses too extensively, entering students for vocational rather than academic qualifications and, as a result, restricting students' opportunities to study A-level sciences.
- More rigorous monitoring and tracking have provided a better basis for teachers to plan with individual students in mind. This development aligns with greater challenge for many students through more effective target-setting.
- Despite some positive initiatives, such as the Primary Science Quality Mark and the Association for Science Education's publication for primary schools 'Be safe', there has been insufficient professional development in science to tackle the lack of confidence among primary teachers, particularly in their understanding of scientific enquiry skills and the physical sciences.
- Lack of specialist training, and their normally short tenure in the role, limited the effectiveness of the science coordinator in developing teaching and raising achievement in some of the primary schools visited.
- Secondary teachers in particular benefited from attending courses at the network of Science Learning Centres, but too few of the schools visited had taken advantage of this high-quality provision.

[2] See Annex B for detailed data.

Recommendations

Primary schools should:

- ensure that pupils are engaged in scientific enquiry, including practical work, and are developing enquiry skills. They should be providing a balanced programme of science education for all year groups that develops science knowledge and understanding and has a significant focus on developing skills
- make provision for effective continuing professional development to support and extend teachers' knowledge, understanding and skills in science and their confidence in teaching it
- invest in developing the role of the science coordinator to provide effective, sustained leadership in the subject and promote improvements in teaching and learning.

Secondary schools and colleges should:

- ensure they use practical work and scientific enquiry as the key stimulus to develop scientific knowledge, understanding and skills
- ensure that changes they make to the duration and nature of the Key Stage 3 curriculum are planned carefully, with a focus on good teaching and learning and to ensure coherence with science provision in Key Stage 4
- provide a range of science courses in Key Stage 4 that are suitably matched to students' needs and relevant to a life of continuing education, training or employment in a technological age
- provide good advice and guidance to students about curriculum choices in science at Key Stage 4 which have clear progression routes into good-quality post-16 education and training
- ensure that the science curriculum is engaging and relevant to students' needs and requires their active participation within and beyond the classroom; and that it promotes strong development of knowledge and understanding to be applied to science activities throughout their school or college career and into continuing education, training or employment.

Part A. Science in primary and secondary schools

Introduction

1. Science has been a core subject since the introduction of the National Curriculum, alongside English and mathematics, in 1989. It has provided a distinct area of learning and development, one that is necessary to prepare all pupils for continuing education, training and living in a technological society. This importance continues and is evidenced by the requirement for all pupils to study science from the age of five to 16. Until 2009 this importance was also signalled by the statutory tests in science at the end of Key Stage 2. In the autumn of 2008, the then Government announced the cessation, with immediate effect, of the requirement for schools to use national tests in science for 14-year-olds. Schools are still required to report on standards in science at these key points, but through teacher assessments.

2. Ofsted has reported on science education since 1993 and has identified areas that are key to success.[3] In 2008, *Success in science* covered the period from 2004 to 2007.[4] An update on some of the report's key findings is given below. Some of them are developed further in this report, building on evidence from the latest three years of science inspection visits.

Key issues from the last triennial science report, 2008

3. **Key finding:** Outcomes of tests and public examinations in science have not changed substantially over the last three years at either primary or secondary level. While being satisfactory, there is clear scope for improvement.

   Update: At the end of Key Stage 1, teacher assessment of pupils' performance showed a slight fall in the proportion of pupils attaining the higher Level 3, but otherwise performance had not changed between 2007 and 2009. At the end of Key Stage 2, teacher assessment of performance showed a small gradual increase in attainment from 2006 to 2009. However, the proportion of pupils attaining the higher Level 5 was static from 2007 to 2009. At the end of Key Stage 3, teacher assessment showed a moderate improvement in attainment from 2005 to 2007 and some continued improvement since then. At the end of Key Stage 4, attainment in GCSE has remained at about the same level since the first awards of grades for the new science GCSEs in 2008.

   In the period 2007–09, there was a slight decline in the proportion of students attaining grades A and B at AS level in each of biology, chemistry and physics. At A level during the same period, however, the proportion of students attaining grades A and B rose in each of the subjects, as did the number of entries. (Annex B provides national data.)

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[3] *Science: a review of inspection findings 1993/94*, Ofsted, 1995.
[4] *Success in science* (070195), Ofsted, 2008; www.ofsted.gov.uk/publications/070195.

4. **Key finding:** Of the schools visited, those with the highest or most rapidly improving standards ensured that scientific enquiry was at the core of their work in science. Pupils were given the opportunity to pose questions, and design and carry out investigations for themselves.

   Update: Scientific enquiry and other aspects of 'how science works' continue to be at the heart of the most successful science education.[5] 'How science works' focuses on the critical analysis of evidence and uses this to support or refute ideas and theories. Effective enquiry work involves exploring questions and finding answers through gathering and evaluating evidence. Pupils need to understand how evidence comes from the collection and critical interpretation of both primary and secondary data and how evidence may be influenced by contexts such as culture, politics or ethics. Practical work is one component of 'how science works' which has had a high profile in the last few years, and its importance has been widely recognised. Supported by the Department for Education and the Gatsby Charitable Foundation, Science Community Representing Education published a report called *Practical work in science: a report and proposal for a strategic framework* in December 2008.[6] This has given rise to 'Getting practical', a programme of professional development that is designed to support teachers, technicians and higher level teaching assistants at primary, secondary and post-16 levels.[7]

5. **Key finding:** Teaching and learning were at least satisfactory in almost all of the schools visited. However, within this generally positive picture, there were recurring weaknesses, particularly in planning and assessment.

   Update: Inspectors saw improvements in collaborative planning in both primary and secondary schools. Where this was in place, there was a greater coherence in the curriculum and sharing good practice was often intrinsic to planning.

6. **Key finding:** Too often, in planning science activities, teachers did not take sufficient account of what pupils had already learned at previous key stages and did not give them clear advice on how to improve their work further. As a result, pupils lost interest and made insufficient progress.

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[5] The National Curriculum requires students in Key Stages 3 and 4 to be taught about 'how science works', one of the four attainment targets. It consists of four components: data, evidence, theories and explanations; practical and enquiry skills; communication skills; applications and implications of science.

[6] Science Community Representing Education (SCORE) is a partnership between the Association for Science Education, the Biosciences Federation, the Institute of Biology, the Institute of Physics, the Royal Society, the Royal Society of Chemistry and the Science Council. SCORE acts under the auspices of the Royal Society and is chaired by Sir Alan Wilson FBA FRS. The report may be found at: www.score-education.org/publications.

[7] 'Getting practical' is led by the Association for Science Education. For further information, see: www.gettingpractical.org.uk/m1-9.php.

Update: It is clear from the scrutiny of assessment and tracking records in previous surveys and in the current one that teachers now know much more about the progress of individuals and plan for smoother transitions between years and key stages. Coherent records are passed on to the next teacher, reducing pupils' repetition of experiences in science.

7. **Key finding:** Most primary teachers had limited opportunities for continuing professional development to enhance their expertise in science, partly because their schools did not see the subject as a priority for development.

   Update: The Royal Society's report in 2010, *Primary science and mathematics education: getting the basics right*, made it clear that a very small number of primary teachers have a significant background in science or mathematics.[8] The report also described the findings of research that showed that primary teachers lacked confidence in teaching science and mathematics. It continues to be the case that there is insufficient, science-specific in-service training for primary teachers. Significant efforts have been made to increase the uptake of science, technology, engineering and mathematics (STEM) subjects at post-16 and at degree level, but a secure and engaging experience of science in the primary school is the foundation needed for successful science in the secondary school and beyond.

8. **Key finding:** In too many primary and secondary schools, teachers were mainly concerned with meeting narrow test and examination requirements and course specifications. This led them to work in ways that did not meet the needs of all pupils or promote independent learning.

   Update: This finding was made at a time when the statutory tests at the end of Key Stages 2 and 3 were in place. Since the last report, these tests have ceased. While the best schools had not been hindered by them, inspectors found that, in the schools visited, the absence of the tests had helped some schools to use their freedom more effectively and had led to considerable curriculum innovation at these key stages.

9. **Key finding:** The secondary schools visited were beginning to develop programmes of study that gave 14- to 19-year-olds access to vocational and academic pathways in science, suited to their needs and interests. However, progress in this area was too slow.

   Update: Provision has moved on rapidly during the period covered by this report. The large majority of the schools visited had provided a wider range of pathways for students aged from 14 to 19. These included GCSE courses in core science, additional science, additional applied science and triple science,

[8] *Primary science and mathematics education: getting the basics right* (DES1819), Royal Society, 2010; http://royalsociety.org/State-of-the-Nation-Science-and-Mathematics-Education-5-14/.

vocational science GCSE and BTEC science. More detail is given in the curriculum section of this report.

Achievement in science

Primary schools

10. In around one in 10 of the primary schools visited, pupils' progress was outstanding, and in around six in 10 it was good. In none of the schools visited was pupils' progress in science judged to be inadequate. The progress made was similar across the ability range of pupils, supporting the view that, in general, pupils were receiving science education that was appropriate to their needs.

11. Levels of attainment in science in the schools visited were broadly similar to those observed during the previous inspection cycle. This reflects the national picture, which is of standards in science in primary schools remaining largely unchanged over the last three years with a slight decline in the standards achieved by the most able pupils. In 2010, 89% of all pupils attained Level 2 or above at the end of Key Stage 1. However, there was a slight decline in the proportion of pupils attaining Level 3 or above to 21% over the period covered by this report. The picture at the end of Key Stage 2 is similar, with 85% of pupils in 2010 attaining Level 4 or above, the same proportion as in 2008. The proportion of pupils at Level 5 or above has declined slightly between 2008 and 2010.

12. Good progress and standards were most often associated with:

- good leadership and management
- effective continuing professional development
- the improved use of assessment
- a clear focus on science work that included a significant component of scientific enquiry and investigation.

13. In the majority of the schools visited, the pupils enjoyed science and, particularly, practical and investigative work. Overall, however, pupils made less progress in scientific enquiry and investigative skills than in their knowledge and understanding of areas of the science National Curriculum. In relation to knowledge and understanding, teachers' assessments indicated that pupils' highest levels of attainment were in 'life processes and living things', and their lowest levels were in 'physical processes'. In the schools where progress was satisfactory, opportunities for pupils to plan and evaluate their own investigative work were more limited.

Secondary schools

14. The progress of students in science was good or outstanding in around two thirds of the secondary schools visited. Progress was outstanding in one in six of the secondary schools compared with one in 10 of the primary schools visited. The progress of all groups of students in science was similar in around three quarters of the schools. In a few cases, there were differences in the progress of boys and girls and between students of different ethnic backgrounds, but in most of these the senior leadership team was aware of the differences and had plans to tackle them.

15. As in the primary schools, attainment in secondary schools was similar to that seen in the previous three-year period, although with some signs of improvement in Key Stage 3 with a rise of 4% in the proportion of students attaining Level 5 or above to 80%. There was a rise of 5% in students attaining Level 6 or above to 48% in 2010. There have been improvements in attainment associated with the greater diversity of provision in Key Stage 4. There has been a large increase in the number of pupils achieving A* or A grades at GCSE in 2010 in the order of 12,000 more for each of biology, chemistry and physics.

16. In around two thirds of the secondary schools visited, the introduction of a greater range of science GCSE courses had provided a better match of courses to individuals' needs, and the curriculum and learning in science had also become more focused on individuals. In the schools where courses were matched carefully to the needs of individuals, their records of progress showed improvement. This diversification had a positive impact on students' attitudes to learning and contributed to the increased number of A* and A grades achieved at GCSE in biology, chemistry and physics. Students who had chosen to follow triple science courses were often well-motivated and described how they found the work engaging and enjoyable.

17. In post-16 studies there has been an improvement each year in standards attained. Over the last five-year period, the proportion of students attaining grades A or B in science subjects at A level has risen by around 5%.

18. Many schools reported higher levels of engagement for students who followed applied science courses, particularly BTEC. Students and staff acknowledged that they had found the assessment requirements for BTEC manageable and better suited to many candidates because the students were continually aware of how well they were attaining and had a clear understanding of how to improve.

19. Schools entering large proportions of students for vocational qualifications such as BTEC have improved their GCSE-equivalent results. However, progression rates to specialist science courses from BTEC are very different from those for students completing GCSE courses. In 2009, the proportion of students studying the three sciences at GCSE who then pursued A-level science courses

was 46%. For those studying GCSE double science it was 9%, and for those studying the BTEC or GNVQ equivalent to two GCSEs it was 1%.

20. In the schools where progress was satisfactory, the opportunities for students to design and carry out experiments were limited; too much of the practical work was prescriptive, with students merely following instructions. These schools were often influenced too much by the specific ways in which practical work and scientific enquiry skills were assessed in Key Stage 4 for GCSE sciences and, as a result, were less concerned with providing opportunities for wider-ranging investigations.

21. The highest standards seen were in the schools where the scheme of work included well-integrated experiences of scientific enquiry and access to experiences that covered all aspects of 'how science works'. In these schools, students were involved in planning and carrying out regular science investigations, so that they understood the processes involved. It was this combination of procedural and conceptual knowledge that promoted the most effective learning in science.

22. Without such regular involvement in all aspects of 'how science works', students were less able to participate and learn actively. For example, when practical work was simply directed by the teacher, with no contribution from the students to planning it, their learning was less effective and they showed less evidence of developing their skills and knowledge. Students needed to participate in all aspects of investigation: forming hypotheses, planning, carrying out and evaluating practical work. Only following instructions from worksheets to complete a practical activity limited the ways in which they could contribute and how they benefited. Students' involvement was key to engaging them with science and thereby increasing their knowledge and understanding. Group work and class discussions, however, had to be well-organised in order to challenge them sufficiently.

23. Also associated with good or outstanding progress was the active involvement of students in peer and self-assessment. In around two thirds of the secondary schools visited, students were aware of their targets and how well they were making progress. The best schools promoted this by close monitoring of students and frequent reference to their performance in conversations between teachers and students. When this was focused on the needs of individuals, students most often responded positively. They described how well they were supported and how much they appreciated the efforts of their science teachers.

Quality of teaching in science

Primary schools

24. The overall quality of teaching in primary schools was similar to that in secondary schools but with a smaller proportion of outstanding lessons. Teaching was at least satisfactory in all the schools visited. It was good in just over seven in 10 of the schools, and outstanding in around one in 20.[9] This is a broadly similar picture to that in the last report. Part B of this report provides case studies of outstanding teaching and examples of how weaker practice might be improved.

25. In all the primary schools visited, teachers' subject knowledge was at least satisfactory. In the large majority of the schools, the teachers' knowledge and understanding of the National Curriculum science requirements were good or outstanding. Teachers had more concerns about their knowledge of physical sciences than that of living things. Limited expertise and confidence restricted the level of challenge that some teachers could provide for more academically able pupils. In around six in 10 of the primary schools visited, the science coordinator was effective in keeping other staff up to date about developments in the subject.

26. Planning to meet the full range of pupils' needs was at least satisfactory in all the schools visited and most teachers provided well for the needs of all the pupils in their class. In the lessons seen, planned activities generally related well to the objectives, and hands-on experiences stimulated pupils' engagement and enjoyment.

27. Inspectors found no evidence of improvements in teaching science in the primary phase that could be attributed to the Primary National Strategy which focused mainly on literacy and numeracy. This view was shared by most of the school leaders in the schools visited.

28. Teachers' use of ICT was good in nearly two thirds of the schools visited and outstanding in three schools. The teachers used ICT well to illustrate phenomena that the pupils could not experience first-hand. There were some good examples of ICT being used interactively, with pupils' responses being required to move the work forward. Inspectors saw examples of pupils' independent learning at computers using commercial programs, but these were not always sufficiently challenging. Inspectors saw very few examples of pupils using ICT to measure or record the outcomes of practical activities they had done.

29. Assessment generally was good or outstanding in about two thirds of the schools visited. However, the guidance provided by the Qualifications and

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[9] The judgement was made in 91 of the 94 schools visited.

Curriculum Development Agency (QCDA) in 'Assessing pupils' progress' had not yet had a strong enough impact on schools' practice.[10] Inspectors saw pupils being involved in peer assessment and self-assessment in only around a third of the primary schools visited. Practice was consistently good in only one in 10 of the primary schools. In a greater proportion of schools, senior leaders had identified this as an area for development.

30. Marking was carried out systematically and was effective in around two thirds of the schools visited. Formative comments and some discussion in the most effective marking helped pupils to understand how they could improve their work. In the weaker schools, marking was inconsistent and did not let pupils know how to improve or where and why they had done well.

31. Setting targets for individual pupils had increased since the last three-yearly report, both in terms of quality and in the proportion of schools that were implementing effective systems for doing so. In one school, for example, pupils in Key Stage 2 had taken responsibility for keeping a record of their attainment and their targets. They had frequent opportunities to talk to teachers about the standard of their work and how to improve. These sessions were, effectively, target-setting meetings. Through self-evaluation and frequent feedback from teachers, the pupils knew how well they were doing and what they needed to do to improve. They were happy to take on this responsibility.

