Mathematics: made to measure

Messages from inspection evidence

This report is based predominantly on evidence from inspections of mathematics between January 2008 and July 2011 in maintained schools in England. Inspectors visited 160 primary and 160 secondary schools and observed more than 470 primary and 1,200 secondary mathematics lessons. The report is also informed by good practice visits to 11 primary schools, one secondary school and two sixth-form colleges, but the evidence from these visits is not included in the proportions quoted in the report.

The report draws attention to serious inequalities in pupils' experiences and achievements. It includes examples of best practice that help avoid or overcome the inequalities and weaker practice that exacerbates them.

This report builds on the inspection findings and case studies of 'prime practice' and 'weaker factors' of the 2008 report, *Mathematics: understanding the score.* It is also informed by the evidence underpinning the report *Good practice in primary mathematics*, which was published in 2011.

Age group: 3–18

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Foreword from Her Majesty's Chief Inspector

Mathematics is essential for everyday life and understanding our world. It is also essential to science, technology and engineering, and the advances in these fields on which our economic future depends. It is therefore fundamentally important to ensure that all pupils have the best possible mathematics education. They need to understand the mathematics they learn so that they can be creative in solving problems, as well as being confident and fluent in developing and using the mathematical skills so valued by the world of industry and higher education.

We've seen some improvements during the last three years: higher attainment in the Early Years Foundation Stage and continued rises in GCSE and A-level results. The increase in the take-up of A-level mathematics and further mathematics has been dramatic. But our report clearly highlights three worrying problems which need to be tackled.

First, too many of our able pupils do not fulfil their potential. The extensive use of early GCSE entry puts too much emphasis on attaining a grade C at the expense of adequate understanding and mastery of mathematics necessary to succeed at A level and beyond. More than 37,000 pupils who had attained Level 5 at primary school gained no better than grade C at GCSE in 2011. Our failure to stretch some of our most able pupils threatens the future supply of well-qualified mathematicians, scientists and engineers.

Second, too many pupils who have a poor start or fall behind early in their mathematics education never catch up. The 10% who do not reach the expected standard at age 7 doubles to 20% by age 11, and nearly doubles again by 16. Schools must focus on equipping all pupils, particularly those who fall behind or who find mathematics difficult, with the essential knowledge and skills they need to succeed in the next stage of their mathematics education.

Third, the mathematics teaching and curriculum experienced by pupils vary too much. We regularly saw outstanding and satisfactory teaching, and sometimes inadequate too, within an individual school. Secondary pupils in the lowest sets received the weakest teaching but other groups are also disadvantaged.

This report calls on schools to take action to ensure that all pupils experience consistently good mathematics teaching. They must pinpoint and tackle the inconsistencies and weaknesses. We also urge the Department for Education to raise national mathematical ambition and take action to improve pupils' mathematical knowledge and understanding. But I want Ofsted to play its part too. I want to support senior and subject leaders to learn from the best schools: those which have the best teaching and assessment, combined with a well organised, mathematically rich curriculum.

So, this is what Ofsted will do.

First, we will produce support materials to help schools identify and remedy weaknesses in mathematics.

Then, we will raise ambition for the mathematics education of all pupils by placing greater emphasis in school inspection on:

- how effectively schools tackle inconsistency in the quality of mathematics teaching
- how well teaching fosters understanding
- pupils' skills in solving problems
- challenging extensive use of early and repeated entry to GCSE examinations.

We know it can be done: over half of the schools visited in the survey were judged to be good or outstanding in mathematics although even in these schools, some inconsistencies in the quality of teaching need to be tackled. We must all play our part to ensure that all of our pupils receive the best possible mathematics education.

Michael Wilshaw

Sir Michael Wilshaw
Her Majesty's Chief Inspector

Executive summary

The responsibility of mathematics education is to enable all pupils to develop conceptual understanding of the mathematics they learn, its structures and relationships, and fluent recall of mathematical knowledge and skills to equip them to solve familiar problems as well as tackling creatively the more complex and unfamiliar ones that lie ahead.

That responsibility is not being met for all pupils. Pupils of different ages, needs and abilities receive significantly unequal curricular opportunities, as well as teaching of widely varying quality, even within the same year group and school. The quality of teaching, assessment and the curriculum that pupils experience varies unacceptably. The disparity in children's pre-school knowledge of mathematics grows so that by the time they leave compulsory education at 16 years, the gap between the mathematical outcomes of the highest and lowest attainers is vast. The 10% not reaching the expected level at age 7 becomes 20% by age 11 and, in 2011, 36% did not gain grade C at GCSE. Pupils known to be eligible for free school meals achieve markedly less well than their peers and increasingly so as they move through their schooling. Key differences and inequalities extend beyond the teaching: they are rooted in the curriculum and the ways in which schools promote or hamper progression in the learning of mathematics.

For most of the period under review, considerable resources were deployed through the National Strategies to improve teaching and learning in mathematics through better assessment, curriculum planning and leadership and management. Teachers' use of assessment to promote learning has improved since the previous survey, but the quality of teaching and curriculum planning was much the same. Leadership and management of mathematics in secondary schools have strengthened, driven at least in part by the increased emphasis on mathematics in the data used to measure schools' performance. Schools have adopted a wide range of strategies to improve pupils' attainment, particularly at GCSE. However, the impact has been mixed.

Schools' work in mathematics was judged to be outstanding in 11% of the schools visited in the survey, good in 43%, and satisfactory in 42%. It was inadequate in two primary and nine secondary schools. This profile is very similar to the figures presented in the previous report, *Mathematics: understanding the score*.[1] Indeed, many of the findings of that report still hold true today.

Attainment has risen in the Early Years Foundation Stage, stagnated in Key Stage 1, and shown only slow improvement in the proportions of pupils reaching the expected levels in Key Stages 2 and 3. GCSE and A-level results continue to rise, as a consequence of the high priority accorded to them by teachers and leaders in secondary schools, but without corresponding evidence of pupils' better understanding of mathematics to equip them for the next stages of their education

[1] *Mathematics; understanding the score* (070063), Ofsted, 2008; www.ofsted.gov.uk/resources/070063.

and future lives. More-able pupils in Key Stages 1 to 4 were not consistently challenged. More than 37,000 pupils who had attained Level 5 at primary school gained no better than grade C at GCSE in 2011. Nevertheless, one clear success has been the dramatic increase in the take-up of AS/A level mathematics and further mathematics against a background of changes to the secondary curriculum and examination specifications.

The most common strategies to raise attainment focused the use of assessment data to track pupils' progress in order to intervene to support pupils at risk of underachievement, and in secondary schools to exploit early entry and resit opportunities on modular courses. Leaders monitored the quality of teaching more frequently than previously and through a wider range of activities such as learning walks and scrutiny of pupils' books. While weak performance was generally challenged robustly, attention to the mathematical detail, so crucial in improving teachers' expertise, was lacking. Moreover, information gleaned from monitoring and data analysis was rarely used to secure better quality provision, usually because analysis was linked to intervention and revision and monitoring focused on generic characteristics rather than pinpointing the subject-specific weaknesses or inconsistencies that impeded better teaching and greater coherence of learning.

Inspection evidence showed very strongly that the 35 schools whose mathematics work was outstanding had a consistently higher standard of teaching, better assessment and a well-organised, mathematically rich curriculum. They used a variety of strategies to improve all pupils' learning of mathematics, such as revising schemes of work, helping staff to enhance their subject expertise, and extending intervention programmes to all pupils who were in need of support, not just those at key borderlines or about to take national assessments. The schools focused on building pupils' fluency with, and understanding of, mathematics. Pupils of all ages and abilities tackled varied questions and problems, showing a preparedness to grapple with challenges, and explaining their reasoning with confidence.

This experience contrasts sharply with the satisfactory teaching that enabled pupils to pass tests and examinations but presented mathematics as sets of disconnected facts and methods that pupils needed to memorise and replicate. Too many pupils who start behind their peers receive such teaching and do not, therefore, catch up. Improving the consistency and quality of teaching within a school is crucial if all pupils, rather than some, are to make sustained good progress. It is important to have clear guidance, understood by all staff, on approaches to secure conceptual understanding and progression in lessons. This is especially important to support less experienced, temporary and non-specialist teachers.

Being 'made to measure' might describe schools' perceptions of, and reaction to, the pressures to raise standards. However, the aim for all schools should be to secure high calibre, 'made-to-measure' mathematics provision to optimise every pupil's chance of the best mathematics education.

Key findings

- Children's varying pre-school experiences of mathematics mean they start school with different levels of knowledge of number and shape. For too many pupils, this gap is never overcome: their attainment at 16 years can largely be predicted by their attainment at age 11, and this can be tracked back to the knowledge and skills they have acquired by age 7. Low attainment too often becomes a self-fulfilling prophecy. Pupils known to be eligible for free school meals fare particularly badly.
- The best schools tackled mathematical disadvantage with expert insight and ambitious determination, with policies and approaches understood and implemented consistently by all staff to the benefit of all pupils. Developing such expertise should be the goal for all schools.
- Despite the wide variation in outcomes, too many able pupils across the 3–16 age range are underachieving. Many more pupils could gain the highest grades at GCSE and be better prepared to continue to A level. Without this, the future supply of mathematicians and the national challenge of meeting the diverse mathematical needs of our technologically advanced world and our economic well-being are threatened.
- Attainment in GCSE and AS/A-level examinations in mathematics has risen. At the same time, however, successive changes in GCSE and A-level specifications and structure have reduced the demand of the examinations for many pupils. Those pupils attaining the highest grades at GCSE are increasingly opting to study AS and/or A-level mathematics, leading to a rapid growth in uptake.
- Attainment in national Key Stage 2 mathematics tests has shown incremental rises in the proportions of pupils attaining the expected Level 4 and the higher Level 5. Improvements have also been made in children's knowledge and skills in the Early Years Foundation Stage. Teacher assessments at the end of Key Stage 1, however, indicate that attainment has plateaued and the downward trend in the proportion reaching the higher Level 3 shows no sign of being reversed.
- Schools have implemented a wide variety of strategies to improve performance in mathematics. The most common strategy has been better monitoring of pupils' attainment and progress coupled with greater use of intervention programmes. In most primary schools, intervention has become more focused and timely in helping pupils overcome difficulties and close gaps. It remained centred on examination performance in the majority of secondary schools, linked to widespread use of early GCSE entry and repeated sitting of units. This has encouraged short-termism in teaching and learning and has led to underachievement at GCSE, particularly for able pupils, as well as a lack of attention to the attainment of the least able. In the better schools, high-attaining pupils' needs are met through depth of GCSE study and additional qualifications.
- Despite these strategies, the percentage of pupils not reaching the expected level or grade for their age increases as pupils progress through their

mathematical education, and is more marked for some groups than others. This suggests, strongly, that attaining a key threshold does not represent adequate mastery of skills and sufficient depth of conceptual understanding to prepare pupils for the next stage of mathematics education.