Secondary schools

32. The quality of teaching in the secondary schools visited was very similar to that in the primary schools, although with a slightly higher proportion of outstanding teaching. Inspectors did not judge the science teaching overall to be inadequate in any of the schools visited. Individual inadequate lessons were observed in a few schools. This is a positive picture compared to school provision more generally: science is a core subject and receives considerable focus; it has a strong subject association and learned societies for all the sciences; it is substantially taught by specialists and has significant funding for high-quality continuing professional development.

33. In around nine in 10 of the secondary schools visited, the planned activities were linked effectively to the learning objectives of the lesson. The schools in which students' progress was good usually provided varied and engaging activities in science, such as:

- presentations by students
- practical and investigative work
- research projects

[10] 'Assessing pupils' progress' is a national approach to assessment, designed to support teachers in making judgements on pupils' progress. For further information, see: www.qcda.gov.uk/assessment/82.aspx.

- use of models, such as those showing how systems carry out a function
- demonstrations
- interactive use of ICT video clips and other media resources
- activities where students put a set of cards in sequence to describe a process or observed phenomena
- group discussions.

34. In these schools, teachers were enthusiastic; they gave lively explanations and managed students' behaviour effectively. They were reflective, keen to improve and used relevant contexts for work in science. In contrast, in the lessons that were no better than satisfactory, the teachers often talked for too long, were poor at managing time in the lesson, and provided insufficient challenge or did not provide for the range of students' needs.

35. Good-quality practical work was a key feature of good teaching in science. However, it was effective only when it was well-planned and managed. Simply exposing pupils to practical work did not, in itself, promote learning, as this example illustrates:

> A teacher introduced her Year 7 students to the practical work, using the words 'macerate', 'extract', 'mortar', 'pestle', 'indicator', 'pH', 'acid', 'alkali' and 'filtration' in her description of extracting vegetable colour from a beetroot in order to determine whether solutions were acid or alkali. She gave the students a worksheet that described what they needed to do. They were required to fill in missing words in the gaps on the worksheet. One girl, when asked by the inspector what she was doing, said, 'It's a bit like cooking.' She mashed her beetroot into a pulp and carried out the instructions on the worksheet but could not describe why she was doing each stage of the procedure. She was aware she had to fill in the gaps and set about doing so by asking the teacher or copying from others. She almost completed the gap-filling but could not say why she had used the words in each gap. At the end of the lesson she, and many others who were asked, did not understand what they had done and why. Their grasp of the new vocabulary was very shaky. The students had, in the words of one, 'done things with stuff' but had learnt very little.

This contrasts with the highly effective practical and investigative work that took place in the lesson described below.

> Year 8 students were completing a unit of work on acids and alkalis that had involved them in research on the effect of acid rain on limestone. They had worked in groups to generate their own questions to pursue. Many of them had taken the time to form hypotheses and had planned and carried out their own practical work. The students had presented the outcomes of their research to the class in the form of high-quality

PowerPoint presentations. Discussion with the students showed how varied these presentations were.

At the end of the final presentation, the teacher invited the presenter to stay at the front of the class and to use the computer to gather the data from the investigations. Using the wireless laptops, each group transmitted its tabulations of data to the teacher's computer and the student displayed these on the interactive whiteboard. As soon as data started appearing, the students began to spot anomalous figures, compare patterns of data, summarise trends, account for differences, evaluate data and suggest improvements. There followed a rich time of discussion and clarification that allowed students access to the ideas and work of others and to build their own knowledge and understanding, not only of the chemistry but of the way that science works.

36. The effective use of ICT was having a positive impact on attainment in science in nearly two thirds of the schools inspected. In the schools where the impact was only satisfactory, this was often because ICT was being used predominantly by the teacher to show information. The students in these schools were not given sufficient opportunity to use ICT for themselves.

37. The very best use of ICT involved students participating actively. Electronic whiteboards were used interactively and banks of laptops had made it possible for them to be used for work that was integral to laboratories, getting around the need to relocate classes to ICT rooms. Students used laptops for a range of purposes and applications, including:

- data logging
- internet research
- simulations
- word processing
- presentations
- digital images
- access to virtual learning environments.

However, there were very few schools in which the science teachers and ICT staff collaborated to plan for progression or to pool their assessments to allow progress in ICT to be tracked.[11]

[11] This finding echoes an earlier report on ICT: 'In the majority of the [177] primary and secondary schools visited, teachers did not evaluate specifically how well pupils and students applied and used their ICT skills when working in other subjects.' See: *The importance of ICT: information and communication technology in primary and secondary schools, 2005/2008* (070035), Ofsted, 2009; www.ofsted.gov.uk/publications/070035.

38. In nine in 10 of the schools visited, the teaching met the range of students' needs, in broad terms. In other cases, there was insufficient differentiation of the work to challenge all students, particularly those who were higher-attaining. More than one third of the schools visited attributed some of the improvement in their practice, such as in assessment for learning and planning lessons, to the work of the Secondary National Strategy.

39. In all the secondary schools visited, the science teachers' knowledge and understanding were at least good overall, although not all science lessons were taught by science specialists. This was particularly true of physics and, to a lesser extent, chemistry. Inspectors' observations of lessons during the period of this survey support the findings of the previous three-year report that the better the specialist match of teachers to the curriculum, the higher the achievement of students.

40. The recruitment of graduates to train as teachers through the Graduate Teacher Training Registry (GTTR) has been reduced in 2010 for almost all secondary subjects. However, the notable exceptions are physics and chemistry, shortage subjects within the sciences, which have seen increases in recruitment against the overall trend. Over the period 2008 to 2010, there has also been an increase in the number of applications for entry to university to study STEM subjects including biology, chemistry and physics. There is, therefore, the possibility of an increased recruitment of specialists to teach science in the future.

41. In around three quarters of the secondary schools visited, the teachers had attended courses provided by awarding bodies, for example those relating to new specifications for GCSE and A level. Around three quarters of the schools also provided continuing professional development for science teachers, but on generic issues such as improving teaching and learning or assessment. Where such training was carried out, teachers responded positively and put the training into action in the classroom.

42. Good assessment usually accompanied good teaching. Good assessment by teachers and students showed areas for improvement clearly; teachers were able to plan work and intervene to enable individual students to make progress. Part B of the report gives examples of outstanding practice.

43. In more than a third of the schools visited, the students were involved effectively in peer and self-assessment. In the remaining schools, developments were at an early stage. Peer and self-assessment strongly promoted students' understanding of the standards they had reached and how they might improve. This knowledge of their performance also built their self-confidence and motivated them to do better.

44. In around two thirds of the schools visited, effective marking helped the students to understand what they had done well and provided feedback on what they could do to improve. However, the quality of marking often varied;

this had an impact on students' progress. In around one quarter of the schools, marking was inconsistent, as was the quality of the feedback that students received. These schools often lacked a clear policy backed up by rigorous monitoring. The implementation of the 'Assessing pupils' progress' initiative was at an early stage and inspectors saw very few examples of good practice in this area in the final year of the survey.

The curriculum in science

Primary schools

45. In around four in five of the primary schools visited, the curriculum in science was good or outstanding, a similar proportion to that in secondary schools. It was outstanding in just under one in 10 primary schools compared to just under one in seven secondary schools. The activities that were planned supported pupils' progress in their knowledge and understanding of science, and allowed them to develop their science skills in increasingly demanding situations. This concern for progression was less evident in the less effective schools, particularly in science skills, and pupils had fewer opportunities to plan and carry out investigative activities.

46. In the very large majority of the schools visited, science was taught regularly each week. This regular exposure to, and consideration of, phenomena through scientific enquiry was important in building pupils' skills and confidence. The development both of skills and confidence promoted the pupils' increased knowledge and understanding of science.

47. Although, increasingly, scientific enquiry was being planned into schemes of work for science, its assessment was not developed well across all the schools visited. There was less planning for different needs in scientific enquiry than there was in knowledge and understanding, where the content was usually matched well.

48. The science curriculum was often planned collaboratively and with the pupils' development in other areas of the curriculum clearly in mind. This collaboration incorporated pupils' development in literacy, numeracy and appropriate areas of other National Curriculum subjects. Teachers in the primary schools visited talked confidently about how the different parts fitted together and this led to some very effective provision. The schools that used a strong team approach for planning could often show evidence of pupils' increased engagement and progress as a result. However, the challenge of communicating with other teachers and schools to ensure pupils' smooth transition between key stages remained. Weak communication and poor continuity between teachers and schools meant that pupils' learning faltered as they met work that they had done before.

49. Enrichment and extra-curricular activities had a positive impact on pupils' attitudes to science. These were strong in the schools in which the pupils'

achievement was good or outstanding. The schools often used their school garden or local environment effectively. As well as the enjoyment they had from growing and eating their own vegetables, pupils showed empathy for living things and grew to understand their interdependency in ecosystems. Pupils also benefited from the knowledge of visiting experts. Activities centred on, for example, birds of prey, dental hygiene and recycling all contributed to pupils' positive engagement. However, there was scope to extend the range of extra-curricular activities to include more work on the properties of materials and on physical processes.

50. The best practice in the Early Years Foundation Stage involved a good range of activities, many of which were practical. In most cases, the schools had a well-planned and balanced programme of activities. There was a greater emphasis on life and living things than on the physical sciences. Teachers said that this was because the area of study 'Knowledge and understanding of the world' gave a higher priority to living things. This predominance persisted into Key Stage 1 where teacher assessments showed pupils' attainment to be highest in life processes and living things, then materials and their properties, followed by physical processes and, finally, scientific enquiry. Emphasising experiences that promoted exploration, either suggested by the teacher or by following children's ideas, provided a good foundation for developing their scientific enquiry skills. However, this was not followed up consistently in Key Stages 1 and 2.

51. The previous science report noted that many schools used the schemes of work published by the Qualifications and Curriculum Development Agency as a basis for their curriculum plan for science. Over the last three years, the most successful schools have adapted their schemes to match their pupils' needs and to reflect their locality and environment more effectively. In primary schools, the curriculum was increasingly thematic; science was taught less as a discrete subject and more as a key component in a unit of work. Where the planning ensured coverage of the National Curriculum and combined learning from other subjects, time was used more efficiently. In one of the schools, for example, the scheme of work for science was based on activities in which science was integrated with components from other subjects. Additionally, a block of several days in each half-term was allocated where science was the focus, but with other subjects planned in where relevant.

52. Since the removal of the requirement for national testing in science at the end of Key Stage 2, some schools have felt able to plan provision for science in a more varied way that pupils found engaging and enjoyable. Consequently, in the schools that have taken the opportunity to remodel the curriculum, Year 6 pupils have been able to continue with a good range of challenging science activities rather than, as happened too often before, being restricted to revising the science they had already done.

53. In the schools where the curriculum was no better than satisfactory, more needed to be done to ensure better-balanced and relevant content, and more effective development of knowledge, understanding and skills.

Secondary schools

54. In 56 of the 94 secondary schools visited, the curriculum was good, with another 14 in which it was judged to be outstanding.

55. Inspectors saw the most effective provision when those teaching the science curriculum planned it collaboratively. Not only did this gather the best ideas from the team, but it also provided a forum for sharing good practice. Where there was a culture of 'plan, do and review', innovation by teachers was encouraged and further improvements were made readily. In this environment, schemes of work often built in cross-curricular elements, such as literacy and numeracy. Similarly, links to other subjects were developed more readily and effectively. The quality of cross-curricular planning was generally not as strong in the secondary schools visited as that seen in the primary phase. However, where such planning was done well, students benefited in their understanding of the part that science plays in society.

56. The range of extra-curricular activities seen in the secondary schools was broader than that in the primary schools, but the activities did not usually engage large numbers of students. As part of the STEM initiative, funding was provided to support STEM clubs. These allowed students to explore, investigate and discover STEM subjects in a stimulating learning environment, away from the constraints of the school timetable or a prescribed curriculum. They encouraged students and their club leaders to work together and explore many different ideas and activities. These involved practical experiments, investigation, discussion and reflection. Most of all, they were engaging and stimulating. They motivated and built confidence in young people who struggled with STEM subjects and also provided an extra outlet for students who already showed aptitude and were interested in furthering their learning.

57. The number of schools planning for a two-year Key Stage 3 beginning in Year 7 had increased since the last report. Often these schools expressed the aspiration to make Key Stage 3 more engaging and relevant for students. They had scientific enquiry and skills development as significant components of the curriculum. These changes promoted high-quality curriculum content that was taught well. Through their monitoring of students' progress, the schools were often able to demonstrate higher achievement. However, in the schools where the time frame for Key Stage 3 was shortened to two years without effective curriculum planning and a focus on good teaching and learning, the levels of students' engagement and enjoyment were lower.

58. An important reason for a two-year Key Stage 3 was to have an extended period of time, up to three years, to teach GCSE sciences in a more enriched way. Schools making the most of this opportunity were able to ensure greater engagement and relevance to students. They planned to avoid excessive didactic teaching, and to ensure that the students experienced 'how science works'. This development ran in parallel with the schools moving further into

monitoring the progress made by individual students and ensuring greater challenge for them.

59. Since the last report, the range of courses made available to students in Key Stage 4 has increased and, in most of the schools visited, this had led to a diversification of the curriculum to meet the needs of all students more effectively. Table 1 highlights recent changes in the number of students in all types of schools following particular science courses.

Table 1: Entries to science courses in all secondary schools between 2008 and 2009

Entry numbers	2008	2009	2008-09 change	% change
End of KS4 cohort	653,083	634,507	-21,065	-3%
Triple science	64,340	80,000	15,660	24%
Core and additional Science	350,300	321,500	-28,800	-8%
Core and additional applied science	49,800	46,000	-3,800	-8%
Core science (single entry)	85,600	87,000	1,400	2%
Applied science (vocational GCSE)	20,200	18,600	-1,600	-8%
BTEC science	20,100	30,000	9,900	49%
Engineering (vocational double award)	6,400	5,100	-1,300	-20%

Data from Department for Education internal analysis.

60. The large percentage increase in triple science entries shown in the national data is particularly notable. There was an even larger increase in entries to BTEC science over the same period. Fifty per cent of maintained comprehensive schools offered their students triple science in 2009 compared with about 30% at the time of Ofsted's last triennial report on science. In 2009, 29% more students in maintained schools were entered for triple science than in 2008 and it was expected that the proportion would continue to increase. All science specialist schools were required to offer triple science courses and the Specialist Schools and Academies Trust expected close to 100% of schools to comply in 2010, compared with 78% in 2009. The increase in the number of students taking triple science has undoubtedly been promoted by the entitlement introduced by the then Secretary of State. This set out to give all students attaining Level 6 in science at the end of Key Stage 3 the entitlement to choose to study the three separate sciences in Key Stage 4. However, the extent to which the schools visited were securing this indicated that the entitlement is not yet universal.

61. In many cases, particularly where students studying triple science were allocated time for three subjects in the curriculum, inspectors found this was leading to higher levels of interest and motivation. Double award science has equipped students with the necessary knowledge, understanding and skills to study science at A level. However, data from the Department for Education and qualitative evidence from inspection visits suggest that students who study three separate sciences are more likely to choose to study science at A level and beyond.

62. Most schools required the majority of students to follow courses leading to at least two GCSE awards in science, with options available from core science, additional, additional applied, and triple science. But, in increasing numbers of schools nationally, vocational courses were also available, and the substantial proportional increase of entries for BTEC science from 2008 to 2009, shown in Table 1 above, was reflected in the schools visited.

63. Some students were well suited to vocational courses. They benefited from frequent assessment and feedback against criteria that guided their improvement. They clearly liked knowing how well they were doing and showed increased self-confidence. However, in a few schools, large proportions of students, or even the whole cohort, were entered for BTEC science, with an associated rise in GCSE-equivalence point scores for the schools. This approach meant that some students were not able to access the more academic courses that would have matched their ability and aptitude more effectively.

64. As seen in a small number of schools, other curriculum models, although benefiting the majority of students, also limited opportunities for other students. For example, in one school visited, all its students started triple sciences GCSE courses in Year 9. This had the advantage that triple science could be provided over three years, using just 20% of curriculum time in Years 10 and 11. There was some flexibility in that students who were finding triple science hard to cope with could change to courses leading to two GCSEs in science in Year 11. However, no vocational science option was available to students in Key Stage 4 and, as a result, the school was not providing the most suitable science courses for the whole ability range. The teaching of triple science in Years 9 to 11 had increased the number of students choosing to follow sciences at A level, but there was no vocational science provision post-16. In some other schools visited, students could follow vocational courses at Key Stage 4, but no vocational science courses were provided at the school post-16.

65. In another example, the school visited had not developed a sufficiently flexible science curriculum at Key Stage 4. It was the school's intention to introduce triple science for all students in September 2010 after a two-year Key Stage 3. It believed that a diversity of courses was not necessary as the science teachers were skilled at differentiating courses for the full ability range. This view was not shared by inspectors and some students spoke negatively about their lack of choice, with all the students being required to follow the same course.

Inspectors judged that this provision did not meet the needs of all students and that the school's aspiration of triple science for all was unrealistic.

Leadership and management

Primary schools

66. In around three quarters of the primary schools visited, overall leadership and management of science were good or outstanding and in 13 schools they were outstanding. The strong collaborative culture of some primary schools promoted the sharing of good practice and the effective pooling of resources and ideas. Innovations could be captured readily and shared with colleagues. However, the frequency with which some headteachers moved responsibilities for the coordination of subjects created problems in some cases, and the short tenure of the role of the coordinator restricted what could be achieved and sustained.

67. When the responsibility for science was changed, professional development was rarely provided to prepare teachers for their role as coordinator. Less than half the subject leaders interviewed said that they had received training for their leadership role. The strength of support received, for example from the local authority, varied greatly from authority to authority. In around three quarters of the primary schools, science subject leaders felt that the school's senior leadership was providing a good balance of support and challenge. It was clear that much of the effective development of teaching and learning had been done as a whole school, with senior staff providing much of the input.

68. In around half the primary schools visited, subject leaders monitored and evaluated provision well through activities such as lesson observations. This is a key mechanism for improving teaching and learning. In the remaining schools, where monitoring did take place it was less frequent and often did not involve observing lessons. The most common ways of monitoring were through data analysis and the scrutiny of pupils' books, but these activities varied a great deal in the frequency and thoroughness with which they were done. Monitoring was particularly effective where there was a constructive dialogue between the colleagues monitoring the standards and those being monitored. The tracking of progress in pupils' skills of scientific enquiry was a strength in only a minority of the schools visited.

69. Subject leaders had provided science-specific training for staff in around four out of five of the primary schools visited. The training that had taken place in some schools had improved teachers' understanding of science and particularly their understanding of scientific enquiry. However, science coordinators were often not trained as science specialists and this could limit the range of training that they were able to provide. The take-up of sources of science-specific continuing professional development from outside the school was very low at around one in 10 schools. The lack of external professional development was reported in the last three-yearly report and the situation has not improved since

then. Few of the headteachers showed awareness of developmental provision in science, such as that offered through the network of Science Learning Centres.[12]

Secondary schools

70. The quality of the leadership and management in science was good overall in more than four out of five of the secondary schools visited. In around one in five of the schools, leadership and management were outstanding and were having a very positive impact on teaching, learning and students' achievement. Again, this is a higher proportion than in the primary schools visited. Common features in these schools included:

- clear systems for tracking the progress of individual students
- effective intervention and planning informed by the tracking data
- collaborative planning and sharing of good practice
- clear roles and responsibilities
- the setting of clear standards for the quality of teaching.

71. This example illustrates many of the factors associated with good leadership and management.

> A well-managed science department engaged in effective self-evaluation, which took account of the views of all major stakeholders. It meant that the head of department had a good understanding of the subject's strengths and weaknesses and demonstrated a good track record of making improvements, including dealing with the issues from the last inspection. The department's robust monitoring and evaluation system tracked the progress of individual students and was used as a basis for planning and interventions. The department had a common vision for the inclusion of all learners and was effective in pursuing this and dismantling barriers to engagement.
>
> The department was well-organised on a day-to-day basis and used resources well, including out-of-school opportunities, to improve outcomes for students and to secure good value for money. It promoted good links with parents and outside agencies to support its work. A training programme focused on the aspects of science which teachers found to be most problematic. The departmental science handbook included guidance on the principles of good teaching and learning, and policy and procedures for assessment to inform planning and target-setting. Subject

[12] The aim of Science Learning Centres is to improve the teaching of science and to inspire pupils by providing professional development for teachers. There are nine regional centres in England and one national centre, each with a number of satellite centres. For further information, see: www.sciencelearningcentres.org.uk.

specialists had collaborated to create a scheme of work in which a good range of learning activities and the development of skills in science enquiry and 'how science works' played a significant part.

72. The most important indicator of weak leadership, observed in a small minority of the schools visited, was a failure to challenge the practice of less effective teachers. In these schools, the result was usually the underperformance of the students in the classes taught by those teachers.

73. Nine out of 10 of the schools visited were setting themselves challenging targets in science. In just under half the schools, staff were able to show the positive impact of these targets in raising attainment. In two thirds of the schools, the monitoring of standards in science was systematic, although the quality of the procedures varied considerably. In the schools where leadership and management were good or outstanding, the head of department had an accurate and balanced view of strengths and weaknesses and had clear plans for improvement.

74. The tracking of students' progress has improved and took place in all the secondary schools visited in the last of the three years covered by this report. All but a small minority of schools used the tracking data to identify underachievement. Progress in scientific enquiry and the skills of 'how science works' were tracked less effectively than progress in the areas of the National Curriculum for science concerned with knowledge and understanding. Knowledge of the progress made by students and their attainment were generally being passed on to the next teacher through coherent records. This was reducing the repetition of science experiences for students and contributed to smoother transitions between classes and key stages.

75. In around half the secondary schools, self-evaluation carried out by the science department had led to clear improvements. However, around one in five of the schools visited conducted self-evaluation where the findings were not used effectively to secure improvement.

76. The heads of department of four out of five of the schools visited believed that they had received an appropriate balance of challenge and support from their senior leadership team. A large proportion of the science departments had a designated link member of the senior leadership team; many heads of department submitted reports to the governing body and were subject to questioning on their performance. In a small minority of the schools, the senior leadership team did not challenge the science team sufficiently to promote greater improvement. These leadership teams did not have a well-evidenced and coherent view of the science department's strengths and weaknesses and so were not in a strong position to challenge it.

77. In the last year of the three-year inspection cycle, only one in five of the heads of departments visited had received subject-specific training on leadership and management. Training had a positive impact on the confidence of heads of

departments who also reported that they had gained a clearer understanding of issues such as effective communication, collaborative working, and monitoring and evaluation. It was also evident from inspectors' discussions with heads of department that subject-specific training had promoted a more coherent and broader understanding of issues affecting standards.

78. More secondary than primary teachers in the survey had received appropriate professional development. While four out of five secondary science departments felt that the professional development they had received was satisfactory, only one in five thought it was good. The quality of professional development received from external providers was variable but that provided by the national network of Science Learning Centres was consistently reported to be good. Part B of this report provides more information about these centres. Much professional development was provided within schools, but this was mainly generic, on topics such as assessment for learning.

79. Where teachers had attended externally provided subject training, evaluation of the impact showed improved teaching and a sharing of good practice in their department. However, a lack of science-specific courses was limiting the capacity of some staff to bring about improvements. Travel time, travel costs and costs of teachers' absence were all given as reasons for limiting the use of external course providers.

Part B

Post-16 science in schools and colleges

80. Throughout the period covered by this report, schools, sixth forms and further education colleges were inspected to different frameworks, although these frameworks were aligned from September 2009 to ensure that post-16 judgements were comparable. Evidence on post-16 science in schools has come from survey visits in which the sixth form work was considered as part of the total provision for the age range 11 to 18. In further education colleges, including sixth form colleges, science was inspected as an area of focus in a proportion of full college inspections. As a result, it has not been possible to make direct comparisons between all aspects of science education in schools and colleges.

81. Generally, further education colleges catered for students of a wider range of ability than those in school sixth forms. Science provision in schools was predominantly at level 3, that is, GCE AS and A-level courses, although with an increasing proportion of vocational science courses. Some colleges provided level 1 (foundation) and level 2 (intermediate), as well as level 3 courses, often with extensive vocational programmes. The number of students following science courses in a school sixth form was generally lower than the number of students doing so in a college.

82. Science was inspected in 31 colleges in 2009/10, under the new Common Inspection Framework. It was good or outstanding in 15 of the colleges; it was satisfactory in 11 and inadequate in five. The proportion of inadequate science provision was similar to that found during the previous cycle of college inspections from 2005 to 2009. This proportion of inadequate provision is a matter of concern. No other post-16 curriculum area in colleges was judged to have such a high proportion of unsatisfactory provision.

83. Where science was judged to be good in colleges, inspectors identified the following key strengths:

- achievement and standards at intermediate and advanced level were high
- students were confident and competent in practical work, using specialist equipment safely and effectively
- science teachers worked well in teams and planned interesting and engaging lessons with a good balance of practical work and theory
- skilfully managed discussions allowed science teachers to assess students' progress informally and to develop students' confidence
- the science teams were led well and had a strong collective emphasis on improving the quality of teaching and learning and raising standards.

84. Where science was judged to be inadequate, the following weaknesses were evident:

- outcomes for students, both in terms of pass rates and progress, were poor
- recruitment processes were insufficiently careful
- levels of attendance and punctuality were low
- teaching was dull and uninspiring, using a narrow range of learning activities that did not meet the students' needs
- teachers routinely used ICT in lessons but the students did not
- target-setting for students was poor
- in some colleges enrichment activities for the sciences were insufficient
- science courses at foundation and intermediate levels were underdeveloped and progression routes to advanced courses were not clear
- curriculum management was weak and did not focus enough on improvement strategies.

85. The example below, from a large sixth form college, illustrates what outstanding science can look like.

> The college, in an inner-city area, recruits mainly but not exclusively from highly deprived areas. Pass rates in the sciences are very high and students' progress is well above that predicted from their prior attainment.

Team working among science teachers is highly effective and curriculum management is excellent. A safe, reflective ethos has been developed which allows teachers to be self-critical and to make sensible and realistic improvement plans. Close working between the highly skilled technical support staff and the teaching staff allows the teachers to concentrate on improving learning.

Teaching is both interesting and challenging. Science lessons are very well sequenced. They are linked effectively to extension activities for the more academically able students and additional catch-up sessions for those who are making less progress. The students are fulsome in their praise for the effectiveness of the extra help that their science teachers give them, which includes referral to appropriate support for literacy, numeracy and study skills. Assessment of students' work and progress is very strong; specific written feedback focuses on how students can improve. Online learning plans and target-setting are used thoughtfully to encourage students to reflect on their progress and set realistic targets for improvement.

A wide range of enrichment activities, including field trips and visits to higher education institutions, is instrumental in encouraging and enthusing the students. As a result of the high attainment and raised expectations, a good proportion of the students apply successfully to courses such as medicine, dentistry and physiotherapy. The college's science departments contribute in no small measure to its ethos as a whole and this brings out the best in the students.

86. Most of the strengths and weaknesses set out above were also features of provision in school sixth forms. Inspection evidence from school sixth forms, however, points to less inadequate provision, although a contributory factor may be the size and nature of the cohorts of students recruited.

87. Nationally, the proportion of students achieving A or B grades at A level has improved steadily since 2004/05 for all science subjects. This increasing success correlates with an increase in standards recorded by inspectors in sixth form lesson observations. Over the period of the survey, the quality of teaching observed in the sixth forms visited improved as teachers took lessons learnt about raising standards in Key Stages 3 and 4 and transferred them to their post-16 teaching. This compares with previous evidence that, while schools adopted strategies for raising standards suggested by such agencies as the Secondary National Strategy, they continued with more didactic and less imaginative methods in the sixth form. The shift in practice may be characterised by less note-taking and more note-making; that is, a shift in emphasis from teachers giving notes to their students to creating activities that require students to engage actively with their studies. The use of a wider range of experiences helped to increase students' knowledge and understanding. The shift in ways of working also coincided with changes to A-level specifications.

Teachers had encouraged greater activity from students as part of their responses to these changes.

88. The good practices in Key Stages 3 and 4 that were transferred to sixth form work included more rigorous target-setting and frequent assessment. Schools had closer monitoring procedures than those visited previously, leading to intervention with students who were falling behind in the standards predicted for them. Rigorous target-setting and regular monitoring of progress were also important features of good science education in colleges.

89. During the period of this survey, the number of students following A-level courses in physics and chemistry increased nationally. Numbers in biology increased initially but they showed a slight drop from 2008 to 2009. Most of the schools visited offered biology, chemistry, physics and psychology at AS and A level. Also during the period of this report, the number of courses available for sixth form study increased with the introduction of vocational science at A level. In schools where the GCSE offer had diversified to include vocational GCSE, some of the schools had secured post-16 pathways for students by introducing the vocational A level. Others, often because of limited staffing and resources, had not been able to do this. In such cases, care needed to be taken in offering students appropriate advice, information and guidance to ensure their progression to post-16 courses being provided by other schools and colleges. The example below is of a school improving the provision for its students.

> Over recent years, the curriculum in Key Stage 4 has been diversified to provide a good range of courses to meet the needs of students and establish a secure basis for sixth form education. Students can follow AS and A2 courses in biology, chemistry and physics. The school also provides a vocational pathway in BTEC First Diploma in science and is planning a vocational course that would lead to qualifications equivalent to AS level. The school is promoting greater consistency in assessing students' work to provide them with guidance on how to improve. It is ensuring that the curriculum choices of students in Year 9 are consistently well-informed and include the range of courses available during the sixth form and beyond. The introduction of a successful transition project enables students to move from Key Stage 4 to the sixth form more securely. The initiative is helpful, particularly to the 50% of students who join the sixth form from other providers. Good enrichment, through well-contextualised science and the STEM club, contributes to the recruitment of students to post-16 science.

Recognising the outstanding

90. This section of the report exemplifies outstanding science lessons. The text is taken from inspectors' direct observations of lessons and the examples cover a range of topics and year groups.

91. Primary example 1: Reception class

> During their time sitting on the carpet, the teacher engages the children in describing the mini-beasts they had seen in their investigation of the school's grounds. In pairs the children talk about their mini-beasts and then share their ideas with the whole class. The teacher brings the teaching assistants into the conversation and they remind the children of their experiences. This helps them to arrive at an understanding of the wide range of living things in their environment. A sense of ownership and care for the environment is generated.
>
> The teacher shows a video of a butterfly and its way of life. The presentation is interactive on the whiteboard and teacher skilfully uses questions and the children's answers to establish what was alive during the observation and the characteristics of living things. The children's level of interest and engagement is very high.
>
> The teaching is animated and enthusiastic and the teacher has a detailed knowledge of the needs of individual children. She shows the class the caterpillars that they observed during the previous week and the children can see how much they have grown. Careful prompts from the teacher are effective in helping the children cooperatively to relate the characteristics of living things to their observations of the caterpillars. During this time the teacher works with individuals or small groups to promote further thought to extend their learning. The teaching assistants are similarly engaged in a purposeful way.
>
> A session of summarising questions and answers leads to pupils demonstrating the caterpillar/butterfly life cycle to reinforce their knowledge and understanding. A child is dressed in a cagoule to represent the 'skin' of the caterpillar and is then wrapped in toilet paper to represent the cocoon. When the pupil breaks out of the cocoon the back of the costume shows the wings of the butterfly. To reinforce the learning, the teacher then takes on the role of the child and the pupils become the teacher in explaining the life cycle of the butterfly.
>
> **Key features**
>
> - high levels of engagement
> - vigilance from the teacher in monitoring progress
> - very good use of guided discussion between children
> - very effective questioning to elicit ideas, to engage pupils and check understanding

- very clear progression of ideas; a very well-planned sequence of learning.
- good individual intervention and extension
- very effective class management, including the deployment of teaching assistants.

92. Primary example 2: Year 3

The lesson begins with an effective question and answer session in which pupils describe what they know about light. This clarifies the pupils' understanding of key vocabulary such as 'translucent', 'opaque' and 'transparent'. There are high levels of response, application and attention.

The teacher uses a penguin puppet to ask about shadows of objects in relation to an overhead projector, discussing size, shape, position and clarity. The pupils have recently been learning about energy and how the environment can be harmed by the poor management of energy. A pupil comments on the heat from the overhead projector and the teacher takes the opportunity to consolidate the pupils' thinking on energy and conservation; not wasting electricity; noise and heat as waste energy from such devices; and the dangers of overheating by poor use.

More discussion follows on what can be seen or not seen in a shadow, and talk of shades of grey, not just black and white, shows that light is dispersed in the atmosphere. The pupils then move around a series of well-planned and well-resourced activities at different stations in the room. Pupils' levels of application and good collaboration are very high. The teacher is very effective at monitoring progress and managing activities so that all the pupils visit all the work stations, consolidating and extending their knowledge and understanding of light.

Key features

- very good classroom management, combined with very good relationships, result in high levels of application
- effective explanations
- excellent questions used to check understanding, promote thinking and engage pupils
- very careful and effective development of vocabulary and its accurate use
- the creation of a positive environment for learning science.

93. Primary example 3: Year 5

Pupils collaborate well on an investigative task about friction. They are working on the question, 'Which is the best shoe for gripping the floor?' Pupils have been planning their investigation, taking decisions on what to measure, the equipment needed and the procedures they will carry out. The teacher has worked with the teaching assistant to plan and anticipate the range of activities that might be proposed. The assessment strategy for the activity was also agreed with the teaching assistant. The teacher and the teaching assistant have considered the 'knowledge and understanding' content of the activity and the science skills, such as the consideration of variables and the need for accurate measurement. The pupils work in groups of four and discuss their plans.