- The quality of teaching varied by key stage, leading to uneven learning and progress as pupils moved through their mathematics education. In each phase, those pupils nearest to external assessments received better teaching. Less experienced, temporary and non-specialist teachers were more likely to teach lower sets or younger pupils. Learning and progress were good or outstanding in nearly two thirds of lessons in Key Stage 4 higher sets, double the proportion observed in lower sets where around one in seven lessons was inadequate.
- Teaching was strongest in the Early Years Foundation Stage and upper Key Stage 2 and markedly weakest in Key Stage 3. Teaching in the sixth form was slightly stronger than at GCSE. Year 1 was the weak spot in primary teaching.
- While the best teaching developed pupils' conceptual understanding alongside their fluent recall of knowledge, and confidence in problem solving, too much teaching concentrated on the acquisition of disparate skills that enabled pupils to pass tests and examinations but did not equip them for the next stage of education, work and life. Teachers' use of assessment in lessons has improved although it remained a weak aspect of teaching. Monitoring of each pupil's understanding was not strong enough to ensure that pupils learnt and progressed as well as they could.
- Very few schools provided curricular guidance for staff, underpinned by professional development that focused on enhancing subject knowledge and expertise in the teaching of mathematics, to ensure consistent implementation of approaches and policies.
- Schools were more aware than at the time of the previous survey of the need to improve pupils' problem-solving and investigative skills, but such activities were rarely integral to learning except in the best schools where they were at the heart of learning mathematics. Many teachers continued to struggle to develop skills of using and applying mathematics systematically.

Recommendations

The Department for Education should:

- ensure end-of-key-stage assessments, and GCSE and AS/A-level examinations require pupils to solve familiar and unfamiliar problems and demonstrate fluency and accuracy in recalling and using essential knowledge and mathematical methods
- raise ambition for more-able pupils, in particular expecting those pupils who attained Level 5 at Key Stage 2 to gain A* or A grades at GCSE
- promote enhancement of subject knowledge and subject-specific teaching skills in all routes through primary initial teacher education

- research the uptake, retention and success rates in AS and A-level mathematics and further mathematics by pupils attending schools with and without sixth-form provision.

Schools should:

- tackle in-school inconsistency of teaching, making more good or outstanding, so that every pupil receives a good mathematics education
- increase the emphasis on problem solving across the mathematics curriculum
- develop the expertise of staff:
  - in choosing teaching approaches and activities that foster pupils' deeper understanding, including through the use of practical resources, visual images and information and communication technology
  - in checking and probing pupils' understanding during the lesson, and adapting teaching accordingly
  - in understanding the progression in strands of mathematics over time, so that they know the key knowledge and skills that underpin each stage of learning
  - ensuring policies and guidance are backed up by professional development for staff to aid consistency and effective implementation
- sharpen the mathematical focus of monitoring and data analysis by senior and subject leaders and use the information gathered to improve teaching and the curriculum.

In addition, primary schools should:

- refocus attention on:
  - improving pupils' progress from the Early Years Foundation Stage through to Year 2 to increase the attainment of the most able
  - acting early to secure the essential knowledge and skills of the least able.

In addition, secondary schools should:

- ensure examination and curricular policies meet all pupils' best interests, stopping reliance on the use of resit examinations, and securing good depth and breadth of study at the higher tier GCSE.

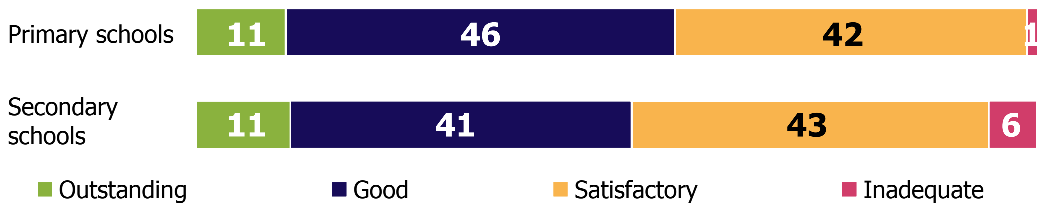
Part A: Mathematics in primary and secondary schools

Overall effectiveness

1. Schools' work in mathematics has shown little improvement over the last three years. The profile of judgements for overall effectiveness was very similar to that for the previous survey, which covered a different sample of 192 schools visited in the period April 2005 to December 2007. In neither survey did the sample include schools whose overall effectiveness had been judged to be inadequate in their last whole-school inspections.

2. The overall effectiveness of schools' work in mathematics was judged good or outstanding in 57% of the primary schools and 52% of the secondary schools. In most cases, the judgements for achievement, teaching, and leadership and management matched the overall effectiveness grades. In around a fifth of schools, the curriculum and/or use of assessment were relatively weak. In September 2010, Ofsted published supplementary guidance on judging each of these aspects.[2]

Figure 1: Overall effectiveness of mathematics in the schools surveyed (percentages of schools)



Percentages are rounded and do not always add exactly to 100.

3. Thirty-five schools, 18 secondary and 17 primary, were judged to be outstanding overall for their work in mathematics. In these schools pupils made exceptional progress in mathematics as a result of consistently good and often outstanding provision. The teaching was good or outstanding in most of the lessons, occasionally satisfactory, and never inadequate. These schools benefited from excellent leadership and management.

4. At the other end of the continuum, nine of the secondary schools and two primary schools were judged as inadequate, usually because important weaknesses in teaching, assessment, and/or the curriculum meant that pupils made inadequate progress in mathematics.

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[2] The guidance was updated in January 2012. It is available at www.ofsted.gov.uk/resources/20100015.

Achievement: the national picture

5. This section of the report evaluates pupils' performance in national tests, assessments and examinations and their progress over time. National data and evidence from the survey confirm serious inequalities in pupils' achievement. In particular, in secondary schools pupils in the lowest sets typically learned less well and made less progress than other pupils.

Pupils' performance in national tests, assessments and examinations

6. The table below shows the proportion of pupils reaching the expected attainment thresholds for each key stage in 2011 compared with 2005 and 2008. It also shows the proportions reaching the higher levels at Key Stages 1 and 2 and grades A*/A at GCSE. An upward trend is clear at GCSE. The picture is of slow improvement elsewhere except Key Stage 1.

Table 1: Percentages of pupils reaching the expected attainment thresholds in mathematics for each key stage in 2005, 2008 and 2011

		2005	2008	2011
Early Years Foundation Stage	Working securely within/above the Early Learning Goals for problem solving, reasoning and numeracy	n/a	68	74
Key Stage 1	Level 2+	91	90	90
	Level 3+	23	21	20
Key Stage 2	Level 4+	75	80	80
	Level 5+	31	31	35
Key Stage 3	Level 5+	74	77	81
	Level 6+	53	57	59
Key Stage 4 (GCSE)	Grade A*-C	50	56	64
	Grade A*/A	11	14	19

Figures for the EYFS profile and Key Stage 1 in 2008 and 2011 are based on teacher assessments.
Key Stage 3 figures are based on teacher assessments in 2011.
GCSE figures are based on the whole cohort rather than the entry. The proportion of the cohort that entered GCSE in 2005, 2008 and 2011 was 95.5%, 97.2%, and 96.5%, respectively. Of the entry in 2011, 66.6% attained grade A* to C.

7. Teacher assessments of children's mathematical development in the Early Years Foundation Stage (EYFS) show a rise between 2008 and 2011 in the proportion working securely within the mathematics early learning goals. This refers to children scoring six or more points in all three aspects: numbers as labels for counting; calculating; and shape, space and measures. Children in the EYFS are best at counting and weakest at calculating, though the latter skill has shown the most improvement. Girls consistently outperform boys, by around five percentage points on each aspect.

8. At Key Stage 1, the proportion of pupils attaining the higher Level 3 has declined from its peak of 31% in 2002. National tests were replaced by teacher assessments in 2005. At the same time, the proportion at Level 1 or below has remained steady. While more rigorous assessment and moderation of teacher assessments have contributed to the decline in the proportion attaining Level 3, the more-able pupils were too often not sufficiently challenged in lessons to make good or better progress.

9. At Key Stage 2, the proportion of pupils reaching the expected Level 4 or better nudged up to 80% in 2008, and has hardly changed since. The proportion achieving the higher Level 5 increased steadily to 35% in 2011.

10. At Key Stage 3, teacher assessments show very little change in attainment over the last three years. As reported previously, schools rarely made a separate assessment of pupils' attainment in the key process skills or 'using and applying mathematics'. Since 2009, national data on pupils' attainment have been based on teacher assessments, which are frequently derived from schools' internally administered tests of a similar nature to the former national tests, but which are not sampled or moderated nationally. Less weight was generally given to longer investigative or problem-solving tasks.

11. At Key Stage 4, attainment in GCSE examinations continues to improve, influenced by the emphasis on mathematics and English in measures of school performance. Although the largest increases have been in the proportion of pupils gaining A* to C grades, the average performance and the proportion gaining A*/A grades have risen too. The proportion of pupils taking GCSE mathematics had been steadily increasing, but fell back by 1.2 percentage points in 2011 to 95.5%.

12. While the upward trend in GCSE results is encouraging, the figures need to be treated with caution because GCSE examinations have undergone a number of changes in recent years. Many more schools now use unit (or modular) examinations and pupils can retake units to improve their grades. Also, the change from three tiers of entry to two in 2008 means that the higher tier examinations now have relatively fewer questions on A and A* grade material, making them less demanding for the most able pupils, but more suitable for pupils who would previously have taken the intermediate tier. The new foundation tier includes questions up to grade C, but most of the paper covers grades D to G. A further change to GCSE mathematics has been the removal of a coursework component. Pupils typically therefore have no experience of tackling extended mathematical tasks in this key stage.

13. The most recent GCSE specifications, with first accreditation in summer 2012, emphasise problem solving more strongly and are generally considered to be more demanding. Teachers and subject leaders often commented that pupils find solving problems more difficult than answering examination questions that test individual techniques. However, they did not always recognise the implications for a shift in teaching methodology to ensure the best grounding

for success with the new specifications. A few schools visited in 2010/11 have planned that their 2011/12 Year 11 cohort will complete the old specification early, in the belief that this will lead to better results than sitting the new examination. One awarding body even introduced an extra resit window in the late spring for the old specification.

14. Another contributory factor to the improvement seen in the A* to C pass rate since the last survey has been the increased use of retakes. This has taken two forms: resitting individual units to improve the final GCSE grade and entering the GCSE qualification more than once.

15. The number of pupils taking GCSE statistics has decreased since 2008. It was offered as an option choice in some of the schools visited but a more common pattern was for the specification to be covered in regular mathematics lessons. Prior to the removal of the coursework component from mathematics GCSE, awarding body regulations permitted the extended statistics task to serve as coursework for both qualifications. An extra GCSE could therefore be gained with little additional teaching required.

16. Participation in AS and A-level mathematics by pupils aged 16 to 18 years in schools and colleges continues to grow rapidly, and has more than recovered from the sharp fall in 2002. Compared with the 2008 figures, A-level entries in 2011 are up by 31% in mathematics and by 35% in further mathematics. The corresponding figures for AS are 58% and 120%, respectively. The previous government's target of 56,000 A-level entries by 2014 was reached in 2008 and a new target of 80,000 was subsequently set.

17. As participation in A-level mathematics has increased, pass rates have been maintained and attainment has shown a slight upward trend.[3] However, the changes to A-level specifications during this period have reduced the demand and breadth of content studied. Some pure mathematics topics previously studied in A-level mathematics are now part of the further mathematics course, for instance, complex numbers and solution of some types of differential equations. Application units such as statistics and mechanics have been reduced in content and the weighting given to them within the qualification.

18. While unitisation of courses has led to lower failure rates at A level, too many pupils fail AS: consistently nearly 20% in AS mathematics and close to 10% in AS further mathematics. Given that the large majority of pupils embark upon AS having gained an A* or A grade at GCSE and rarely a C grade, these failure rates are a concern and raise questions about pupils' readiness for successful study of advanced-level mathematics.

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[3] The proportion of pupils achieving the higher grades (A* to B) in mathematics and in further mathematics leapt by 10 percentage points at the first award of the new specification in 2002 and the proportion has increased by a further 10 percentage points for A-level mathematics in the subsequent period, so that 67% of entries in 2011 gained A* to B grades.

Pupils' progress over time

19. Although variation from school to school is considerable, national data suggest that, on average, pupils make one National Curriculum level of progress every two years from the end of Key Stage 1 to the end of Key Stage 3. This figure has been steady for the last four national cohorts to 2011.

20. In 2011, 82% of Year 6 pupils had made at least the expected two levels of progress during Key Stage 2, rising from 78% in 2008.[4] While this overall improvement in pupils' progress is welcomed, two issues have emerged. First, the decline in the proportion of pupils reaching Level 3 by the end of Key Stage 1 reflects underachievement of the most able but this is masked by the expected two levels of progress measure in Key Stage 2. If, for instance, an able Year 2 pupil was not sufficiently challenged and reached Level 2a instead of Level 3, her/his progress to Level 4 by Year 6 would be considered to be in line with expected progress, whereas in reality Level 4 would represent underachievement for that pupil. Crucially, expectations of the same pupil five years later would be grade C GCSE, yet that pupil perhaps should have been on track to reach Level 5 at Key Stage 2, then an A*/A grade at GCSE, leaving her/him appropriately equipped to pursue the subject at A level or beyond.

21. A further question arises from the analysis of the progress of those pupils working at Level 2c at the end of Key Stage 1. They are much less likely to reach Level 4 four years later than their peers who attain Level 2b (58% compared with 86%). A similar pattern exists for those pupils reaching Levels 4c and 4b at age 11: 48% and 70% respectively of these pupils gained at least a GCSE grade C. While it is reasonable to anticipate that those who only just reach a particular level or grade might do less well subsequently than their peers who performed a little more strongly, the differences in progression rates are substantial. This raises important questions about how well teaching and intervention to secure threshold levels prepare pupils for the next stage of their education. A research project by the Primary National Strategy showed that a distinguishing weakness evident at Level 2c at age 7, but not at higher levels, was pupils' understanding of place value.[5]

22. Attaining a key threshold should ideally represent adequate mastery of skills and sufficient depth of conceptual understanding to give preparedness for the next stage of mathematics education but, as discussed above, national progress data suggest strongly that this is not so. Part of the problem is that external assessment in mathematics at all ages is generally based on a compensatory model: success with some questions in a test or examination compensates for poor performance on others, irrespective of the relative importance of the topic

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[4] A step of two National Curriculum levels of progress is expected between the ends of Years 2 and 6; for example, Level 2 to Level 4.

[5] *Research project: children who get 'stuck' at level 2C in mathematics*; The National Strategies/Primary 2010; www.school-portal.co.uk/GroupDownloadFile.asp?GroupId=255682&ResourceID=3829440.

being assessed. This is particularly pertinent at higher tier GCSE where, for example, pupils can attain grade A having mastered little in the way of algebra.

23. At a national level, progress in mathematics between the end of Key Stages 2 and 4 shows an improving trend, largely driven by better GCSE results. To make 'expected progress' from age 11 to 16, pupils who attained Levels 2, 3, 4 and 5 at the end of Key Stage 2 would have to achieve GCSE grades E, D, C and B, respectively. The proportion doing so rose from 56% in 2008 to 64% in 2011. However, variation in the progress of different groups of pupils is considerable.

Measuring the gaps: attainment and progress

24. Assessments at the end of each key stage show that some groups of pupils perform much more strongly than others. These gaps are persistent: they were generally as wide in 2011 as they were in 2008. Moreover, the gaps increase as pupils move through primary and secondary education.

25. To a large extent, pupils' prospects of gaining a grade A* to C in GCSE mathematics are determined by their attainment in primary school. In 2011, this standard was achieved by the vast majority of pupils who had attained Level 5 at the end of Key Stage 2 and two thirds of those who had reached Level 4. Among pupils who had attained Level 3 or below, around one eighth achieved grade C. Analysis of national data for 2011 leads to the shocking statistic that only 30% of low-attaining pupils made the expected 'three levels of progress' during their five secondary years. This explains why so few reached grade C at GCSE. The exacerbating factors include weaknesses in the quality of teaching received by lower-attaining sets. Schools' strategies to raise the proportions attaining grade C vary in their emphasis on low-attainers.

26. Pupils who are known to be eligible for free school meals (FSM) fare badly in comparison with their non-FSM peers and this position has not improved during the last three years. By the age of 7, approximately 20% of these pupils do not reach the expected Level 2 in comparison with 8% of their classmates. At Levels 2b and 2a, the gap in attainment is larger at around 20 percentage points and it is 14 percentage points at the higher Level 3.

27. Because the progress made by FSM pupils is significantly weaker than that of their peers, the gap widens. In 2011, 75% of FSM pupils made expected progress through Key Stage 2 in comparison with 84% of their peers. The proportions reaching the expected Level 4 were 67% and 83%, respectively, a slightly narrower gap than in the previous two years. However, this means that a third of FSM pupils enter secondary education below the expected level and their chances of progression to grade C or better at GCSE are slim. They also lag well behind at the higher Level 5, the figures being 19% and 38%, respectively, in 2011, with very similar data for the previous three years.

28. By the end of Key Stage 4, the gap in the rates of progress had more than doubled: only 45% of FSM pupils made expected progress in 2011, compared with 67% of their peers, leading to only 42% of FSM pupils gaining GCSE grades A* to C in 2011, in stark contrast with 68% of their peers. At the highest A*/A grades, the successful 7% of FSM pupils is much lower than the 21% of their peers. This has serious implications for FSM pupils' opportunities and chances for success in mathematics at A level. The decrease in the proportion of pupils not entering GCSE mathematics in 2011 is also a concern. Overall, 9% of FSM pupils either failed or did not enter GCSE mathematics, in contrast with 4% of non-FSM pupils.

29. Other differences in the performance of groups of pupils are not as marked as those above. Since 2008, boys have outperformed girls in Key Stages 1 and 2 by around five percentage points at the higher Levels 3 and 5, respectively. However, by GCSE, there is no gender difference at grades A*/A. The gender difference at AS/A level relates to participation, with the ratio of boys to girls being around 3:2 for mathematics in 2011 and roughly twice as many boys as girls took further mathematics.

30. The attainment of pupils from different minority ethnic groups shows some variation at GCSE but none of these groups attains significantly less well than FSM pupils except for Traveller of Irish heritage and Romany or Gypsy. Some groups, most notably Indian and Chinese pupils, made stronger progress in mathematics than White British pupils throughout primary and secondary school. The 2011 data show that 95% of Chinese pupils had made expected progress by ages 11 and 16. This compares with 89% and 84%, respectively, of Indian pupils, which in turn is much higher than the comparative figures of 82% and 63% for White British pupils.

31. Interpretation of data for pupils who have special educational needs is not straightforward due to their widely differing needs and variation in schools' practice in identifying those needs as 'school action', 'school action plus', and formal statements of special educational need. Overall, pupils who have special educational needs make slower progress than their peers, but better progress overall than low attainers.

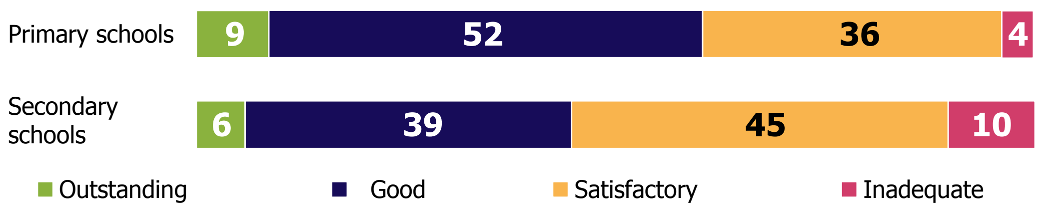
Achievement: the picture from the survey

32. Inspectors judge how well pupils have achieved in mathematics by analysing their attainment in relation to their varied starting points, taking into account their progress in lessons and over time. Achievement was judged to be good or outstanding in 56% of the schools visited during the period of this survey. It was inadequate in two primary and eight secondary schools.

33. Learning and progress show considerable variation across the key stages, including within individual schools. In the sixth form, learning and progress were stronger than previously in Year 12, although still lagging behind Year 13, and too many pupils do not complete AS successfully. Compared with the

previous survey, learning and progress declined in Key Stages 1 and 3, with Year 7 seeing the biggest drop. Worryingly, learning and progress were judged inadequate in 10% of the secondary lessons.