Discussions with pupils show that they understand fair testing clearly and can describe why they chose to carry out the investigation in the way they planned. Their attitudes to science work are very positive. They cite 'doing practical' as one of the things they enjoy most. They have considered the different surfaces on which they do not want the shoe to slip. They demonstrate their understanding of the need for accuracy and the purpose of repeating procedures and measurements to raise reliability. They choose a scale for measurement that will be most appropriate and they agree on their roles in the procedure.

Overall, the groups investigate a good range of variables and measurements and the outcomes are shared effectively with others. The process is very well managed by the teacher. A plenary discussion demonstrates the pupils' good and developing knowledge and understanding of forces, friction, surface area, changing mass to change force, and the range of variables considered.

Key features

- a very well-planned lesson in which the teaching assistant was fully aware of lesson objectives and assessment goals
- teacher vigilant in monitoring progress
- excellent collaboration; pupils take on roles and work constructively with each other
- pupils were taking decisions rationally and with understanding of scientific enquiry
- pupils were planning confidently and were selecting appropriate equipment; they were not simply following instructions: they knew what they were doing and why
- very good assessment procedures, coordinated between teacher and teaching assistant
- procedures carried out accurately: the pupils understood the need to repeat measurements and calculate averages to make the findings more reliable

- a very effective plenary session, in which the pupils were learning from each other's work, leading to good understanding of the range of knowledge elicited by this practical work.

94. Primary example 4: Year 6

The pupils' behaviour is excellent, they are engaged well. The teacher teaches enthusiastically and confidently through a well-planned lesson. She uses ICT effectively to illustrate a view of the future as she sets the scene to learn about evolution. The simulation shows the world in five million years' time.

She uses questions and answers well, with many of the questions directed at individuals for specific reasons: keeping attention, building self-confidence, encouraging, and checking understanding. She explores ideas such as plate tectonics through the effective ICT presentation. Evolution and adaptations are talked about with high levels of interaction with pupils. They make suggestions and answer questions confidently.

Pupils then carry out a 'beak experiment' very successfully. They use forceps of different shapes as model beaks to tackle four different samples of living things: small seeds, walnuts, apples, worms. They work in groups and their enjoyment of the activity is very evident. They discuss spontaneously how the shape of the beak affects what they can do with it and hence affirm the ideas of adaptation, the shape of the beak affecting how successful they were at feeding on particular food items.

Finally, pupils watch a video of an evolving lizard that lives on the salt flats, catching flies on its frills and so on. Pupils not only enjoy the video but they readily identify the key features of the lizard and how these help it to survive in that environment.

Key features

- a very well-prepared lesson
- very confident and enthusiastic teaching
- a well-sequenced series of activities that engaged pupils effectively
- imaginative practical work that built skills, knowledge and understanding effectively
- very good-quality resources including well-researched and relevant video clips.

95. Secondary example 1: Year 7

A very enjoyable and engaging starter activity involves the class in calling out the names of electrical components represented by symbols on flash cards. This not only reviews previous learning but introduces new symbols effectively in preparation for other tasks in the lesson.

The teacher carefully explains the objectives of the lesson. She describes electrical current and its unit, the ampere, using a PowerPoint presentation during which she elicits the students' own ideas; for example why the unit was represented by a capital A. The teacher gives a very clear description of the practical procedures and checks students' understanding by effective questioning and answers. The description is very detailed and draws on students' contributions; this results in very secure understanding. The practical work involves series and parallel circuits. Some students predict less current in the parallel circuits compared with that in the series circuits; others are challenged to agree or to make other predictions.

The practical work that follows demonstrates good understanding of the underlying theory. The students apply themselves well and there is no off-task activity. Good collaboration ensures successful practical work and students' full involvement. The teacher is very effective in actively checking on progress and providing additional challenge.

Key features

- very good classroom management
- very good planning for practical procedures
- exemplary exposition and very clear instructions
- clear focus on working scientifically
- students involved in predictions and concerned with accuracy
- very high levels of application and good collaboration
- students very willing to answer and ask questions
- very good links to prior learning and concern for scientific literacy.

96. Secondary example 2: Year 10

Throughout this session, levels of application and engagement are high. The students are sorting photo cards into sets representing selective breeding and natural selection. Discussion in groups about the task and the decisions being made is very good. The teacher is very effective in challenging ideas and promoting further thought through targeted questioning and intervention. The additional challenges are made seamlessly; they 'stretch' students effectively. The groups then carry out one of two research tasks, using ICT and printed sources, on natural selection and how this accounts for adaptation and speciation.

Groups are engaged in self-evaluation and explain their successes in learning to the others. The plenary session is managed very effectively so that the learning within the groups becomes available to the whole class.

Key features

- very high levels of application

- questioning was very effective at checking understanding and promoting the students' engagement through their answers
- very good pace with no slack time; high levels of demand and high expectations
- excellent planning and sequencing of activities, supported by very good resources
- a clear framework displayed for pupils' self- and peer evaluation; using the framework was an integral part of the task
- very clear feedback requirements for peer evaluation, which were adhered to.

97. Secondary example 3: Year 10

The session begins with the teacher's lively presentation of the task. His well-targeted questions check the students' understanding skilfully and he uses some of their light-hearted responses effectively to motivate them and clarify the task. All the students are engaged.

The revision of ecology as part of the preparation for the International Baccalaureate in biology becomes an enjoyable task that promotes high levels of application and activity. The research-based activities are managed well and the pace of learning is good. Good reflective practice is used to bounce back students' ideas to them for further refining.

The students, including those who are learning English as an additional language, are challenged to use appropriate language. They present their findings in a range of ways. One student's research presentation on Charles Darwin is of high quality, accurate, and reported with obvious understanding. When he is challenged by fellow students, his explanations are lucid. The students are clearly used to debate and discussion. They pose questions well and respect the views of others. The atmosphere is one of fair debate. The teacher's close monitoring is effective throughout the lesson and provides additional challenge. The plenary session involves the students in using ICT to test their own understanding.

Key features

- very inclusive lesson; all were encouraged and kept engaged
- teacher vigilant in monitoring progress
- very good management of the lesson, with positive encouragement rather than negative interventions
- very well-structured lesson with excellent resources and use of ICT
- students understand the work and show good skills of independent learning
- teaching was very responsive and focused on the learning needs of individuals.

98. Secondary example 4: Year 13

The teacher gives a very clear explanation of particle vector motion which is illustrated well using ICT. The students are engaged by effective question and answer techniques in preparation for tackling A-level questions.

The work is challenging. The teacher gives the students excellent advice about how they might set about answering the questions by outlining a response using their ideas. The following session includes a good balance of individual, paired and whole-class work with all the students contributing to an effective response to the set question. The teacher uses the interactive whiteboard very well to capture the different ideas and responses.

The teacher is very effective at monitoring students' progress and demonstrates his very secure subject knowledge. His responses to the students' questions are effective and, in turn, these provide additional challenge. Students begin to spot anomalies in the responses of others and in the data presented. They are well-tuned to the requirements of the questions and correctly understand what they need to do to maximise their marks. Relationships between the teacher and students are very positive and humour is used on both sides to good effect.

Key features

- high levels of application and involvement of students in the lesson
- explanations were clear and well-understood
- students responded well in answering questions and, in turn, raised their own questions
- a good range of activities allowed for individual, paired and group work; whole-class activities consolidated students' understanding
- students had excellent attitudes to work
- the teacher was very skilled at asking questions for a range of purposes
- the teacher was vigilant in monitoring progress.

From satisfactory to good and beyond

99. The following examples are descriptions of satisfactory science lessons. Suggestions are made about how the lesson might be improved to raise the quality to at least good.

100. Primary example 1: Reception Class

The teacher begins to outline the activities for the morning. During their time sitting on the carpet, the children are restless and their attention is only satisfactory. The range of activities is quite prescribed and there is little evidence of the teacher using suggestions the children make. There are two teaching assistants who do little to encourage the children's engagement with what the teacher is explaining.

The class splits into different activity groups: work on floating and sinking, use of computer programs, and water play, filling plastic bottles and plastic containers of different shapes and sizes. The experiences are well-planned but not carried out fully in practice. The teaching assistants are not taking a full part in the learning activities but tend to child-mind and concentrate on mopping up water spills and so on. The children are active and engaged for much of the time. In the main, they are focused on the tasks they have been set. They are learning but the pace is only moderate. There is some good development of language because the teacher interacts with the children during their activities. There is no plenary work by the teacher in the groups, so the learning is not shared as well as it might be.

Areas for improvement

- The session needed more structured interaction between the adults and children. The children naturally enjoyed the exploration activity but the interaction with adults to talk about what was happening and to encourage more focused observations was limited.
- The teaching assistants should have been better briefed, so that they had a clear understanding of their role in promoting learning and were able to raise the quality of the learning by more effective intervention. Their limited contribution was the weakest feature of the session.
- Developing the children's language should have been a priority for all the adults in the class. This was proceeding well for the children who had the teacher's attention but the teaching assistants were under-deployed in this area and did not engage children as much as they could have done.
- The children's ideas and suggestions could have been better exploited. Opportunities to evaluate and build on their ideas could have had a positive impact on promoting their engagement and guiding learning.

101. Primary example 2: Year 2

At the start of the lesson, many pupils respond to the teacher's question and answer session but not all pay good attention. Vocabulary such as 'photosynthesis' arises but there is no overt checking of understanding by the teacher. Clearly, some pupils have used the word and associate it with plants making food from sunshine. For some their understanding is not secure and this is not recognised or challenged by the teacher. During the questions and answers, the teacher describes the roots 'taking up food'. This is inaccurate and can lead to misconceptions, as it is water and minerals/nutrients that are taken from the soil by the roots. Pupils' attitudes are good and most are keen to answer the teacher's questions.

The notion of fair testing is understood by many and their responses to questions, expressed in their own language, indicate good understanding.

There is an ICT display of seasonal pictures with different forms and stages of life, which provides a rolling presentation of living things and growth.

The class is organised into groups efficiently and the teacher uses ICT effectively to set out procedures and instructions for the work to be done. She elicits their ideas well but does not respond effectively to a couple of the more inventive ideas that she was not expecting. The pupils set up apparatus to investigate water absorption, but the equipment provided is not well-matched to the activity; for example, one-litre jugs are used for measuring 100ml. Spillages and inaccuracies are not challenged and nor are the pupils spotting the problem that this poses. The teacher's main concern seems to be to complete the activity, and there is insufficient focus on the quality of the practical work and the refining of the pupils' thinking. They enjoy the work and behave responsibly, even if the accuracy and the pace of learning are only satisfactory.

Areas for improvement

- The lesson would have been more effective if the teacher had had a clearer understanding of what the pupils already knew or did not know about plants and the way that they make food. Assessment for learning techniques could have informed her of areas of misunderstanding, as could initial discussions between pupils, working in pairs or small groups.
- Although it is challenging to do so, the teacher needed to ensure that she used scientific terms accurately. Consulting the science coordinator before each unit of work to check the key vocabulary and its meaning is an effective way of doing this. Some schemes of work have key words highlighted to alert teachers to their accurate use. The problems in science can often involve words where the common meaning is different from the more precise scientific usage.
- The practical equipment used should have been appropriate to the task, allowing pupils to make sufficiently accurate measurements. The teacher herself clearly did not have an adequate understanding of the need for accuracy.

102. Primary example 3: Year 4/5

The pupils are working on planning an investigation of materials suitable for making a model ship. The work is set within a theme involving Tudor ships. The teacher leads a class discussion on fair testing, changing variables and measuring. This goes on for too long and pupils begin to lose interest.

The class is split into groups depending on their attainment. The different groups have different questions to tackle related to the strength, flexibility and floating properties of the materials. The pupils are using a standard planning sheet to provide focus and minimise the language required to plan their work. When the pupils move on to their own planning, many find it difficult, particularly in setting up a fair test.

The materials provided include a cardboard cereal box, a foil tray, a length of wood, cardboard tubes, felt and other materials. All these are of different sizes and shapes and no means is provided of cutting the materials to the same shape and size. Some pupils are puzzled by this and teacher passes over the questions they ask about it. The teaching assistant does some very good work with a group of low-attaining pupils by asking pertinent questions and giving clear guidance to move their ideas along. The teacher circulates around the groups, checking on their progress but a few groups struggle to come up with a plan for an investigation they can undertake. The teacher's lack of direction does not help the pupils to make suitable progress and it allows some less-committed pupils to wander off-task.

Areas for improvement

- The lesson illustrated the challenge of combining science and design and technology. A lack of understanding of this combination led to inappropriate materials and equipment being deployed in a task that frustrated pupils. The science learning objectives needed to be clearer.
- A better approach to the notion of fair testing would have been to start with a well-structured class discussion in order to pick off issues one by one, to develop a common understanding of the challenge and identify a number of strategies to tackle the problem. The provision of different questions to different groups, with the assumption that a fair test could be applied to them all, showed a misunderstanding of the subject's demands.
- Although the teaching assistant's contribution to the pupils she worked with was good, this was on her own initiative. The whole class could have benefited from support being better allocated across the different groups.
- The pupils needed more judicious use of instruction and direction when they were unclear about how to proceed. This would have helped their confidence and made it possible for them to work more constructively. The teacher's withholding of direction and her lack of response to questions were not effective in getting pupils to think.

103. Primary example 4: Year 6

The theme of the lesson is the rate at which a solid dissolves. The teacher asks the pupils to put their ideas about the variables involved on sticky notes and to place them on laminated cards, in groups, to see how many and what types of variables are identified. Some confusion begins as the pupils start work. Out of the six groups, two have not understood the challenge and are reinforcing misunderstanding through their discussions with one another. Teaching assistants had watched the initial 'start up' but do not challenge the misunderstandings sufficiently and it is some time before the teacher gets round to all six groups.

The pupils are well-motivated and keen to take on the task. They have satisfactory practical skills. There is confusion among some of them as to what they are to measure; some are measuring the independent variable rather than the dependent variable. The idea behind the practical work is sound and simple, but the execution is weaker than it could be because the teacher and teaching assistants are not tuning pupils into the work with sufficient clarity, and intervention is limited by the inefficient deployment of the teaching assistants.

While learning is progressing satisfactorily, the rate could be quicker. The phrasing of the questions to investigate is difficult for some pupils and the teaching assistants become more active in helping pupils to clarify their ideas and language as the lesson proceeds. The teacher refers to dissolving, inaccurately, as a change of state. Some pupils decide to measure how much sugar is added to the water by measuring the volume of sugar. The teacher uses 'volume' in talking to these pupils while with others she refers correctly to the 'mass' of sugar, and pupils set about measuring the sugar by using electronic scales. Some pupils do not understand what the difference is between mass and volume and this also leads to some confusion.

Areas for improvement

- The teacher could have taken more time to clarify the pupils' thinking about and understanding of the task before they started on it.
- A whole-class session of question and answer would have clarified pupils' prior knowledge and understanding. This would have helped the teacher to determine how well individuals understood. She could then have worked with the weaker pupils to promote their understanding while encouraging the higher attainers to 'get on with it'.
- The teaching assistants should have been briefed more clearly about the lesson's learning priorities. They were under-deployed initially, although they eventually focused appropriately on groups and individuals who were struggling with organising language, ideas and equipment.
- The teacher's inaccurate use of some scientific vocabulary could have been a stumbling block to effective learning. Whenever practicable, teachers should check their own understanding, for example with the science coordinator.

104. Secondary example 1: Year 7

The inspector observes the second half of a lesson, in which the students are engaged well in making 'fruit batteries'.

They have been following satisfactory printed instructions, but some students start on the activity without sufficient reference to the written instructions and so waste time. The teacher has to call repeatedly for attention, and partially succeeds, but some students continue their practical work quietly and do not pay attention to what she says.

The teacher is active in circulating around the class and checking progress, and she makes some effective interventions with individual students, most often the more voluble ones. Quiet students do not attract her attention sufficiently. Overall, the students' application is good. Their practical skills are satisfactory and they are clearly enjoying the practical work. However, the process of measuring current does not get as far as repeating measurements for reliability. The teacher manages behaviour by chivvying individuals rather than creating a more purposeful environment for learning. These interventions are effective for a limited time only and then need repeating.

The plenary session is aimed at finding which fruit produced the highest reading on the voltmeters. However, some students refer to 'current'. Their contributions are not challenged, with the result that 'voltage' and 'current' become interchangeable in the class's vocabulary. The question and answer session is not well-targeted, so some students have a quiet time compared with the majority who readily offer answers to the teacher's questions. The final part of the plenary is a well-run session on evaluating the experiment and making improvements; this involves more students and engages them better. The activity and involvement of the teaching assistant in the room are minimal. She has the lesson plan but clearly had not engaged with it or with the teacher. Overall, the pace and challenge are only satisfactory.

Areas for improvement

- There needed to be clearer 'rules of engagement' for behaviour. The teacher tolerated students talking while she was talking; even when this was fairly quiet, it was symptomatic of their inattention.
- The teacher repeatedly made announcements while the pupils worked. She should have said all that she needed to say with the students' full attention and then let them get on while she modified their thinking and activity by intervening with groups or individuals.
- Questioning needed to be better targeted to challenge the knowledge and understanding of all students. This should avoid individuals being allowed to sit quietly and not to be required to answer a question.