Figure 2: Learning and progress in mathematics lessons in the schools surveyed (percentages of lessons)



Percentages are rounded and do not always add exactly to 100.

34. A key aspect of good learning is that pupils are developing their mathematical understanding. Despite the improving attainment at GCSE, there was no evidence of an increase in the proportion of lessons that were helping pupils to gain a better understanding of mathematics. Other factors, including schools' examination strategies, intervention and revision and a strong focus in teaching to the next examination generally accounted for the difference.

35. Learning and progress were strongest in the EYFS and Years 5 and 6 with around three quarters of lessons good or outstanding. They were least effective in Key Stage 3, where only 38% of lessons were good or better and 12% were inadequate. Compared with the previous survey, learning and progress in Key Stage 1 were less strong at just under one half of lessons good or outstanding, and they were weaker in Year 1 than Year 2.

36. In primary schools, no marked difference in learning and progress was noted between mixed-age and single-age classes. Outstanding learning and progress occurred more often in mixed-ability primary classes than in those set by ability. However, the most able pupils in nearly a quarter of primary schools were insufficiently challenged, often because they were set very similar work to their middle-attaining peers before moving to extension tasks.

37. The same issue arose in the secondary schools visited. All the pupils in a class often tackled the same work, continuing to practise beyond what was necessary rather than moving on swiftly to more complex or unusual questions that stretch and deepen pupils' thinking. Particular issues around the achievement of able pupils at GCSE are discussed later in this report.

38. Placing pupils in sets based on their prior attainment is common practice in mathematics in secondary schools. Any mixed-ability teaching is normally confined to Year 7. In Key Stage 4, learning and progress varied widely across the sets. They were good or outstanding in nearly two thirds of lessons in higher sets, in nearly half of middle sets, but in less than a third of lower sets. In Key Stage 3, learning and progress were weaker overall but with less variation between different sets. While the mixed-ability lessons accounted for

less than 5% of lessons observed in the survey, learning and progress were inadequate in nearly a quarter of them and good or better in little more than a quarter. These inequalities align with those discussed earlier regarding national data on attainment and progress. For instance, pupils in the lowest sets typically learn less well, make less progress and attain low grades.

39. Nearly all the secondary schools had set themselves targets for increased proportions of pupils to pass five or more GCSEs at grade A* to C, including English and mathematics. Consequently, they were keen for more pupils to attain grade C or better in mathematics. Quick-fix approaches were particularly popular. Aggressive intervention programmes, regular practice of examination-style questions and extra provision, such as revision sessions and subscription to revision websites, allowed pupils to perform better in examinations than their progress in lessons alone might suggest.

40. These tactics account for the rise in attainment at GCSE; this is not matched by better teaching, learning and progress in lessons, or by pupils' deeper understanding of mathematics. In almost every mathematics inspection, inspectors recommended improvements in teaching or curriculum planning, in most cases linked to improving pupils' understanding of mathematics or their ability to use and apply mathematics.

41. Relatively few schools sought pupils' views on what makes learning mathematics successful. One effective primary school explored Key Stage 1 pupils' views on how they liked to learn in mathematics lessons. The staff adopted the pupils' suggestions and found that independent learning had subsequently improved.

42. It remains a concern that secondary pupils seemed so readily to accept the view that learning mathematics is important but dull. They frequently told inspectors that in other subjects they enjoyed regular collaboration on tasks in pairs or groups and discussion of their ideas, yet they often did not do so in their mathematics lessons, or even expect to do so. Frequently, their comments showed appreciation of their teachers' efforts to support them as they approached examinations, but also exposed recognition that their understanding of mathematics was insecure. An able pupil summed this up:

> 'You need to understand and not just do it. You think you know how to do it but you get to an exam and you can't. You realise that nobody's told you why it works and why you do what you do, so you can't remember it.'

Another pupil added,

> 'The harder it gets the more I dread it.'

43. Lower-attaining Year 11 pupils' experiences were different:

> 'Teachers give different explanations which is confusing.'

'Teaching assistants don't always know the maths. Sometimes they do the work for you.'

'It would be good to have more practice tests then you would know what your weakest topic was.'

'I thought I was doing well until I got an E for my module.'

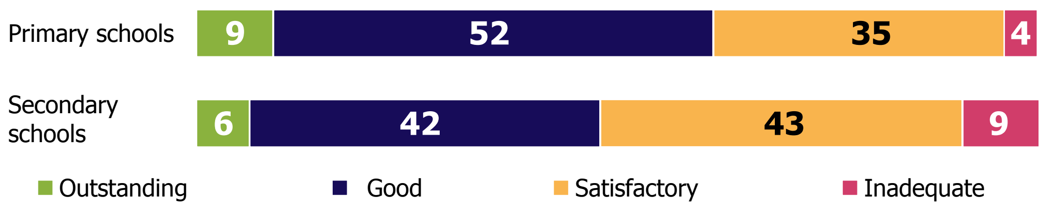
Teaching

44. This section of the report draws attention to serious inequalities in the quality of teaching experienced by different groups of pupils, the underdeveloped use of information and communication technology (ICT) to enhance learning, and weaknesses in the range and depth of strategies to promote pupils' problem-solving skills. It also highlights variations in the effective use of teaching assistants to support learning, and evaluates the quality of assessment and teachers' marking. As in other sections of the report, examples of prime and weaker practice are provided to support school improvement.

The quality of teaching: pluses, minuses and inequalities

45. The profile of judgements on the overall quality of teaching in schools was similar to that seen in the last survey. Teaching was good or outstanding in 48% of the secondary lessons and 61% of the primary lessons.

Figure 3: Teaching in mathematics lessons in the schools surveyed (percentages of lessons)



Percentages are rounded and do not always add exactly to 100.

46. The quality of teaching varied widely between key stages and different sets, leading to unevenness in pupils' learning and progress. Of particular concern was the inequality in Key Stage 4 with high sets receiving twice as much good teaching as low sets. Teaching was strongest in the EYFS and Years 5 and 6 with around three quarters of lessons good or outstanding. It was weakest in Key Stage 3, where only 38% of lessons were good or better and 12% were inadequate, and weaker in Key Stage 1 than Key Stage 2.

47. The quality of teaching varied considerably within individual schools. In general, those pupils nearest to external assessments received the better teaching. In the secondary schools visited, younger and less-able pupils received weaker teaching than their older and more-able peers. This was partly a matter of deployment, with less experienced, temporary and non-specialist teachers more likely to teach lower sets or younger pupils. In the case of non-specialists, this

is a matter of necessity, since the mathematics covered in higher Key Stage 4 sets is often outside their expertise to teach.

48. The differences noted above were not restricted to the schools judged satisfactory or inadequate for their work in mathematics. Few schools had teaching that was consistently at least good or consistently no better than satisfactory. Most had a mixture of stronger and weaker teaching, with the more effective schools having twice as many well-taught lessons on average than the weaker. Despite this variability, it was rare to find a school that had a systematic approach to raising the quality of teaching in mathematics across the school.

Weaker factor: variation in quality of teaching within a school

The inspector observed four Year 9 lessons involving a 'newspaper comparison' task of seeking statistical ways of distinguishing newspapers, for instance by considering the average word or sentence length and hence reading demand. One lesson was taught well, two satisfactorily but with some important weaknesses and one inadequately. The good lesson was with a high set, the satisfactory lessons were with middle and low sets, and the inadequate lesson was with another low set.

In the best lesson, the teacher gave the pupils enough direction that they all collected data systematically to support some analysis. They had data from contrasting texts, and were expected to choose how to illustrate the results, for example with a bar chart or a pie chart.

In one of the satisfactory lessons, pupils spent time talking about what data they might look at, rather than focusing on an aspect that would allow analysis. They would have benefited from more guidance during this phase of the lesson. Pupils were encouraged to form a hypothesis before all had understood the task fully. The teacher's suggestion that the more-able pupils would need to look at Spearman's rank correlation was bizarre, given that the task did not lend itself to the generation of bivariate data, raising a question about the teacher's subject knowledge.

In the second satisfactory lesson, the teacher and the teaching assistant were circulating as pupils worked but they did not spot some pupils' lack of understanding that their method for collating the data was inefficient and less reliable than some other methods. The teacher told pupils to use tally marks, but several were counting the number of occurrences of each word length and then making that number of tally marks, rather than just writing the number counted. Neither these pupils, nor the teacher seemed to realise that their method obviated the need for tally marks. Some pupils spent time recounting their tally marks to make sure that they agreed with the number of words that they had already counted.

In the inadequate lesson, the teacher told the pupils that they could choose how to collect their samples. Some pupils decided to look at the first 100 words for each newspaper, which is an appropriate starting point. Other pupils picked 100 words 'at random' but neither they nor the teacher appeared to understand that this approach was likely to produce a biased sample, with few short words being included in the so-called 'random samples'. This reflected the teacher's insecure knowledge of statistical sampling. The teacher chose not tackle this issue, even after it was brought to his attention.

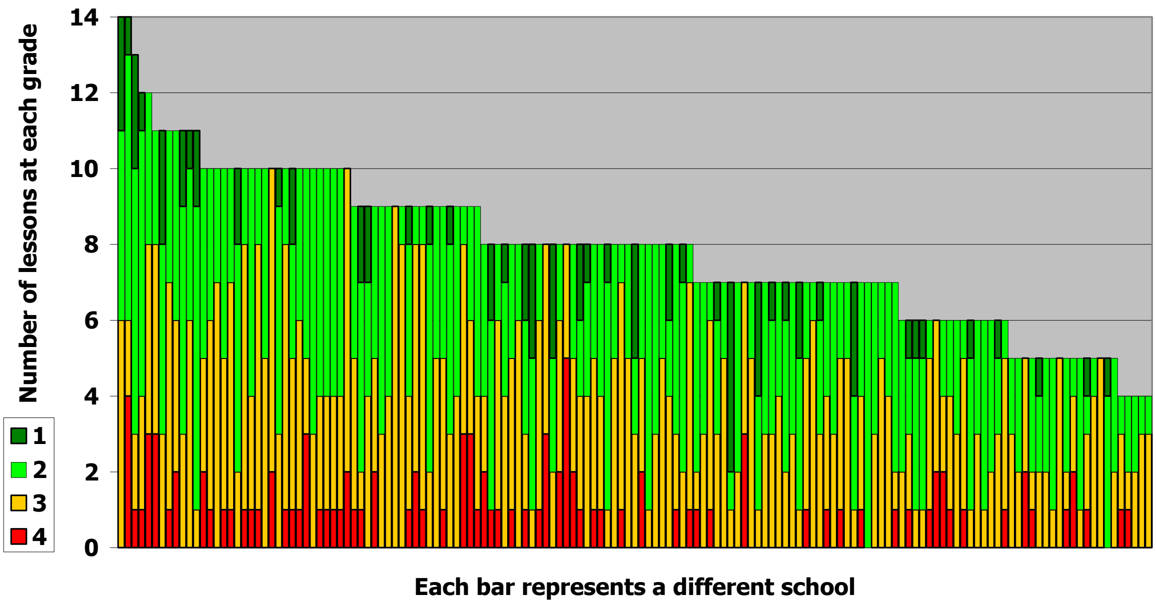
How might it be improved?