- Careless use of specialist language should have been challenged, and accurate use of vocabulary established as critical for future progress.
- The teaching assistant should have been more gainfully employed. Although the teacher had given her a copy of the lesson plan, there had been no discussion to tune her into the lesson. The assistant could have been useful in checking on students' understanding of what they were doing and could have offered some challenge on matters such as the accuracy of their measurements and recording.

105. Secondary example 2: Year 9

The teacher explains the aims of the lesson in general terms and refers to the pupils' earlier knowledge and experience from Year 7. However, the lesson plan underestimates the time needed for an effective starter activity. The teacher's amusing example of a clockwork frog illustrates energy transfers, and the questions and answers are effective during the demonstration to engage the students.

When the teacher gets on to the main topic, the teaching is enthusiastic but slightly unfocused at times, allowing the students' concentration to drift. He draws some simple electrical circuits on the interactive whiteboard and involves the students in including voltmeters and ammeters into the circuits. The emphasis on the differences between series and parallel circuits is good.

The teacher organises the class into small groups but they have to wait to collect equipment in turn. This gives much scope for off-task chat. The teacher's instructions to draw a circuit, build it and record meter readings are rambling and unfocused. The instructions therefore need to be repeated and time is lost. A few students ignore the supplementary instructions and continue to fiddle with the equipment. A few spend an inordinate amount of time drawing their circuit diagrams. They do not generally carry out the measurements in parallel and series circuits as planned. Although the students enjoy the lesson and make a variety of circuits, the learning is only satisfactory.

Areas for improvement

- The teacher needed to be more focused on the expected learning, as a means of keeping students on track. More thorough use of targeted questions during the start-up session would have made it more likely that the students knew what was wanted in procedural terms. This clarity would have led to stronger conceptual development.
- The distribution of equipment needed to be more efficient. The groups waiting to be called quickly lost concentration. A number of collection points for equipment would have make a rapid start more likely, as would the better organisation of tasks within the groups.

- Greater priority needed to be given to teaching students how to work together more effectively in small groups.
- The teacher needed to monitor the work of the groups more closely to ensure that they remained fully on task and met the learning objectives.

106. Secondary example 3: Year 10

The students have an introductory word search to settle them down. The teacher does not make connections between the word search and the main objectives of the lesson which are concerned with food additives.

The teacher directs students into groups without engaging them through questioning or discussion of the topic. Each group is given different information and is told to use not more than 15 words and drawings to communicate the information to other groups. Groups get straight into the activity, but not all read of them the briefing material thoroughly. They work on flipchart paper but the hexagonal connected benches in the room make it difficult for the whole group to see what is going on. In most of the groups, one student does the reading and suggests ideas while the others occupy themselves in drawing the pictures and colouring in letters, or just sit and watch. The learning is not rapid, although some students are clearly acquiring vocabulary and knowledge.

The teacher moves around the groups, stressing the time and the constraints of the word count. The teaching assistant does some constructive work with two groups by giving clues as to the direction to take. The final flip charts are thin on detail and have an elementary treatment of the issue of additives in food. Conversations between students show that not all have understood terms such as 'emulsifier' or 'antioxidant'.

Areas for improvement

- A more purposeful starter activity could have been used by the teacher to find out what students already knew about food additives.
- Since the students were intended to learn by reading from the source material, the classroom activity needed to ensure that all of them did so. As only a few students read the materials, the work began with many students not understanding the vocabulary and not having a clear view of their role.
- The group work needed to be much better structured to achieve the planned learning objectives. Group work is not simply a matter of seating students in groups and letting them get on with a task. Effective group work should make sure all the students are involved and have clear roles for which they are accountable. The way that this class was organised meant that significant 'spectator activity' was allowed rather than active involvement.

- The teacher's monitoring of progress should have focused on students' understanding rather than on superficial factors.

107. Secondary example 4: Year 12

The teacher initiates a discussion with students about pigments in leaves, the changes that are observed with time and what might account for the changes. There is no visual stimulus but simply recollections of experiences. Not all students seem to have such recollections, as their lack of contributions makes clear. The teacher's questions are not directed towards particular students. Half the class seems very keen to answer questions and discuss ideas but the other half is not drawn in. The exchanges with the teacher are loosely organised, resulting in more than one participant talking at once.

Descriptions of the following practical work are given and read, but not discussed. Students carry out the practical work appropriately, but with some gaps in their knowledge of details, such as different rates of translocation in chromatography, which they covered in Key Stage 4. These are not discussed again with the teacher at this setting-up stage of the lesson. The teacher had not established the consideration of accurate measurement sufficiently well to challenge students in the way that they carried out the procedures. Some students raise some good questions; these are answered rather superficially and then set aside.

The atmosphere in the class is friendly but, at the same time, unchallenging, particularly for the most academically able. By the end of the lesson, learning had taken place but not at a pace or depth that could be regarded as more than satisfactory.

Areas for improvement

- The teacher's questioning needed to be more purposeful and better focused. Well-structured and directed questions at the start of the lesson could have ensured that all students understood the challenge well and any areas of uncertainty could have been cleared up.
- Questioning could also have established what the students already knew. Some of the teacher's assumptions about what the students knew or could recall from their work in Key Stage 4 were inaccurate.
- Students' questions should have been answered properly and exploited to provoke deeper thinking, rather than being left and lost by the end of the lesson.
- The lesson needed a better-structured start to enable the students to get into the practical work more quickly and effectively, and with the required accuracy and attention to detail that set A-level work apart from that at Key Stage 4.

Getting on the right path

108. As described earlier in the report, there have been significant changes to the curriculum in secondary schools since September 2006. The increased range of courses and the freedom to vary the length of Key Stage 3 and GCSE courses have made it more possible to match the courses to the needs of students. The increased number of courses makes the choice of courses key to securing pathways through and beyond secondary school. Choices made at the end of Key Stage 3 should be informed not only by what the courses in Key Stage 4 will entail but what they can lead to beyond the age of 16.

109. In February 2010, Ofsted carried out a short survey to look at what students were choosing in response to the increased curriculum choice available since the new GCSE science courses were introduced in September 2006.[13] The survey provided evidence of the extent to which advice, information and guidance were secure in the secondary schools visited in keeping options open for students' future education, training and careers.

110. The majority of the Key Stage 4 students spoken to during the survey were content with the science courses that they were following. Only 5% of the students who completed an electronic questionnaire were unhappy with their courses.[14] Inspectors judged that the schools were directing the vast majority of students appropriately to suitable courses at the end of Key Stage 3. Very few students felt misdirected.

111. The match of students to courses was commonly based on analysis of performance data, teachers' views of students' likely success with test-based or coursework-based examinations, and students' previous effort in and commitment to learning. Where students were allocated to vocational pathways, it was most often because the qualification was awarded through coursework only; the teachers believed that the students would achieve higher grades as a result of this method of assessment.

112. All the schools visited as part of the February 2010 survey provided information to students and their parents and carers about science courses. Half of the schools had considered the readability of the information and made suitable adjustments, but others had used verbatim text from examination board information; for example in relation to examination formats and different kinds of assessment strategies.

113. Most of the Key Stage 4 students interviewed did not know enough about their attainment, their areas of weakness and how they might improve. They were, therefore, less well-placed to take some responsibility for their progress through

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[13] *Guidance for students studying science* (100045), Ofsted 2010; www.ofsted.gov.uk/publications/100045.

[14] A total of 1,623 Key Stage 4 students returned questionnaires which were recorded electronically and analysed in detail for the survey.

their science course. The questionnaire showed that 22% of the students had been given information about careers that they could enter with science qualifications. Staff were aware of the limitations and career implications of following particular courses, but this awareness did not necessarily find its way into the advice offered. Essentially, the information and advice were of little use since most of the students did not actively express a preference between courses nor did they want to.

114. The Year 12 students interviewed were better informed and their choices for post-16 courses were managed more rigorously, and with better support, than those for students at the end of Key Stage 3 who were choosing 14–16 options. A large majority of the 195 sixth form students spoken to in the schools visited had a good understanding about science courses and the connection to further careers. The sixth form survey also suggested that almost every student was content with her or his choice of science studies.

115. In the schools visited that had sixth forms, the uptake of post-16 separate science level 3 courses was not limited by whether the students had studied double award GCSE or triple science but by whether they had reached a minimum threshold grade for entry to the post-16 course. The sixth form students chose science mainly because of their interest in and enjoyment of it; they often cited good teaching as a factor that attracted them to it. For the majority of these students, a science qualification was also necessary for their particular career intentions. But, significantly, the ambition to follow a science career came from enjoying the study of science at Key Stage 4.

116. Students who had followed a vocational course at Key Stage 4 had limited opportunities for studying vocational science at either level 2 or level 3 at post-16 level, and were ill-prepared for separate sciences at AS and A level. Students who had studied applied science at GCSE could progress to applied science A level, but were not easily able to pick up a separate A-level science. This limitation was not the case for students who studied double award or triple science at Key Stage 4: they could choose vocational or applied level 3 science courses as well as the separate science AS/A levels.

117. Most of the students spoken to in Key Stage 4 and in the sixth form said that practical investigative work was the aspect of science that they enjoyed most. They also described a healthy mix of academic challenge, independent research, group work and discussion of difficult and topical scientific concepts as promoting their interest and enjoyment. Students spoken to in the sixth form who had chosen not to follow science courses at AS and A level had done so because they found other subject areas more personally interesting, and only occasionally because they had not enjoyed the style of teaching they had experienced in science at Key Stage 4.

Supporting science in the primary school

118. A number of issues relating to science in primary schools have been described in this report and are reflected particularly in the lower levels of outstanding provision in these schools compared to the secondary schools visited:

- the lack of confidence of some primary teachers in teaching science
- the low take-up of science-specific continuing professional development
- the reduced levels of support provided by local authorities.

These factors have contributed to a lack of overall improvement since the last report on standards, as measured by teacher assessment data in Key Stages 1 and 2.

119. However, inspectors found examples of some primary schools making improvements. These schools had focused on analysing and developing their science practice and, consequently, had improved pupils' engagement, enjoyment and achievement, as in this example.

> In aiming to achieve the Primary Science Quality Mark, the teachers were determined to inspire and motivate pupils in science.[15] They decided that the opportunities provided should be relevant and exciting. By conducting initial interviews with a sample of pupils, the teachers identified a number of opportunities to improve science teaching. The profile of the subject was raised through:
>
> - the training of all members of staff
> - the introduction of a whole-school science week
> - a significant increase in the number of science-related trips and visiting speakers.
>
> Inspectors' discussions with school council members across the age range showed that the aims had been met. Key improvements identified by the pupils, teachers, governors and parents were:
>
> - an increase in practical science
> - more visits, visitors and links with outside organisations
> - more opportunities for pupils to experience science outside lessons
> - increased understanding of teaching and learning of science
> - governors' and parents' greater awareness of science in the school
> - the development of the role of the science manager.

120. Inspectors identified some important mechanisms for bringing about improvement in primary science. One of these was the Primary Science Quality Mark. This aims to raise the profile of science in primary schools, provide an

[15] Further details of the Primary Science Quality Mark are given in the Notes.

effective framework for developing and evaluating science teaching and learning in primary schools, and promote a commitment to excellence in primary science. Inspectors' interviews with staff in the schools that participated in the initiative confirmed the improvements in teachers' confidence and ability to teach science, with a consequent positive impact not only on pupils' performance but also on their engagement and enjoyment.

121. The initiative has shown how strongly motivated professionals in science education can work with science-based industry and other agencies to promote higher standards in science education.

Quality in continuing professional development

122. In 2010 Ofsted published *Good professional development in schools.*[16] The key strengths and areas for development which inspectors identified in science inspections closely reflected those in this wider-ranging survey. The strengths included:

- the strong commitment of senior managers to developing their staff
- the close alignment of professional development with performance management, institutional self-review and priorities for improvement
- the flexible use of time, resources and expertise
- the successful balancing of individual and institutional needs.

123. A further strength identified in this report was the focus by the institutions on developing not only the teaching staff but also the wider workforce. Inspectors found several examples of staff who had been given the financial support and time to gain extra qualifications that considerably extended their career capabilities. Investment in professional development had a very positive impact on recruiting and retaining staff.

124. Despite these strengths, inspectors identified three barriers to improvement. First, there were continuing weaknesses in the evaluation and assessment of the value for money of professional development. Second, teachers' knowledge of subjects other than English and mathematics was seldom refreshed by suitable professional development, especially in primary schools. Finally, schools in which staff, particularly leaders, lacked skills in self-evaluation and in dealing with weaknesses needed help before professional development needs could be met.

125. The report identifies four key questions that leaders need to ask themselves if they are to be successful in planning professional development. These relate to:

[16] *Good professional development in schools* (080254), Ofsted, 2010; www.ofsted.gov.uk/publications/080254.

- the extent to which professional development is integrated with school improvement
- how well the school provides policies and frameworks to secure consistency and quality in the work of staff
- the extent to which the expertise of staff is used
- how well the school monitors and evaluates its professional development.

126. The important contribution of continuing professional development (CPD) to raising standards in science is described elsewhere in this report. The predominance of generic CPD and the paucity of science-specific CPD, particularly in primary schools, are also noted. The importance of high-quality CPD for science was recognised by the introduction of the network of Science Learning Centres. Since 2004, in collaboration with the Wellcome Trust, the former Department for Children, Schools and Families had established a network of Science Learning Centres to provide high-quality professional development for all those involved in science education in primary and secondary schools and further education.

127. There are nine regional centres in England and a national centre at the University of York to serve all the United Kingdom. Their mission is broad, embracing psychology, earth science, astronomy, citizenship and other areas, in addition to the three traditional sciences. The intention is to improve subject knowledge, encourage inspirational and innovative teaching, and bring contemporary science into the classroom. Reflecting this mission, all the centres have close links to higher education institutions and have a wide range of partners from industry and the professions, as well as schools and local authorities.

128. During the period covered by this report, inspectors visited almost all the Science Learning Centres, held interviews with course members and were present at evaluation sessions with course members. The teachers indicated that they were benefiting from the experiences and had very positive views about the courses they were following. The impact of CPD at one Science Learning Centre is illustrated below.

> During the second session of a course in leading science in challenging circumstances, the head of science from an average-sized secondary school gave an account of the impact of training he had received. He was in his late forties and described how he had been 'stuck in a rut' when his headteacher 'sent him' on the course. After his initial resentment and lack of warmth towards the course, he was influenced by the quality of presentations and the vigour of fellow course members. The structure of the course required members to carry out some development work in their own schools before attending the second session later in the year. He had worked on improving the assessment and tracking system in science and making clear links between data gathered and planning for individuals. He

described how morale had lifted among science teachers and how the outcomes for students had improved.

129. Further examples of evaluations of other training courses run at Science Learning Centres highlight their influence on teaching, learning and the curriculum:

On a physics course: 'I found that updating my skills was very rewarding as it helped to motivate my students. I enjoyed learning about these techniques and thinking how to incorporate them into my lessons. There has also been a spin-off benefit to my colleagues. Some students made comments about how they had enjoyed the lessons more since I started to incorporate more collaborative tasks, and I hope to see an improvement in their grades in the summer. I will continue developing my use of the materials covered on the course. Also, I wish to arrange some INSET opportunities for colleagues who would like some help with teaching the physics topics at Key Stage 3. Influenced by the research we studied, I want to analyse the take-up of triple science in our school to check that no features of the teaching or school curriculum are dissuading girls from following this route.'

On a science management course: 'I decided to attend "New and Aspiring Heads of Science" because I wanted to be able to fully support and challenge all the members of my department, including technicians and teaching and learning assistants, through effective leadership, target-setting, monitoring, reflection and evaluation of practice. I also wanted to make a positive impact on the everyday teaching and learning experiences of students during their study of science.

'The course material was provided using inspirational teaching and learning methodologies, modelling good practice, role-plays, lab sessions, and action-planning. Research and development tasks carried out back in school were assessed for their impact.

'I particularly enjoyed the sessions on "creating a science team rather than a science department", "creating and communicating a shared vision", "from good to outstanding" and "coaching". Every session was packed full of great, useful ideas to be brought back to the classroom and, because of this, the course has had a significant impact on how science is delivered and managed in my school.

We made changes to teaching methods used by all teachers in the department by providing INSET to give teachers opportunities to experiment with "new" pedagogy. Schemes now make "skills teaching" more explicit. Students love the active teaching and learning methodologies brought back from the course.

‘I’ve put many aspects of the course into practice. I’ve learnt how to run effective meetings, how to be assertive, how to be creative with my budget, and many more skills.’

130. The proportion of secondary schools visited that had used the services of Science Learning Centres, however, was relatively low, although most of these schools were aware of the Centres’ existence and purpose. Some were aware of the courses offered but did not apply for them because of perceived financial constraints and the distance from their nearest centre. A large majority of the primary schools visited were not aware of the courses and services. They were also unclear about what other sources of professional development were available. Secondary schools had a better understanding of the training opportunities that the centres offered, and all of those who had used them had found the support helpful.

Notes

This report is based on evidence gathered during the period June 2007 to March 2010. Through the subject survey programme for science, Her Majesty’s Inspectors (HMI) and additional inspectors visited a sample of 94 primary, 94 secondary and two special schools across England. No school that was in one of Ofsted’s categories of concern (that is, having a notice to improve or requiring special measures) was included in the sample of schools visited. The survey has also drawn on inspections of post-16 science education in colleges.

The report was also informed by evidence gathered through conferences and meetings with organisations such as the Qualifications and Curriculum Development Agency, the Secondary National Strategy, Science Learning Centres, and the National Advisers and Inspectors Group for Science. In addition to these, HMI gathered information and views from a range of organisations concerned with science education. These included: the Association for Science Education; the Royal Society; the Royal Society of Chemistry; the Institute of Physics; the Society of Biology; Science Community Partnership Supporting Education; the Earth Science Teachers’ Association; and the Consortium of Local Education Authorities for the Provision of Science Services.

Some of the schools visited by inspectors were part of the pilot phase of the Primary Science Quality Mark, funded by The Wellcome Trust. The pilot phase in 2008 (12 schools in the East of England) involved other partner organisations contributing in kind: Science Learning Centres; the Association for Science Education; and Barnet local authority. The second phase of the scheme, involving 49 schools, began in 2009. The target is for 1,800 schools to achieve the Primary Science Quality Mark award between 2010 and 2013, rising to over 30% of all United Kingdom schools by 2018.

Further information

Publications by Ofsted

Guidance for students studying science (100045), Ofsted, 2010; www.ofsted.gov.uk/publications/100045.

Subject-specific guidance for inspectors on making judgements during subject survey visits to schools, Ofsted, 2010; www.ofsted.gov.uk/publications/20100015.

Success in science (070195), Ofsted, 2008; www.ofsted.gov.uk/publications/070195.

Other publications

Science and innovation investment framework 2004–2014: next steps (06/1245), HM Treasury, 2006; http://bis.ecgroup.net/Search.aspx.

In 2004, the then Department for Education and Skills collaborated with Her Majesty's Treasury, the Department of Health, and the Department of Trade and Industry to produce a discussion paper about the position of science in education and the economy. It presents the next steps in five key policy areas: maximising the impact of public investment in science on the economy through increasing innovation; increasing research councils' effectiveness; supporting excellence in university research; supporting world-class health research; and increasing the supply of science, technology, engineering and mathematics (STEM) skills.

Websites

Association for Science Education (ASE)

This is the UK's largest science association dedicated to the teaching of science.
www.ase.org.uk

Consortium of Local Education Authorities for the Provision of Science Services (CLEAPSS)

CLEAPSS is an advisory service providing support in science and technology for a consortium of local authorities and their schools, including establishments for pupils with special needs. Independent schools, post-16 colleges, teacher training establishments, curriculum developers and others can apply for associate membership.
www.cleapss.org.uk

Earth Science Teachers' Association (ESTA)

The aim of the ESTA is to advance education by encouraging and supporting the teaching of earth sciences at all levels, whether as a single subject such as geology, or as part of science or geography or other courses.
www.esta-uk.net

Institute of Physics (IoP)

The Institute of Physics runs a web-based resource for schools and colleges. It provides information about its latest curriculum development initiatives, the Affiliated Schools Scheme and professional development courses, as well as links to and information about various support networks.
www.iop.org/activity/education/index.html

National Advisers and Inspectors Group for Science (NAIGS)

NAIGS is the subject group for science inspectors, advisers and consultants. It is affiliated to and administered by the Association for Science Education. Its role is to provide continuing updating of information and developments in science, professional development and networking opportunities. It has close links with schools in all phases to support and advise staff on science education.
www.ase.org.uk/professional-development/naigs

Royal Society

The Royal Society is the national academy of science of the UK and the Commonwealth and is at the cutting edge of scientific progress. The teachers' section of the website can be found at:
http://royalsociety.org/

Royal Society of Chemistry

The education activities of the Royal Society of Chemistry cater for chemical scientists of all ages. The organisation produces resources for teachers, lecturers and students, provides training and continuing professional development, maintains professional registers and contributes to education policy.
http://rsc.org/

Science Learning Centres

Science Learning Centres are a national network for professional development in science teaching. Their aim is to improve the teaching of science and to inspire pupils. There are nine regional centres in England and one national centre, each with a number of satellite centres. The national centre aims to reach all the secondary schools in the UK.
www.sciencelearningcentres.org.uk

SCORE: Science Community Partnership Supporting Education

SCORE is a partnership of six organisations: the Association for Science Education, the Institute of Physics, the Royal Society, the Royal Society of Chemistry, the Science Council and the Society of Biology.
www.score-education.org

Society of Biology

The Society of Biology is a single unified voice for biology: advising Government and influencing policy; advancing education and professional development; supporting its members, and engaging and encouraging the public's interest in life sciences.
www.societyofbiology.org

The Learning and Skills Improvement Service

The Learning and Skills Improvement Service is responsible for building capacity in the learning and skills sector to design, commission and deliver programmes which support the improvement of quality and strategic change.
www.lsis.org.uk

Annex A. Providers visited

Primary schools	**Local authority**
Ambleside Primary School	Cumbria
Appleton Roebuck Primary School	North Yorkshire
Archbishop of York’s CofE Voluntary Controlled Junior School, Bishopthorpe	York
Badgerbrook Primary School	Leicestershire
Becontree Primary School	Barking and Dagenham
Beeston Rylands Junior School	Nottinghamshire
Benhurst Primary School	Havering
Bishopthorpe Infant School	York
Blacklands Primary School	East Sussex
Blue Bell Hill Primary and Nursery School	Nottingham
Bow Community Primary School	Devon
Broughton Jewish Cassel Fox Primary School	Salford
Catcliffe Primary School and the Meadows Children’s Centre	Rotherham
Caton Community Primary School	Lancashire
Cherry Lane Primary School	Hillingdon
Conisbrough Station Road Primary School	Doncaster
Cuddington Community Primary	Surrey
Diocesan and Payne Smith Church of England Primary School	Kent
Downsbrook Middle School	West Sussex
Drayton Park Primary School	Islington
Edleston Primary	Cheshire East
Eton Park Junior School	Staffordshire
Flockton Church of England Voluntary Controlled First School	Kirklees
Fordcombe Church of England Primary School	Kent
Funtington Primary School	West Sussex

Gilthill Primary School	Nottinghamshire
Glade Primary	Redbridge
Granby Junior School	Derbyshire
Greengates Community Primary School	Knowsley
Harlesden Primary School	Brent
Harlyn Primary School	Hillingdon
Hawksworth Wood Primary School	Leeds
Hillview Primary School	Halton
Holy Cross Catholic Primary School	St Helens
Holy Family Catholic Primary School	Knowsley
Honeywell Junior School	Wandsworth
Kettlefields Primary School	Cambridgeshire
Kirby Hill Church of England Primary School	North Yorkshire
Laleham CofE VA Primary School	Surrey
Leck St Peter's Church of England Primary School	Lancashire
Limehurst Community Primary School	Oldham
Linden Road Primary School and Hearing Impaired Resource Base	Tameside
Lionwood Junior School	Norfolk
Little Gaddesden Church of England Voluntary Aided Primary School	Hertfordshire
Markington Church of England Primary School	North Yorkshire
Meridian Primary School	Greenwich
Murton Community Primary School	Durham
Mytham Primary School	Bolton
New Penshaw Primary School	Sunderland
Old Fletton Primary School	Peterborough
Old Priory Junior School	Plymouth
Oldbury on Severn Church of England Primary School	South Gloucestershire
Paxton Primary School	Lambeth

Pevensey and Westham CofE Primary School	East Sussex
Preston Park Primary School	Brent
Redlands Primary School	Reading
Richard de Clare Community Primary School	Essex
Rokesly Junior School	Haringey
Rolleston Primary School	Leicester
Rose Hill Primary School	Stockport
Roseberry Community Primary School	North Yorkshire
Ruislip Gardens Primary School	Hillingdon
Rushey Green Primary School	Lewisham
Sandhill Primary School	Barnsley
Sidegate Primary School	Suffolk
Spelthorne Junior School	Surrey
Springmead Primary School	Hertfordshire
Springwell Junior School	Hounslow
St Anne's (Stanley) Junior Mixed and Infant School	Liverpool
St Anne's and St Joseph's Roman Catholic Primary School, Accrington	Lancashire
St Cuthbert's Roman Catholic Voluntary Aided Primary School, New Seaham	Durham
St Dominic Catholic Primary School	Hertfordshire
St George's Church of England Primary School	Stockport
St Hugh's CofE Primary School	Oldham
St Nicolas CofE Junior School	West Berkshire
St Paul's Primary School	Wiltshire
St Peter's Catholic Primary School	Birmingham
St Thomas More Catholic Primary School	Birmingham
Stanton Road Primary School	Wirral
Stretham Community Primary School	Cambridgeshire
Taxal and Fernilee CofE Primary School	Derbyshire

The Billinghay Church of England Primary School	Lincolnshire
Throston Primary School	Hartlepool
Town Farm Primary School	Surrey
Trowell CofE Primary School	Nottinghamshire
Upland Primary School	Bexley
Wellfield Methodist and Anglican Church School	Lancashire
Wembrook Primary School	Warwickshire
West Twyford Primary School	Ealing
Westbury-On-Trym CofE Primary School	City of Bristol
Wheldrake with Thorganby Church of England Voluntary Aided Primary School	York
Whitchurch CofE Primary School	Herefordshire
Whitecote Primary School	Leeds
Woodcock's Well CofE Primary School	Cheshire East

Secondary schools	**Local authority**
All Saints CofE School	Stockton-on-Tees
Allerton Grange School	Leeds
Archbishop Holgate's School	York
Archbishop Temple School, A Church of England Specialist College	Lancashire
Balcarras School	Gloucestershire
Barnwell School	Hertfordshire
Beaminster School	Dorset
Bishop Challoner Catholic Secondary School	Hampshire
Bishopshalt School	Hillingdon
Bristnall Hall Technology College	Sandwell
Broughton Hall High School, A Technology College	Liverpool
Brownedge St Mary's Catholic High School	Lancashire
Bury St Edmunds County Upper School	Suffolk

Calderstones School	Liverpool
Callington Community College	Cornwall
Camborne Science and Community College	Cornwall
Cams Hill School	Hampshire
Cockshut Hill Technology College	Birmingham
Copthall School	Barnet
Court Moor School	Hampshire
Cove School	Hampshire
Cramlington Learning Village	Northumberland
Crofton School	Hampshire
Crown Hills Community College	Leicester
Driffield School	East Riding of Yorkshire
Durrington High School	West Sussex
East Barnet School	Barnet
Finchley Catholic High School	Barnet
Four Dwellings High School	Birmingham
Framwellgate School Durham	Durham
Gladesmore Community School	Haringey
Glenthorne High School	Sutton
Gosforth Central Middle School	Newcastle upon Tyne
Great Sankey High School	Warrington
Hailsham Community College	East Sussex
Hardwick Middle School	Suffolk
Harris Academy At Peckham	Southwark
Heart Of England School	Solihull
Holly Lodge Girls' College	Liverpool
Horsforth School	Leeds
Huntington School	York
Kettlethorpe High School, A Specialist Maths and Computing College	Wakefield

Kidbrooke School	Greenwich
King Edward VI Church of England Voluntary Controlled Upper School	Suffolk
Kirkby Stephen Grammar School	Cumbria
Knutsford High School	Cheshire East
Lake Middle School	Isle of Wight
Leysland High School	Leicestershire
Malton School	North Yorkshire
Manhood Community College	West Sussex
Marlborough School	Hertfordshire
Marshland High School	Norfolk
Millais School	West Sussex
Nab Wood Middle School	Bradford
Netherthorpe School	Derbyshire
Ponteland Community High School	Northumberland
Poole Grammar School	Poole
Prendergast-Hilly Fields College	Lewisham
Queens Park Community School	Brent
Ralph Sadleir Middle School	Hertfordshire
Rickmansworth School	Hertfordshire
Ripon Grammar School	North Yorkshire
Rodborough Technology College	Surrey
Rydens School	Surrey
Settle College	North Yorkshire
Settlebeck High School	Cumbria
Sir John Nelthorpe School–A Specialist Technology College for Science, Mathematics and Computing	North Lincolnshire
Sir William Borlase's Grammar School	Buckinghamshire
South Molton Community College	Devon
St Damian's RC Science College	Tameside

St Francis Xavier's College	Liverpool
St James' Catholic High School	Barnet
St John Fisher Catholic High School	North Yorkshire
St Joseph's RC High School and Sports College	Bolton
St Katherine's School	North Somerset
St Mark's Catholic School	Hounslow
St Mary's Catholic Comprehensive School	Newcastle upon Tyne
St Michael's Roman Catholic Voluntary Aided Comprehensive School	Stockton-on-Tees
Stoke-by-Nayland Middle School	Suffolk
The Bishops' Blue Coat Church of England High School	Cheshire West and Cheshire
The Ellen Wilkinson School for Girls	Ealing
The Honywood Community Science School	Essex
The John Warner School	Hertfordshire
The King's School (the Cathedral School)	Peterborough
The McAuley Catholic High School	Doncaster
The North School	Kent
The Purbeck School	Dorset
The Thomas Alleyne School	Hertfordshire
The Windsor Boys' School	Windsor and Maidenhead
The Winston Churchill School A Specialist Sports College	Surrey
Thomas Hepburn Community Comprehensive School	Gateshead
Upper Shirley High School	Southampton
Waldegrave School for Girls	Richmond upon Thames
Willingdon Community School	East Sussex

Special schools	**Local authority**
The Alternative Centre for Education	Brighton and Hove
Nunnykirk Centre for Dyslexia	Northumberland

Further education and sixth form colleges	Location
Alton College	Alton
Aylesbury College	Aylesbury
Barton Peveril College	Eastleigh
Cadbury Sixth Form College	Birmingham
Cheadle and Marple Sixth Form College	Stockport
Christ The King Sixth Form College	Lewisham
City of Westminster College	Westminster
East Norfolk Sixth Form College	Great Yarmouth
Gateway Sixth Form College	Leicester
Greenwich Community College	Greenwich
Harrow College	Harrow
Hartlepool Sixth Form College	Hartlepool
John Ruskin College	South Croydon
Leyton Sixth Form College	Leyton
Loreto College	Manchester
New College Telford	Telford
Orpington College of Further Education	Orpington
Portsmouth College	Portsmouth
Prior Pursglove College	Guisborough
Queen Mary's College	Basingstoke
Salford City College	Salford
Sir George Monoux College	Walthamstow
Southgate College	Southgate
Southwark College	Bermondsey
St Brendan's Sixth Form College	Bristol

St John Rigby RC Sixth Form College	Wigan
St Mary's College, Middlesbrough	Middlesbrough
Stockton Riverside College	Stockton-on-Tees
Stockton Sixth Form College	Stockton-on-Tees
The Sheffield College	Sheffield
Wirral Metropolitan College	Wirral

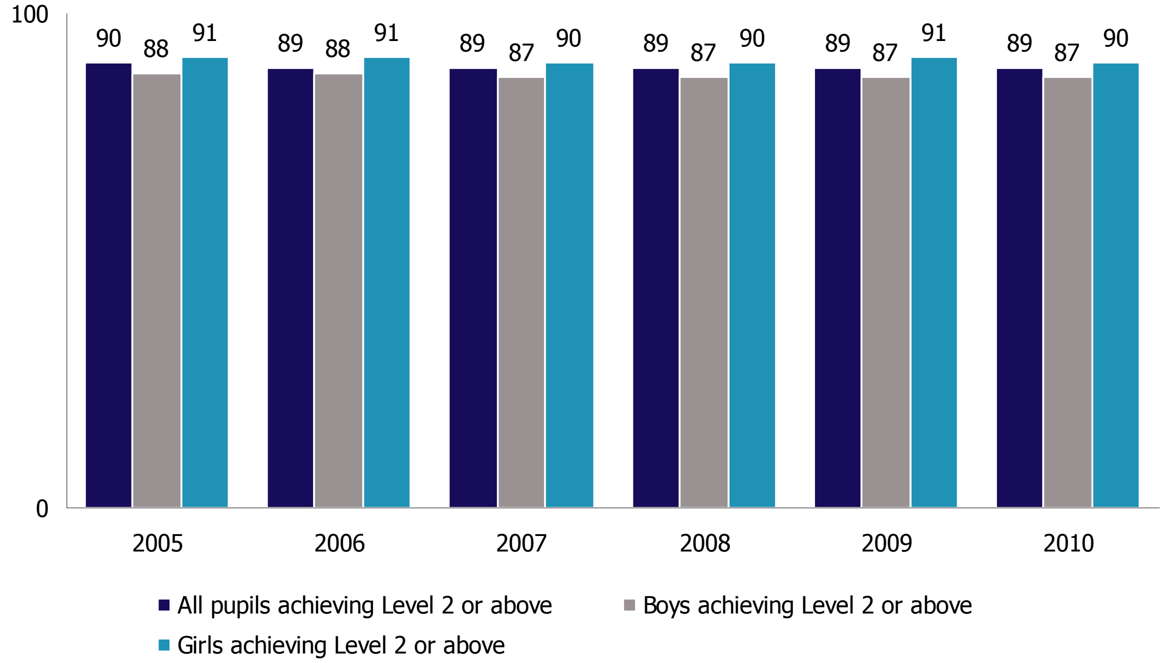
Annex B. Results in national assessments and public examinations

Standards in science in primary schools
National data from 2005 to 2010

Key Stage 1

Between 2005 and 2010, there has been very little change in the proportion of pupils achieving Level 2 or above in Key Stage 1 teacher assessments; the proportion has remained at 89% since 2006. The same picture is evident for gender. However, the proportion of girls achieving Level 2 or above has remained at least three percentage points higher than that for boys between 2005 and 2010. There has been a gradual decline in the total number of pupils in Key Stage 1 over the period of this report and a consistent fall in the number of pupils involved in Key Stage 1 teacher assessments from 559,800 in 2006 to 533,000 in 2009.