The teachers could have worked together to discuss the task, and the opportunities it offered for different groups of pupils to use their statistical knowledge and skills. This would allow any gaps in teachers' subject knowledge to be identified and rectified as well as enabling the teachers to benefit from the stronger practice in guiding pupils appropriately as they went about the task.

49. To eradicate inconsistency in teaching by improving the quality is a key priority for all but the very best schools. These schools, by their very nature, did not rest on their laurels but sought continuously to develop teachers' expertise further.

50. Of the secondary schools visited during the survey (excluding a few small schools where fewer than four lessons were observed), only 18 had good or better teaching in at least four fifths of the lessons observed and nearly half had some inadequate teaching. This variation in the quality of teaching needs to be tackled vigorously, especially given that the lower attaining and vulnerable pupils are more likely to be in the classes receiving the weaker teaching. Less than half of the schools had a majority of lessons judged as good or outstanding and just less than one third had effective teaching in only a small minority of lessons. Similar analysis is not included for primary schools because fewer lessons were observed during each inspection.

Distribution of teaching grades in secondary school lessons



51. In the very best schools, all lessons had a clear focus on thinking and understanding, for example, developing primary pupils' grasp of place value and the effect of multiplying or dividing by 10 as part of their ongoing conceptual understanding of structure and relationships in number. Whole-class teaching was dynamic with pupils collaborating extensively with each other. It challenged them to think for themselves, for instance by suggesting how to tackle a new problem or comparing alternative approaches. Teachers' explanations were kept suitably brief and focused on the underlying concepts, how the work linked with previous learning and other topics and, where appropriate, an efficient standard method. Their questions were designed to encourage pupils to give reasoned answers.

52. Critically, pupils were directly engaged in mathematics for a substantial portion of each lesson. As a result, they had time to develop a high degree of competence and to tackle challenging, varied questions and problems that helped to deepen their understanding. Pupils worked on a mix of group tasks, exploratory activities in which they tried to devise their own methods, and exercises completed individually. The exercises allowed pupils to progress from routine practice of skills to two-step questions, where the method was not immediately apparent, and questions with unusual twists that required some adaptation to the standard method.

53. A further benefit of pupils working for sustained periods on suitably demanding exercises is that the teacher can devote more time to moving around the classroom, assessing each pupil's progress and understanding. The most skilful teachers were able to adapt their lessons on the basis of the information they gathered. Sometimes this involved giving specific support to pupils who were struggling, or an extra challenge to those finding the work easy. On other

occasions, it involved bringing the whole class together to deal with a common difficulty or to allow pupils to share their ideas. Wrong answers were welcomed as an opportunity to explore how a misconception had arisen. Pupils did not fear making mistakes as they too recognised how unravelling an error helped their understanding.

54. A common feature of the satisfactory teaching observed was the use of examples followed by practice with many similar questions. This allowed consolidation of a skill or technique but did not develop problem-solving skills or understanding of concepts.[6] The teachers typically demonstrated a standard method, giving tips to pupils on how to avoid making mistakes and, sometimes, 'rules' and mnemonics to help them commit the methods to memory. Many of their questions concerned factual recall so that pupils' 'explanations' often consisted of restating the method rather than justifying their answers.

55. Pupils often spent a substantial part of such lessons listening to the teacher and, in secondary lessons, copying down worked examples. What was intended to be whole-class teaching typically engaged a small minority, who answered most of the teacher's questions, leaving the majority as spectators. These lessons lacked a close tailoring of support and challenge that would enable individual pupils to achieve their best.

56. Time was not used consistently well in lessons, for instance in introducing lesson objectives. Typically, pupils copied them down at the start of the lesson but the teachers varied in how well they explained them. A good approach adopted by one primary school was to print the objectives for each group of pupils on sticky labels and stick them into their books before the lesson. The teachers then spent time discussing the objectives with a good focus on what they meant, emphasising new and key vocabulary. Occasionally, teachers deliberately did not reveal the objectives until later in the lesson at which point they challenged the pupils to articulate for themselves what they had learnt.

57. Better use of lesson time, which also led to stronger learning, included some simple steps such as selecting a sub-set of questions from an exercise to give variety and make pupils think more carefully. Occasionally, teachers allowed pupils to choose when to move more quickly away from routine exercises to problems that challenged and helped deepen their understanding and application of mathematics. The expectation that pupils should take responsibility for their learning in this way was a strength of secondary practice in Finnish schools.[7]

58. A key issue for the majority of schools was to improve pupils' understanding of mathematics by focusing more on concepts and the development of insight,

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[6] Characteristics of good and satisfactory teaching were published as an annex to *Mathematics; understanding the score* (070063), Ofsted, 2008; www.ofsted.gov.uk/resources/070063.
[7] *Finnish pupils' success in mathematics*; (100105), Ofsted, 2010; www.ofsted.gov.uk/resources/100105.

and by relying less on teaching 'rules'. The following case study illustrates the problem and suggests how the teaching might have been improved.

Weaker factor: teaching procedural rules rather than developing understanding

In this first lesson on indices for a Year 8 top set, pupils were taught to apply the rules of indices in a variety of routine questions.

The teacher presented the rules for multiplying and dividing powers as facts when they could easily have been deduced. Negative indices were introduced as the result of division of powers, but pupils did not know how to interpret them as reciprocals.

By the end of the lesson, pupils could use the addition and subtraction rules, $a^m \times a^n = a^{(m+n)}$ and $a^m \div a^n = a^{(m-n)}$, to answer straightforward questions on indices, such as $a^3 \times a^5 = a^8$ and $a^3 \div a^5 = a^{-2}$.

However, the lesson did not promote understanding, since pupils were not given any chance to work from first principles. They also did not appreciate that a^{-n} is the reciprocal of a^n, written $\frac{1}{a^n}$

How might it be improved?

The lesson could have been improved by drawing on pupils' existing knowledge to establish the general rules, for instance by starting with several examples similar to:

$$\begin{aligned} a^4 \times a^3 &= (a \times a \times a \times a) \times (a \times a \times a) \\ &= a \times a \times a \times a \times a \times a \times a \\ &= a^7 \end{aligned}$$

and developing the idea to establish the general case, $a^m \times a^n = a^{(m+n)}$

A corresponding exploration of the division of powers would lead to the generalisation $a^m \div a^n = a^{(m-n)}$.

Using examples similar to $a^3 \div a^7$ and working from first principles would lead naturally into negative indices and their meaning as reciprocals. For instance:

$$a^3 \div a^7 = \frac{a \times a \times a}{a \times a \times a \times a \times a \times a \times a} = \frac{1}{a \times a \times a \times a} = \frac{1}{a^4}$$

Applying the rule gives $a^3 \div a^7 = a^{-4}$

Hence $a^{-4} \equiv \frac{1}{a^4}$

59. Most schools had some effective teachers who promoted understanding through a variety of teaching styles and strategies and, often, other teachers

who aspired to teach in such a way, but who lacked the necessary experience or subject expertise. However, pupils regularly experienced lessons where the sense behind the mathematics was not explained to them or developed collaboratively with them. This was not an issue about particular teaching styles, but about the mathematical correctness and coherence of the teaching within individual lessons, through sequences of lessons, and over time.

60. A feature of much of the satisfactory teaching was that teachers tended to talk for too long. Sometimes they were too quick to prompt or to answer their own questions. For example, in a bingo game based on percentages, the teacher asked '25% of 108?' but then followed her question immediately with 'What fraction is 25%?' rather than leaving time for pupils to work out the first step for themselves. Similarly she followed '20% of 240?' with 'Find 10% first.'

61. At other times, as illustrated in the example below, teachers missed opportunities to make teaching points out of pupils' responses.

Weaker factors: a missed opportunity to build on a pupil's response and inaccurate modelling leading to misunderstanding.

In this lesson, a high-attaining Year 10 set were simplifying surd-form expressions by rationalising the denominator.

Having explained the method, the teacher moved on to the second worked example, $1/\sqrt{12}$, and asked 'what do we do first?' A boy answered $1/(2\sqrt{3})$, (which is equivalent to $1/\sqrt{12}$ because $\sqrt{12} = \sqrt{4} \times \sqrt{3} = 2\sqrt{3}$), and is therefore a possible first step. However, the teacher ignored the boy's response. After another pupil had offered the response she sought, which was to 'multiply top and bottom by $\sqrt{12}$', she worked the question through. The boy then politely explained that he had got the same answer through a different method. The teacher then looked at his work and could see his method was correct but she did not use this as a teaching point for the rest of the class.

Although the teacher spoke about the method of multiplying the numerator and denominator by $\sqrt{12}$, her presentation was imprecise. As the first step, she wrote

$$\frac{1}{\sqrt{12}} \times \sqrt{12}$$

Strictly, this means that only the numerator is multiplied by $\sqrt{12}$. This inaccurate notation confused another pupil who followed the demonstrated first step closely and consequently couldn't see where her answers were going wrong.

How might it be improved?

The teacher did not immediately spot what the boy had done as his first step. She could have asked him to explain how he got $1/(2\sqrt{3})$. His response should not have been ignored. At the very least, she should have discussed his answer with him once the class was working.

Having looked at his work, she could have shown both methods to the pupils to allow comparison, thus:

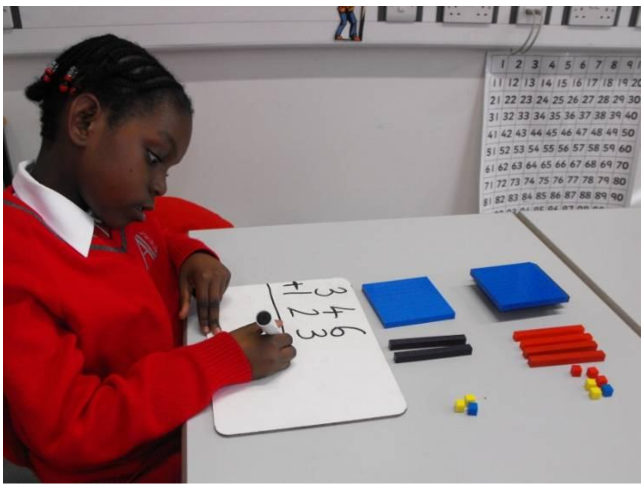
$$\frac{1}{\sqrt{12}} = \frac{1\mathrm{x}\sqrt{12}}{\sqrt{12}\mathrm{x}\sqrt{12}} = \frac{2\sqrt{3}}{12} = \frac{\sqrt{3}}{6} \quad \text{and} \quad \frac{1}{\sqrt{12}} = \frac{1}{2\sqrt{3}} = \frac{1 \mathrm{~x~} \sqrt{3}}{2\sqrt{3} \mathrm{~x~} \sqrt{3}} = \frac{\sqrt{3}}{2\mathrm{x}3} = \frac{\sqrt{3}}{6}$$

In discussion with the teacher after the lesson, it emerged that her careless notation did not represent a gap in her subject knowledge. She recognised the importance of modelling mathematical language and conventional notation accurately.

Underexploited information and communication technology and practical resources

62. Carefully chosen practical activities and resources, including computer software, have two principal benefits: they aid conceptual understanding and make learning more interesting. Too few of the schools used these resources well.

63. The schools visited during the primary good practice survey drew on a wide range of practical resources in developing fluency through plenty of hands-on experience in the EYFS and Key Stage 1. They returned to them when developing new ideas in Key Stage 2. For instance, the schools recognised the common obstacle in vertical addition and subtraction of ‘exchange’, for example 45 + 27 or 45 – 27, and used resources like place-value cards and base 10 equipment (such as Cuisenaire rods and Dienes blocks) to support pupils’ understanding. Use of practical equipment or visual images helped pupils to link the recorded method with the physical operation.



A pupil using Dienes equipment to support three-digit addition.

64. Practical resources were particularly underexploited in the secondary schools surveyed but were used well in the following example.

Prime practice: good use of practical resources and ICT

Hands-on resources and visual images enabled low-attaining Year 10 pupils to gain a good understanding of nets of boxes in a meaningful problem-solving situation. This was the third lesson on nets and solids with a small set of eight pupils, five of whom had statements of special educational need. Except two pupils, who were following an entry-level course, all had gained Level 3 at Key Stage 3 and were studying GCSE. The lesson objective was to design a box in the shape of a cube or cuboid to hold an item of each pupil's choice.

The main part of the lesson started with an animation on the interactive whiteboard, of a box unfolding into a net and folding back into a box, rotating to show different views. The pupils showed their understanding of the two-dimensional and three-dimensional images in discussing them and the various cereal and other boxes provided by the teacher, some of which had been cut along their edges to make nets. The pupils' comments and questions showed they could envisage a cuboid and knew which lengths in a cuboid were equal.

Moving on to the design of their own boxes, skilled questioning by the teacher helped the pupils to realise that a 'good box' needed to be measured so that the object fitted well. The objects were irregular in shape and of interest to individual pupils, such as a toy ambulance for one boy. The pupils selected from a range of practical apparatus, including measuring equipment, plain and squared paper, card, and plastic shapes that clicked together to make two- and three-dimensional shapes.

The teacher and teaching assistants circulated as pupils grappled with the task. With support, the two lowest attainers managed to make a net of a cube. The other two groups struggled to make cuboid nets but persevered very well, returning to the cut-up boxes at intervals to help their thinking. The good quality of dialogue between pupils and with the adults enabled the pupils to find their own way through this challenging task. The pupils worked enthusiastically together to complete their boxes, and insisted on finding the inspector to show them to her at break time.

65. More generally, the potential of ICT to enhance learning in mathematics continues to be underdeveloped. The principal uses of ICT in the lessons observed were for presentation of material by teachers in whole-class teaching and by pupils for revision, practice and homework. The examples given below, from three different schools, show ICT being used well as an integral part of young pupils' learning and to aid the conceptual understanding of older pupils.

Prime practice: three examples of good use of ICT

At the start of the day at a primary school, pupils registered on arrival at their classes using the interactive whiteboards. Year 2 pupils, for instance, placed their name in the correct quarter of a Caroll diagram, indicating whether they were a girl or not, and were having school dinners or not.

In a Year 6 class, pairs of pupils used computers to draw acute and obtuse angles. The software allowed them to draw an estimate for a given angle, for example, 170°, after which it told them what angle they had created, and allowed further improved angles to be drawn. This aided pupils' conceptualisation of angles of different sizes.

The teacher of a Year 7 class used ICT effectively to show the rotation of a shape around a point on coordinate axes. The movement of the original shape to its new position modelled the transformation clearly. The teacher also demonstrated rotation of the shape about different points including a vertex, a point within the shape and about the origin. This led into a good discussion about the relationship between images after different rotations.

66. In other lessons, ICT could have enhanced pupils' conceptual understanding, particularly in providing clear visual images.

Weaker factor: a missed opportunity to use ICT to enhance pupils' understanding of time and the reading of clocks

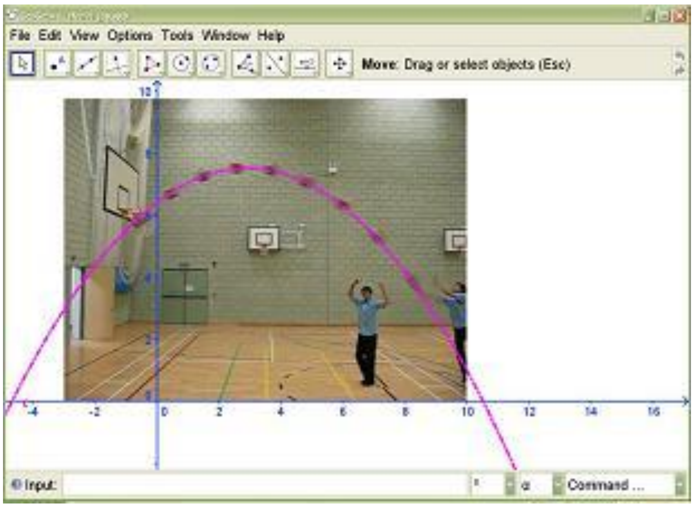
Year 2 pupils were learning about time. The hands of the clock that the teacher used for her demonstration did not have a proper winding mechanism so that the movements of the hour and minute hands were not synchronised. When she read times at half past, quarter past, and quarter to the hour, the teacher placed the minute hand in the correct position but not the hour hand. As she demonstrated and talked about the passage of time her explanation that, 'when the minute hand passes 12, the hour jumps to the next number' was not helpful.

How might it be improved?

The teacher could have used a clock with a proper winding mechanism so that the hour hand moved incrementally around with the minute hand. Some schools have sets of small clocks with winding mechanisms which enable pupils to gain experience of moving the hands for themselves.

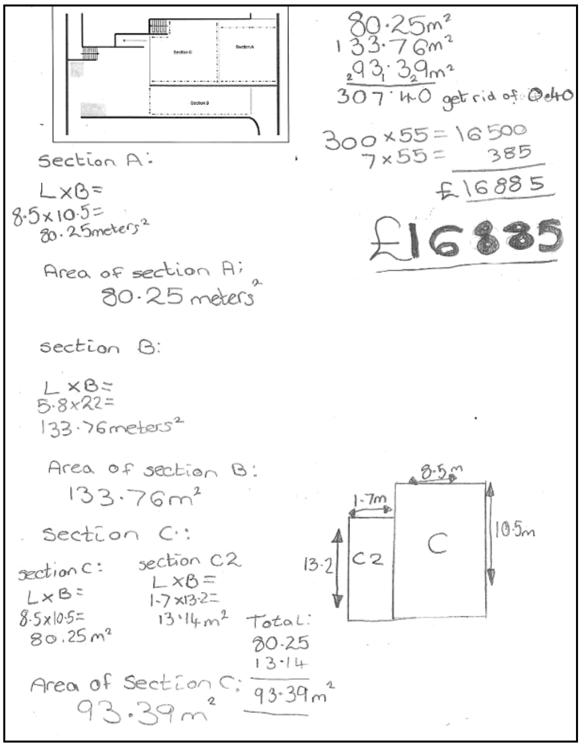
The use of software to demonstrate an analogue clock and the simultaneous movement of the minute and hour hands to show the passage of time would have provided a clear visual image to aid conceptual understanding of telling the time, calculating later and earlier times, and working out time intervals. Some such programs are available as free resources on the internet.

67. ICT was rarely used for mathematical modelling. In this example, Year 10 pupils had thrown a basketball in the sports hall, photographed the ball's path, and used software to fit a parabola over the path that was traced out.



The problem of too little problem solving

68. The emphasis almost all of the schools in the good practice survey placed on pupils using and applying their arithmetic skills to solving a wide range of problems was striking. Diverse opportunities were provided within mathematics, including measures and data handling, and through thematic and cross-curricular work. Pupils' extensive experience of solving problems deepened their understanding and increased their fluency and sense of number. Many relevant problems involved using money in real-life contexts, such as calculating best value for different supermarket offers, or pricing new equipment for the school's playground from alternative suppliers who offered different discounts, while keeping within the given budget. The illustrations below show Year 5/6 pupils measuring sections of the school's playground and preparing an estimate for the cost of resurfacing.



69. More commonly in the schools visited during the last three years, problem solving tended to be an activity that occurred towards the end of a topic; for instance several problems, all of which required the use of long multiplication. While this provided some useful practice, it did not place pupils in the position of thinking deeply about how to solve the problem or alternative methods. Some schools used acronyms such as RUCSAC (read, understand/underline, choose, solve, answer, check) so routinely that pupils did not stand back and think about the problem. Sometimes, pupils were taught to associate words with particular operations, for example, 'more', 'altogether' and 'sum' were linked to addition, but that was not always helpful. For instance, the question 'How many more apples has Dan than Suzi?' is likely to require subtraction not addition.