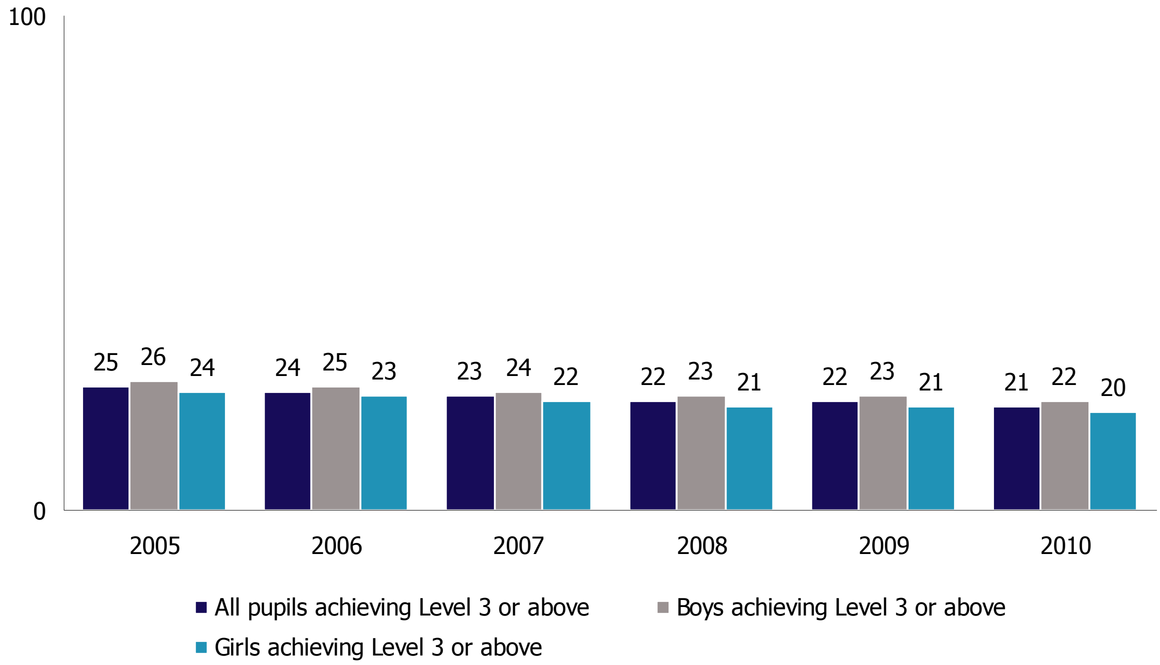
Figure 1: Percentage of pupils achieving Level 2 or above in Key Stage 1 science teacher assessments, 2005 to 2010



Source: DfE SFR26/2010: National Curriculum Assessments at Key Stage 1 in England, 2009/10 (Provisional).

Since 2005, there has been a steady decline in the proportion of pupils achieving Level 3 or above in Key Stage 1 teacher assessments, falling from 25% to 21%. Similar patterns were seen for boys and girls. However, the proportion of boys achieving Level 3 or above has been consistently two percentage points higher than that for girls.

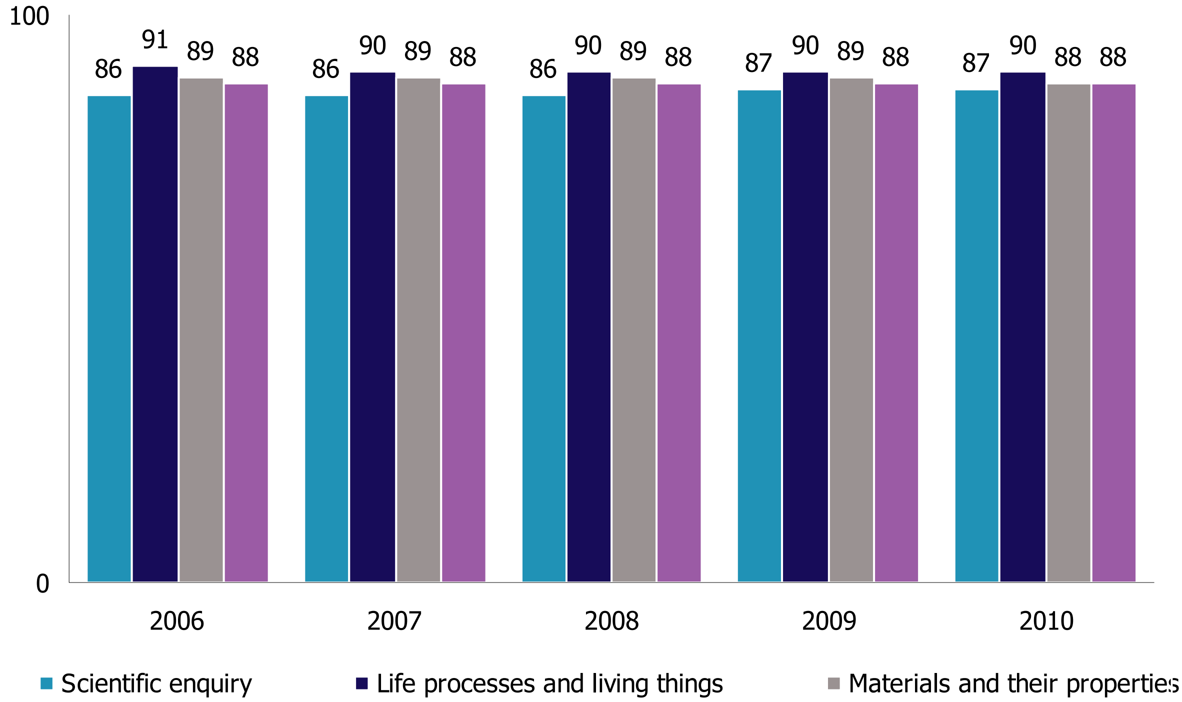
Figure 2: Percentage of pupils achieving Level 3 or above in Key Stage 1 science teacher assessments, 2005 to 2010



Source: DfE SFR26/2010: National Curriculum Assessments at Key Stage 1 in England, 2009/10 (Provisional).

The proportion of pupils achieving Level 2 or above in the four attainment targets has been steady between 2006 and 2010. Scientific enquiry has the lowest proportion of pupils achieving Level 2 or above at 87% in 2010 compared with 90% of pupils achieving Level 2 or above in life processes and living things.

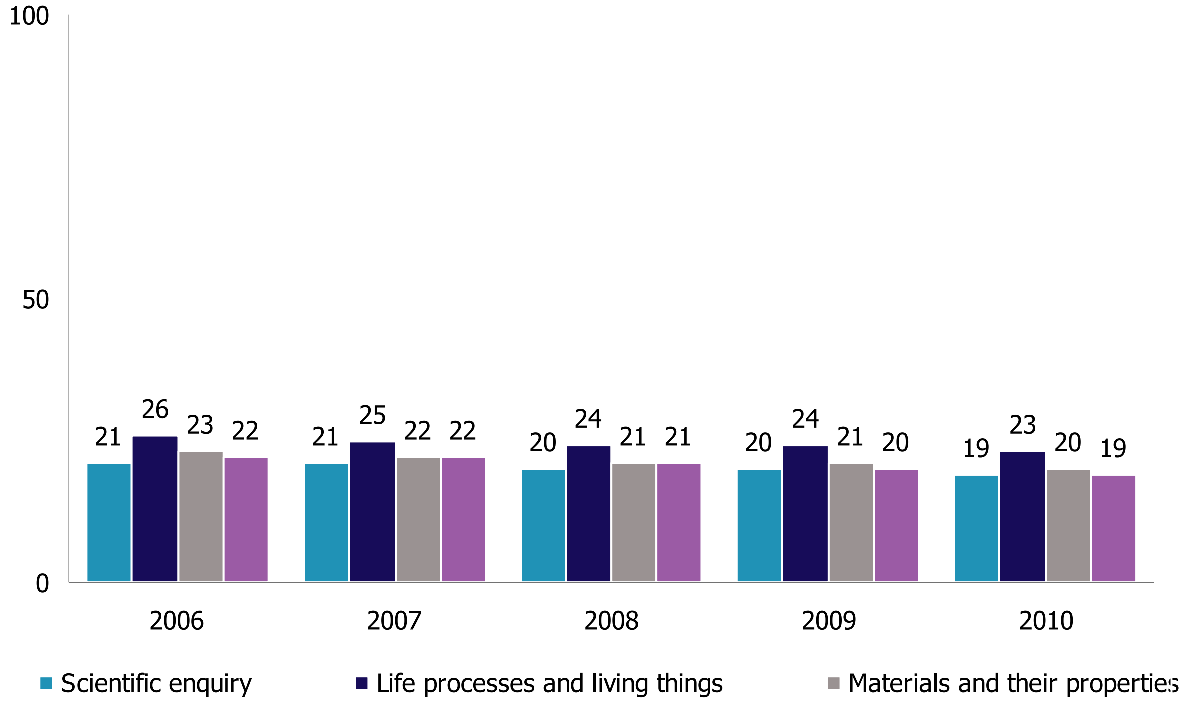
Figure 3: Key Stage 1 science teacher assessments of pupils gaining Level 2 or above between 2006 and 2010



Source: DfE SFR26/2010: National Curriculum Assessments at Key Stage 1 in England, 2009/10 (Provisional).

The proportion of pupils achieving Level 3 or above in each attainment target has changed very little between 2006 and 2010. The proportion of pupils achieving Level 3 or above in scientific enquiry was the lowest of the four attainment targets while life processes and living things has the highest proportion of pupils achieving Level 3 or above.

Figure 4: Key Stage 1 science teacher assessments of pupils gaining Level 3 or above between 2006 and 2010

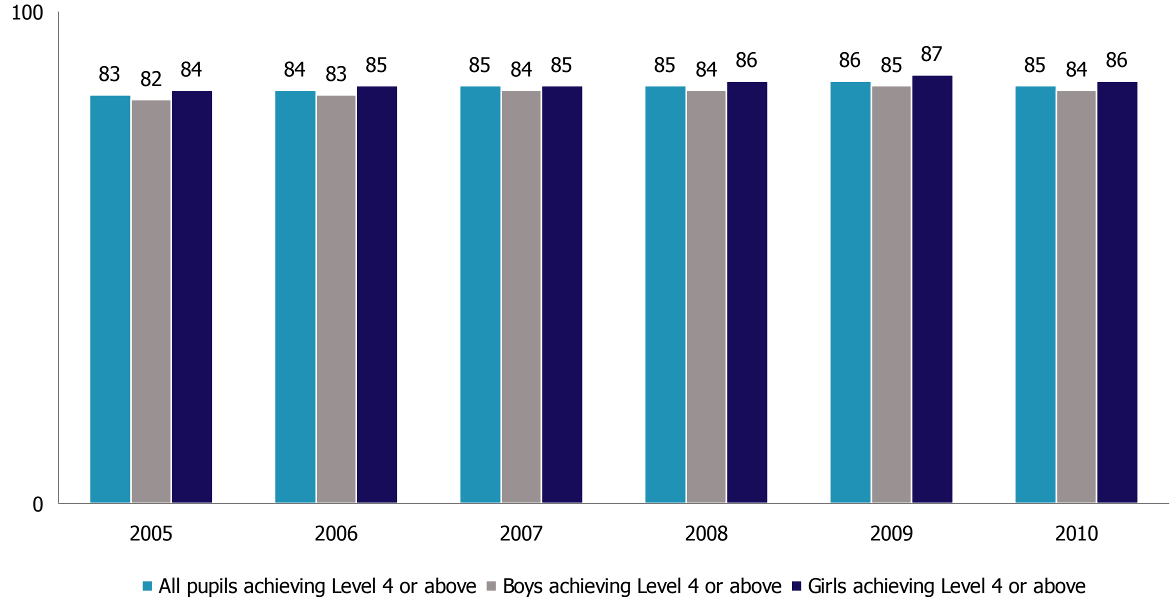


Source: DfE SFR26/2010: National Curriculum Assessments at Key Stage 1 in England, 2009/10 (Provisional).

Key Stage 2

The proportion of pupils achieving Level 4 or above in Key Stage 2 teacher assessments rose slowly between 2005 and 2009 from 83% to 86% but dropped to 85% in 2010. This trend can be seen in data for both boys and girls. As with Key Stage 1 teacher assessments at Level 2 or above, the proportion of boys who achieve Level 4 or above has been about two percentage points below that of girls since 2005. The total number of pupils whose performance was teacher assessed has risen steadily since 2006 (2005 pupil numbers were not included in the first statistical release for 2005). The biggest rise in the total number of pupils being assessed occurred in 2007 and 2008; the figure increased by more than 99,000 pupils.

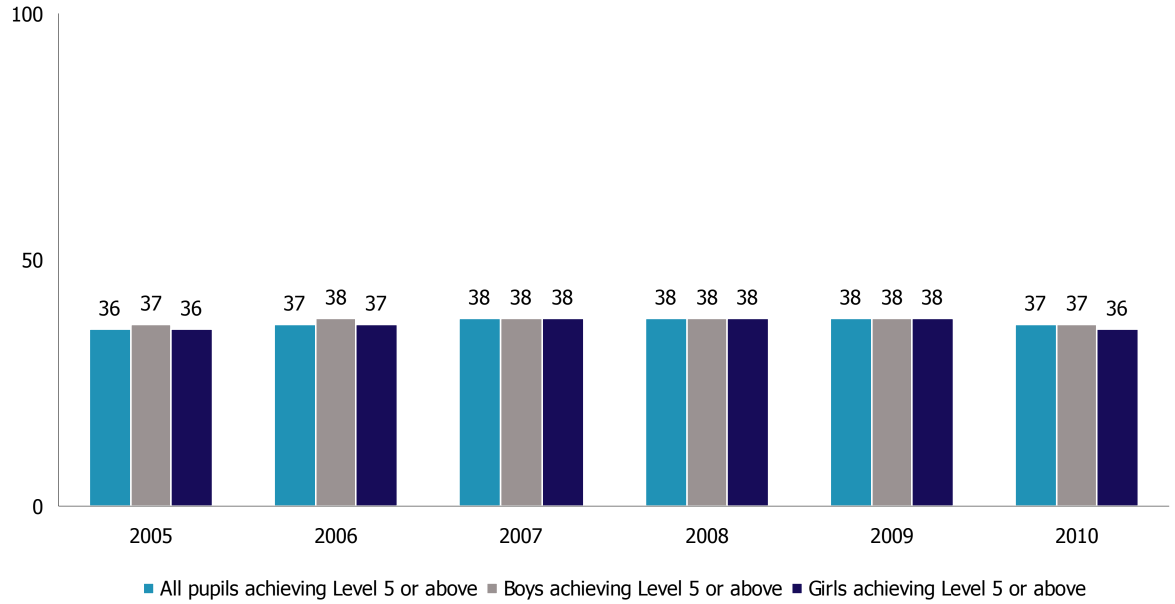
Figure 5: Proportion of pupils, by gender, achieving Level 4 or above in Key Stage 2 teacher assessments



Source: DfE National Curriculum Assessments at Key Stage 2 in England, SFR36/2010 (Revised).

The proportion of pupils achieving Level 5 or above remained at 38% between 2007 and 2009, having risen from 36% in 2005. It fell to 36% in 2010. Similarly, the percentage of boys and girls achieving Level 5 or above has been at 38% from 2007 to 2009, falling to 37% in 2010.

Figure 6: Proportion of pupils, by gender, achieving Level 5 or above in Key Stage 2 teacher assessments



Source: DfE National Curriculum Assessments at Key Stage 2 in England, SFR36/2010.