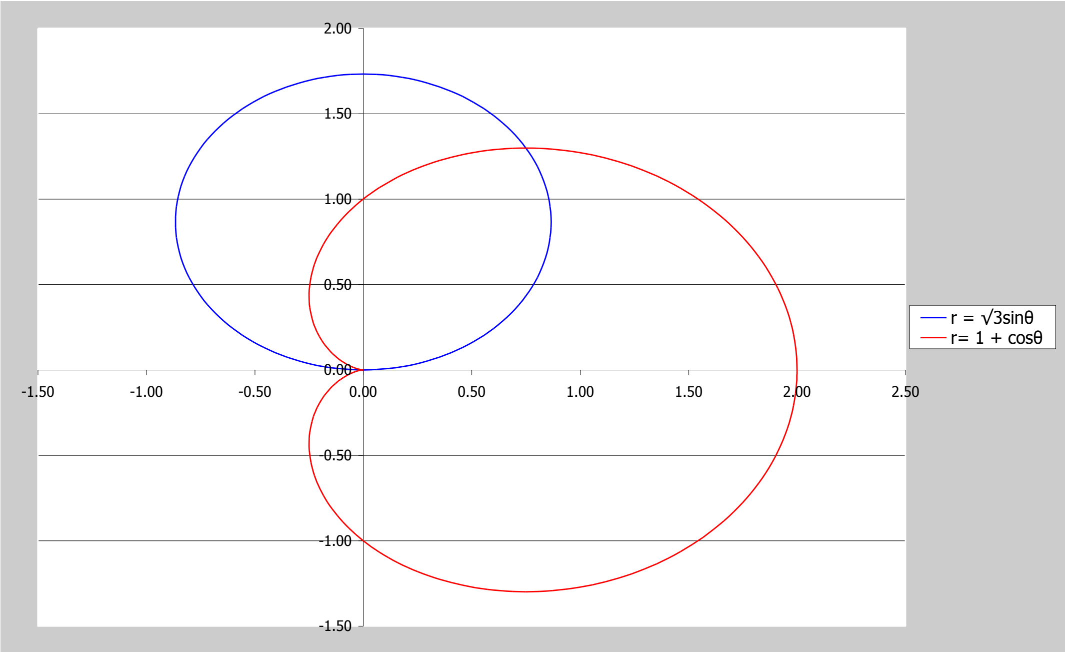
70. Similarly, in most of the secondary schools visited, problem solving typically followed the acquisition of a new skill. For instance, having practised many routine questions on calculating missing lengths in given right-angled triangles using Pythagoras' Theorem, pupils eventually move on to solving problems for example about ladders leaning against walls, before perhaps tackling a two-step problem such as calculating the area of an equilateral triangle of given side length. A distinguishing feature of the good teaching was that all the pupils in the class tackled a wide variety of problems.

71. In a few good and outstanding lessons, pupils were given substantial problems to solve that required them to think hard about the problem, draw on their previous knowledge, and grapple with applying it in a new, unusual or complex context. In the following example, a group of sixth-form further mathematics pupils persevered with a problem for a whole lesson.

Prime practice: a substantial problem that linked new and previous learning

The problem was on a new topic, to find an area enclosed by two curves expressed in polar coordinates (as illustrated). The problem had multiple steps but was not broken down for the pupils by the teacher. The pupils thought out and discussed their ideas, realising that to solve the problem they had to sketch the curves, find where they intersected, figure out how to find the area, and then calculate it.

At each stage of the problem the pupils' prior learning, though sometimes rusty, was brought into play, but for a purpose. Learning in this lesson made good links with new and earlier learning and the pupils had to think very hard for themselves.



Teaching assistants: making the most of this resource

72. The role of teaching assistants has developed and extended beyond classroom support since the previous survey, most markedly in primary schools where teaching assistants have become more actively involved in teaching small groups within lessons and in providing intervention sessions. The most effective were alert to spotting misconceptions and gaps in learning, took responsibility for assessing pupils in their groups, and helped to identify the next steps and plan subsequent activities with the class teachers. They participated in reviewing pupils' progress and were particularly effective in identifying and supporting personal problems that presented barriers to learning.

73. Some evolving good practice in primary schools included well-trained teaching assistants supporting different ability groups within a class so that the teacher worked with all groups of pupils on a regular basis. This arrangement worked best where the staff planned the lessons closely together. Some secondary mathematics departments were benefiting from the regular support of a teaching assistant whose mathematical expertise was increasing over time through working closely with the department and, less commonly, where they were involved in departmental meetings and/or training.

74. More commonly, teaching assistants in the primary and secondary schools were deployed to support small groups or individual pupils who were low-attaining or had special educational needs and/or disabilities. Their effectiveness varied widely. Modified materials and supporting resources were not routinely made available to the pupils. For example, one activity involved pupils in taking turns to look for one minute at a poster displaying various sequences and patterns before returning to their groups and describing and drawing what they could remember. A visually impaired pupil who was supported by a teaching assistant

found it difficult to see the detail on the poster, even when the teacher allowed her a little extra time. No enlarged version was provided for her.

75. The most effective teaching assistants demonstrated initiative in using practical resources to support learning and help pupils overcome difficulties, for example by using strings of counting beads to aid early multiplication. They were careful not to over-direct pupils' learning, as illustrated in the following example.

Prime practice: effective teaching by a higher level teaching assistant

In a mixed-age Key Stage 1 class, a higher level teaching assistant was working with a lower-attaining group on a measuring task.

Pupils first matched each of the diverse group of party guests (baby mice through to a giant) to various balloons. Then they had to measure string of differing lengths (5cm to 2m) for tying onto the balloons for each guest. The higher level teaching assistant encouraged good debate between the pupils around whether the string should be measured and cut before tying, or tied first and then measured. She did not steer them towards the other approach when they decided to measure and tie the string first. The pupils wrestled with measuring the string after tying it to the balloons which enabled them to appreciate the difficulty of measuring accurately once the string was attached to the balloon. They also realised that some of the string was used up in tying it to the balloon. This led to good discussion around which approach should be taken. The pupils revised their strategy for the task, which they went on to complete successfully.

76. Teaching assistants were not always used well during starter activities; for example, a girl offered '11' as the next number in the sequence 3, 6, 9, … The teacher asked her what the pattern was but, when she did not respond, moved on to another pupil who gave the correct answer, 12. The teaching assistant could usefully have noted the question and incorrect response, and followed it up individually later in the lesson, as could the teacher. Because the pupil's thinking was not probed, her difficulty was not identified and tackled.

77. Some teaching assistants would benefit from guidance on key questions to use with pupils. For instance, a temporary teaching assistant was working with low-attaining pupils in a Reception class. They were playing happily with water, filling and emptying various jugs and bottles but were making no progress towards the aim of the activity which was to discover which utensils would hold more than or less than a one litre jug. In a Nursery class, children were creating pictures using geometrically shaped stickers, such as circles, squares, rectangles and triangles. The interaction between the teaching assistant and individual children did not probe or extend their mathematical understanding. Questions were limited to the type of shapes used, their colours, and what the picture was. One girl talked to the inspector about her picture of a rocket. She

identified two squares, distinguishing the 'baby square' from the 'big square'. When asked, she counted the eight stickers she had used and was able to work out that she needed two more to make 10. The teaching assistant did not ask such questions of the children and therefore was not probing or developing their knowledge and understanding of shape or number.

78. Some teaching assistants had unidentified gaps in their mathematical knowledge, as this example illustrates.

Weaker factor: gaps in subject knowledge

A higher level teaching assistant (HLTA) talked to an inspector about how she works with pupils who have difficulty with area and perimeter of rectangles. She explained that she highlights the edge of a shape to look like a perimeter fence, to help with finding the perimeter. She also gets them to imagine the length and width of a swimming pool to help with the terminology of the formula, area = length x width. Although a useful aide memoire for the pupils, the swimming pool image reinforces the misconception that the length has to be the longer side. More fundamentally, however, the HLTA had never seen how the formula for the area of a rectangle can be established by counting rows or columns of squares (and, similarly, building the volume of a cuboid from rectangular layers of cubes). Her reaction to this discussion about developing these formulae was very positive: she said that she would use such approaches in future work with pupils.

How might it be improved?

Identifying gaps in subject knowledge is not always easy, as one teacher put it, 'You don't know what you don't know.' It was possible that some of the teachers in this school were also unaware how to develop the formula for area from first principles.

Use of practical equipment such as tiles or blocks and counting systematically in rows/columns enables pupils to spot that the area can be obtained by multiplying the number of rows by the number of columns and thereby generalise to length x width.

Pupils often become confused when working simultaneously on area and perimeter, particularly when they are unclear as to what each measures. Schools might consider whether introducing the two concepts at different stages, perimeter first, could help to avoid such confusion.

Use of assessment in lessons

79. Assessment has improved over the last three years, when compared with the previous survey's findings, but it remained a weaker aspect of teaching in the primary and secondary schools visited. Particular areas for development in teachers' use of assessment include: questioning to check and probe

understanding; identifying and tackling misconceptions; planning to meet individual needs; and adapting planning in the light of ongoing assessment during the lesson.

80. The best questioning probed pupils' knowledge and understanding, with follow-up questions that helped pupils to explain their thinking in depth and refine initial ideas.

Prime practice: good questioning skills

Year 4 pupils had previously been working on measures and collecting and interpreting data. In this lesson they would use Venn diagrams to classify mathematical objects. The teacher was skilled in asking questions, encouraging pupils to refine their answers. Pupils suggested sorting the geometric shapes displayed on the interactive whiteboard. His question 'What do you mean by shapes?' pushed the pupils into describing geometric properties for sorting. The teacher asked many incidental questions, such as 'What type of triangle is that?' Pupils realised that sorting by numbers of vertices gave the same groups as sorting by numbers of sides. The teaching assistant was working with low-attaining pupils using tiles that matched the shapes on the interactive whiteboard and which the pupils could physically sort into groups.

Having sorted the shapes in different ways, the teacher moved onto one- and two-digit numbers. When one pupil chose to sort the numbers into the 'two- and three-times tables', the teacher asked, 'Does this leave any numbers over?' which it did. This generated considerable discussion around multiples. After the numbers had been sorted in different ways, the teacher set each group a different activity: all made good progress.