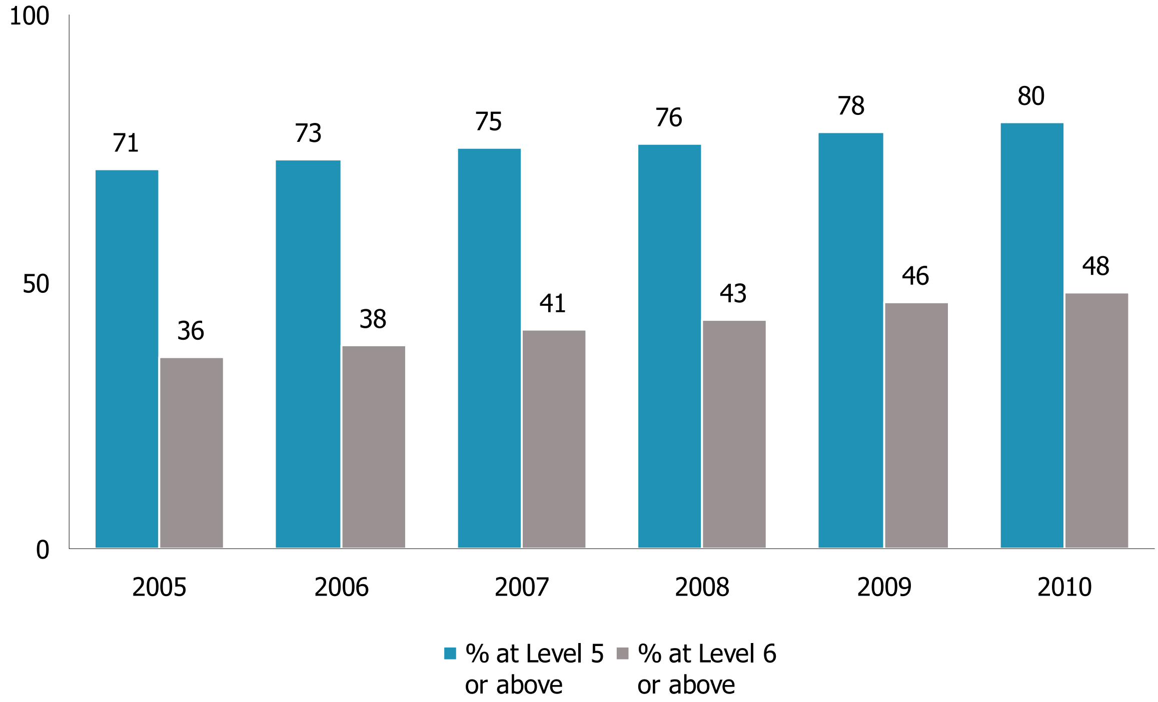
Standards in science in secondary schools

National data from 2005 to 2010

Key Stage 3

Key Stage 3 teacher assessments indicated that the proportion of students gaining Level 5 or above in science rose by nine percentage points, from 71% in 2005 to 80% in 2010. Attainment at Level 6 rose by 12 percentage points during the same period.

Figure 7: Percentage of pupils achieving Level 5 or above and Level 6 or above in science teacher assessments of core subjects, 2004/05 to 2009/10



Source: DfE National Curriculum Assessments: Teacher Assessments at Key Stage 2 and 3 in England, SFR23/2010.

Key Stage 4

In 2007/08, 491,600 students attempted core science for GCSE with 354,500 attempting additional science. The percentage of boys attaining A* to C in core science was 58% compared with 60% for girls. For additional science, 67% of boys and 69% of girls attained A* to C. For students studying individual sciences, including physics, chemistry and biology and individual GCSEs, A* to C attainment was above 90% for both boys and girls across the three subjects.

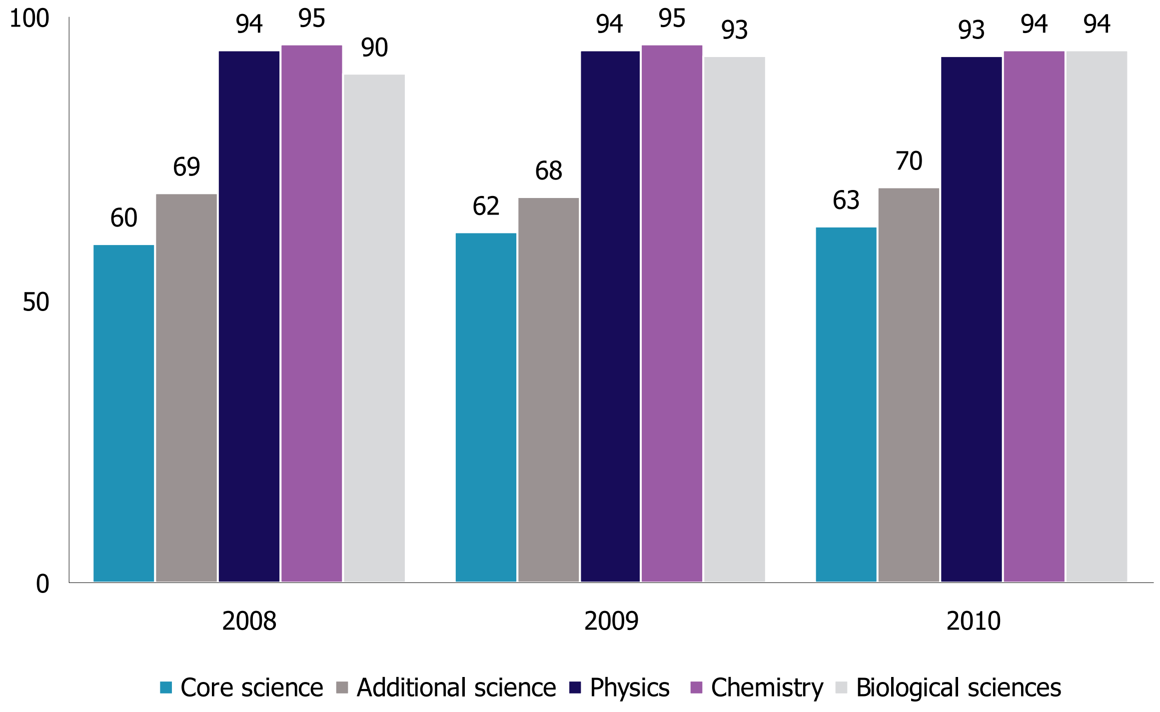
In 2008/09, 456,000 students studied core science for GCSE and 324,300 studied additional science. There was a rise in attainment at A* to C for boys and girls in core science by two percentage points to 60% and 62% respectively. Boys achieving

A* to C grades in additional science fell by two percentage points to 65%; similarly, girls' attainment fell by one percentage point to 68%. For individual sciences, attainment at A* to C saw little change except in biological sciences where girls' attainment rose by three percentage points to 93%.

In 2009/10, 404,900 students studied core science for GCSE and 288,500 studied additional science. There was a slight rise in attainment at grades A* to C for girls in core science and a two percentage point increase in additional science. While there was a slight increase for boys in additional science, attainment in core science had decreased by one percentage point. For individual sciences, attainment at A* to C saw little change.

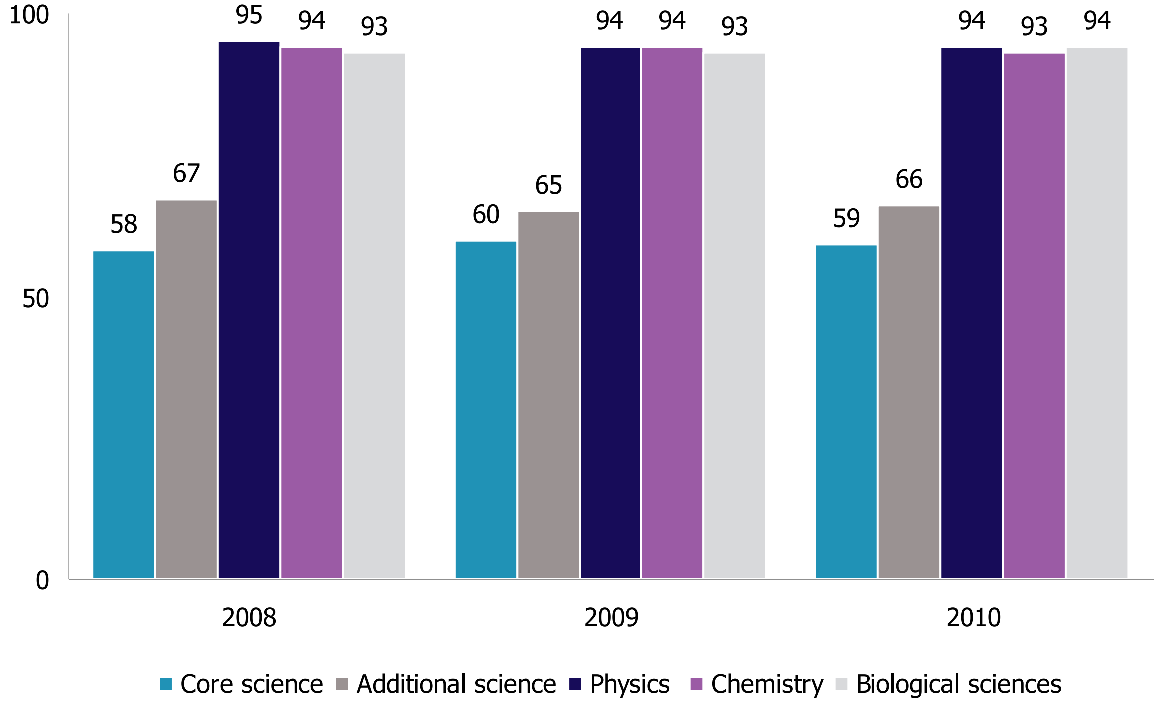
While the numbers of students attempting core science and additional science have both fallen, the numbers of students taking individual sciences have increased between 2007 and 2010: in physics from 67,300 to 112,100, in chemistry from 68,300 to 113,100, and in biology from 74,700 to 115,700.

Figure 8: GCSE attempts and achievements in selected subjects by girls at the end of Key Stage 4, 2008 to 2010



Source: DfE: GCSE and Equivalent Results in England, 2009/10 (Provisional), SFR30/2010.

Figure 9: GCSE attempts and achievements in selected subjects by boys at the end of Key Stage 4, 2008 to 2010



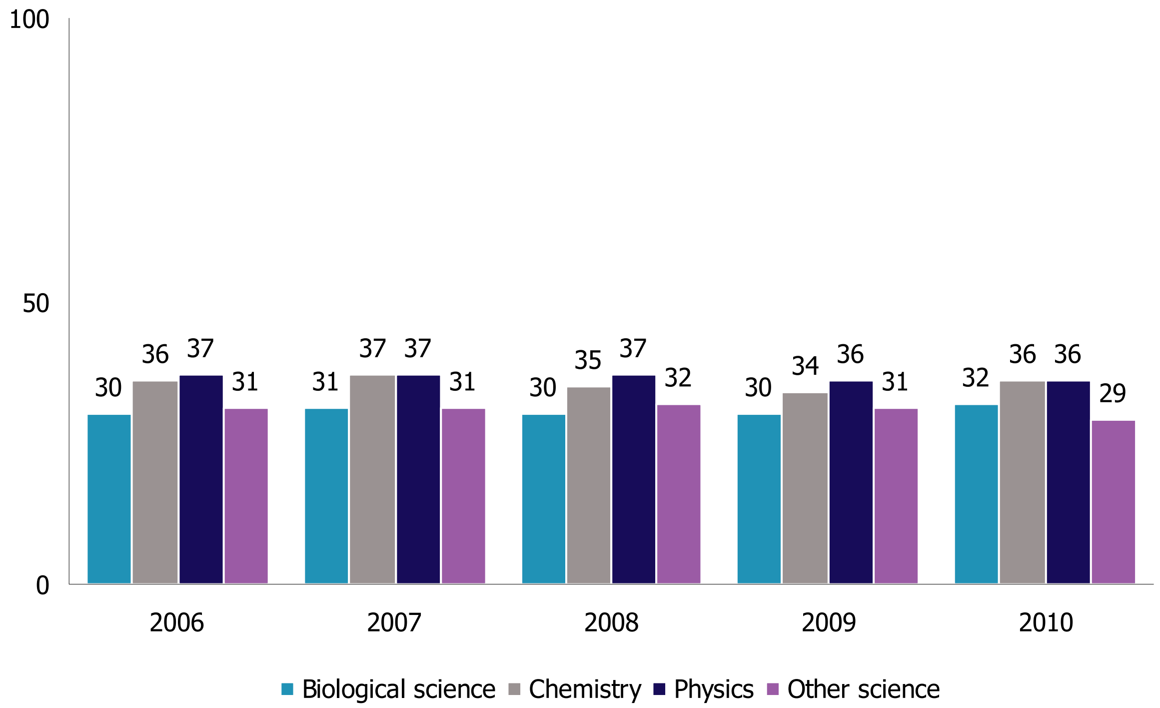
Source: DfE: GCSE and Equivalent Results in England, 2009/10 (Provisional), SFR30/2010.

Post-16

The proportion of students attaining A to E grades in all four AS-level science courses remained consistent between 2007 and 2010. For biological science, 81% of students attained the A to E benchmark, except in 2009 when 80% did so; 83% achieved the benchmark for chemistry and physics each year although in 2010 it increased to 84% in chemistry. Attainment for other sciences fell slightly from 82% in 2007 to 81% in 2010. Attainment has been consistent despite yearly rises to entries in biological science, chemistry and physics.

Girls outperformed boys in the proportion of students who achieved A to E grades in 2010 in all science AS levels, except for other science, where the proportion of boys who gained A to E grades was equal to that of girls at 82%.

Figure 10: Percentage of learners who achieved A or B grades in AS-level biological sciences, in schools and colleges, 2006 to 2010

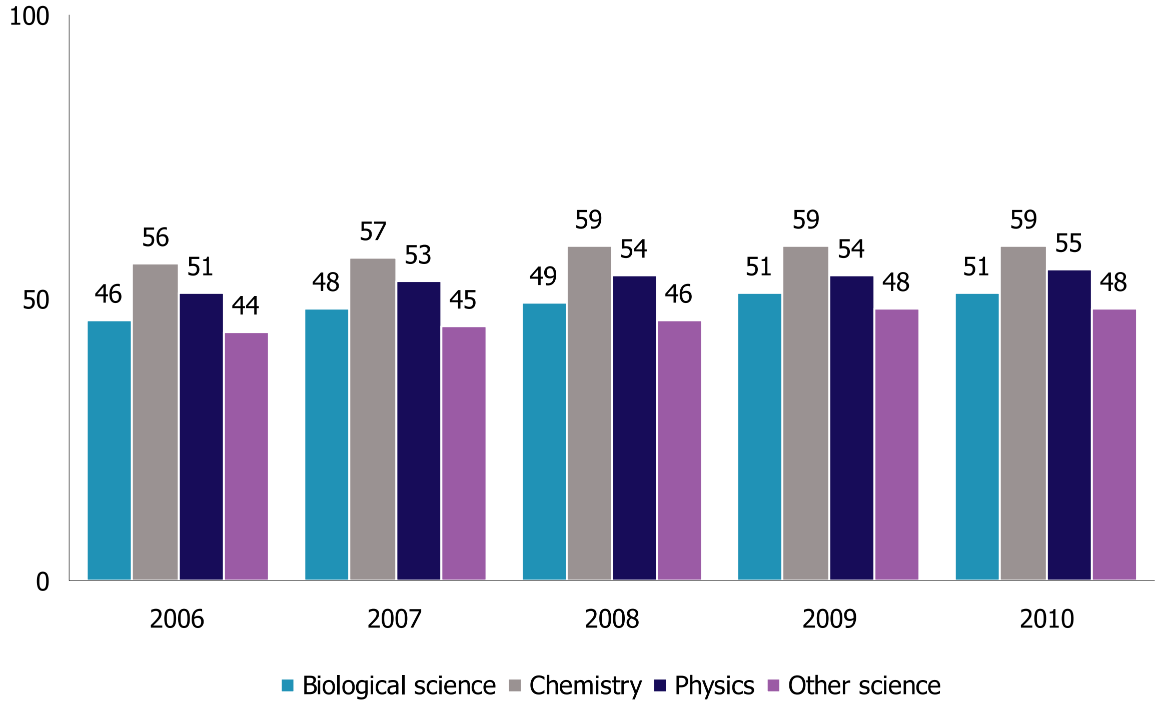


Source: DfE: GCE/Applied GCE A/AS and Equivalent Examination Results in England, 2009/10 (Provisional), SFR31/2010.

Ofsted

A-level results at grades A to E in 2010 were higher than those at AS level, with all sciences above a 97% A to E achievement rate. Since 2006 there has been a steady increase in the proportion of students achieving A to E grades for all science subjects. Girls' attainment at grades A to E was, again, slightly higher than that for boys for all years between 2006 and 2010.

Figure 11: Percentage of learners who achieved A or B grades in A-level sciences in schools and colleges, 2006 to 2010.



Source: DfE: GCE/Applied GCE A/AS and Equivalent Examination Results in England, 2009/10 (Provisional), SFR31/2010.