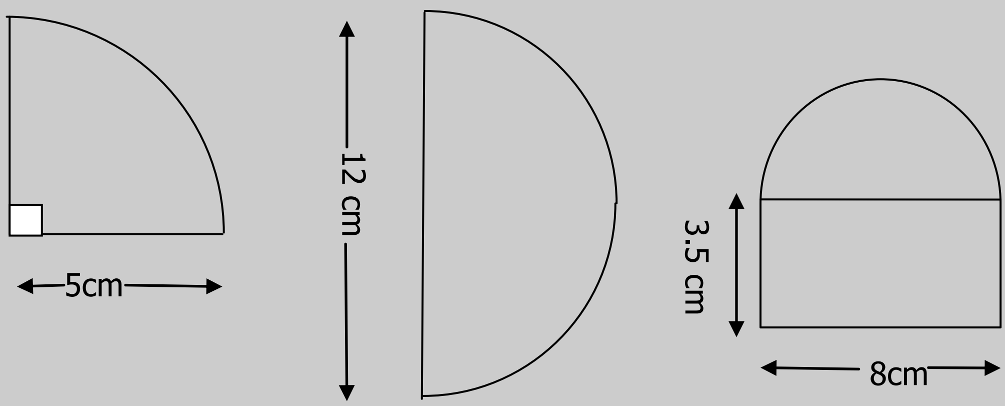
81. Teachers generally circulated to observe pupils as they worked independently or in groups. This is an important improvement since the previous survey. It has become relatively rare to see secondary teachers rooted to the front of the class or primary teachers remaining entirely with one focus group while the other groups work on set tasks. The more effective teachers used the information that they gathered through monitoring pupils' progress and understanding to support their learning and to adapt the lesson to meet emerging needs. Crucially, they made quick sweeps of the class to check on every pupil before deciding where and how to intervene. Their next steps depended on the circumstances but included a variety of strategies such as: using probing questions to pin down the source of a pupil's difficulty; providing alternative resources for certain pupils; picking out pupils who had something interesting to share with the class and following it up in a mini-plenary session.

82. Skilled teachers made good use of starter or introductory activities to establish how much pupils already knew about a topic, using the information to tailor their subsequent teaching. In the following example, a newly qualified teacher wanted to establish how much Year 11 pupils recalled of previous work on

areas of circles and compound shapes. She did not want simply to re-teach the topic.

Prime practice: good assessment through an interesting introductory activity

The teacher asked the pupils to calculate the area of these three shapes:



The teacher stopped the lesson after a few minutes having circulated to observe the pupils at work. She had recognised that their prior knowledge was insecure. Her questioning tackled errors such as use of incorrect formulae. She then modelled the solution for the semi-circle clearly, leaving the answer in terms of π (pi), before allowing the pupils time to complete the other two shapes.

Although the pupils had initial difficulty with this task, the three shapes selected by the teacher gave suitable variety and made pupils think more than a routine exercise on calculating the area of circles would have done. Her effective monitoring of their progress with the task meant that her intervention was timely.

83. This type of assessment requires a high degree of skill: it was done consistently well in few of the schools. At a basic level, teachers did not always set pupils enough independent work to give themselves time to move around the class, often because too much of the lesson had been spent on the starter and introductory activities. Creating the opportunity for assessing pupils' progress was an important first step, but teachers then varied in how well they interpreted the clues in pupils' work and oral responses to pinpoint their difficulties precisely. At other times, such errors and misconceptions were missed or not acted upon.

84. Weaknesses in teachers' subject knowledge were an impediment to effective assessment because the teachers were not able to anticipate misconceptions or spot fundamental errors and use them to enhance pupils' understanding. These weaknesses also affected the quality of questioning.

Weaker factor: not anticipating or spotting misconceptions

The starter activity for this lesson was a revision quiz on number patterns. This Year 11 bottom set contained 11 pupils, nine of whom had special educational needs. The teacher was not a mathematics specialist.

After the pupils had worked for several minutes on the quiz questions, the teacher asked individual pupils for their answers. One question was 'What is the first number in the sequence 3n+1?' A pupil correctly answered '4' and the teacher praised him and moved on to the next question. However, this answer could be derived incorrectly by ignoring the n in the expression 3n+1 and simply adding 3+1. The teacher did not check that the pupil knew to substitute 1 for n. Later, the inspector reminded the pupil about the question and his correct answer of 4 for the first number, and then asked what the second number in the sequence was. The pupil replied '5', adding 'then 6, and 7'.

How might it be improved?

The teacher did not know the common difficulties that pupils have with expressing sequences algebraically. When asked to find the value of an expression such as 3n+1, pupils who do not understand algebra often ignore the variable n and just calculate using the numbers, 3+1 in this case. This means that the correctly calculated answer for the first term is indistinguishable from the incorrect, as will always be the case for the first term of such a sequence. Asking the pupil how he worked out the answer, and going on to check the value of the next few terms would ascertain whether the pupil understood fully.

Moreover, pupils often write incorrect expressions like n+3 for a linear sequence that 'goes up in 3s', for example, 5, 8, 11, 14 … instead of the correct nth term, 3n+2. They struggle to move from spotting the term-to-term pattern to writing a general expression for any term in the sequence.

Assessing attainment: one piece of work at a time?

85. Many of the schools had prioritised the improvement of assessment, supported by materials from the National Strategies on assessment for learning. Typically, this involved whole-school training and changes to the assessment policy. For instance, some schools insisted that at regular intervals a piece of marked work should be assigned a National Curriculum level. However, too few schools recognised that the policy needed to be tailored to particular subjects. In mathematics, the nature of the subject content is hierarchical with many individual topics assigned to discrete levels and each level comprising a range of topics. Therefore, because levels are largely governed by the topic being covered, assigning a level to one piece of work is not representative, or even possible, especially if much of the work is incorrect. For example, work on circumference and area of circles is generally considered to be a Level 6 topic.

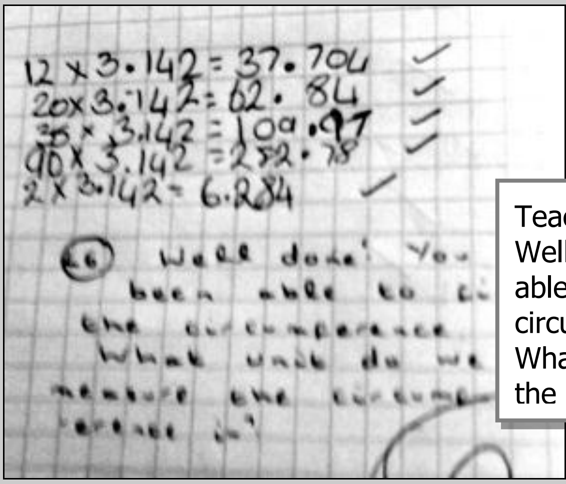
Incorrect or misunderstood work cannot be called Level 5. Similarly, to improve a piece of work to achieve a higher level is not always possible in mathematics; for instance the closest topic to work on circles might be volumes and surface area of cylinders, but this represents new learning rather than how to improve existing work. To get around this problem, schools typically set a test and give a level based on the mark awarded. However, this does not necessarily lead to an accurate or diagnostic assessment of what pupils can do well or need to improve.

86. The following extracts from pupils' work illustrate how levels had been assigned without sufficient (a) depth of coverage of the whole topic and (b) mastery of the topic.

Weaker factor: thin assessment evidence

(a) The pupil has calculated the circumference of five circles of different diameters.

The answer to each calculation is presented as it would be shown on the calculator when the approximation of 3.142 is used for π (pi). The pupil has not rounded the answer or given the units of measurement, as noted by the teacher, who adds a prompt about this.

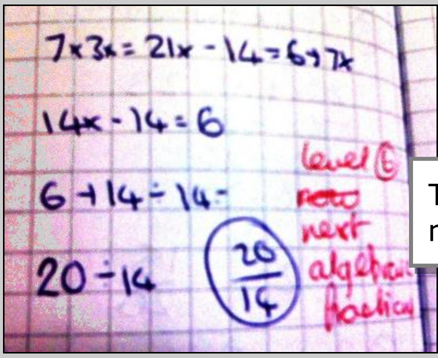


Teacher's comment: **L6**
Well done! You have been able to find the circumference.
What unit do we measure the circumference in?

This is a narrow set of questions: the pupil has not found the circumference when the radius rather than the diameter is given, or solved a variety of problems involving the circumference, diameter and radius of a circle. The teacher has assessed this work as Level 6 (written as L6), but the work does not provide convincing evidence of adequate depth of knowledge and understanding of the topic.

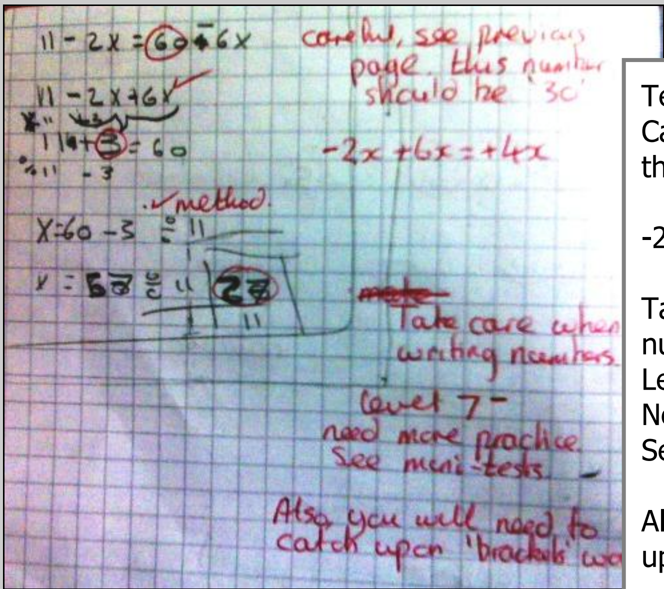
(b) Neither of the two illustrative extracts below show a sufficiently good grasp of linear equations to be assessed at Level 6 in the first example and a low Level 7 in the second. In both cases, the pupils had tackled several linear equations, with these being the last and most difficult question.

The solution below to 7(3x – 2) = 6 + 7x was correct but was poorly set out and the answer presented as an unsimplified vulgar fraction, rather than $x = 1^{3}/_{7}$. The teacher's 'next step' comment, 'algebraic fractions' appears to point to the next topic rather than the next step for the pupil.



Teacher's comment: Level 6
next algebraic fractions

The solution below to 11 – 2x = 6(5 – x) had more errors than the teacher had identified and the method was not correct. However, the teacher's comments are constructive.



Teacher's comments:
Careful, see previous page.
this number should be '30'.

-2x + 6x = +4x

Take care when writing numbers.
Level 7^{-}
Need more practice.
See mini-tests.

Also you will need to catch up on 'brackets' work.

How might it be improved?

To use only one piece of assessed work every six weeks or half a term is not a reliable way to track a pupil's attainment and progress. A broader range of evidence, such as homework and classwork, tests and longer problem solving and investigative work would give a richer assessment. Some schools make good use of 'Assessing Pupils' Progress' sheets to capture a more holistic view of what pupils can do and their progress within each aspect of mathematics.[8]

[8] Assessing Pupils' Progress is a structured approach to assessment against National Curriculum levels.

87. Almost all the schools gathered such assessment information on a regular basis, typically termly or half-termly, and used it systematically to track pupils' progress and identify underachievement. However, if the assessment is not accurate, the system becomes flawed, and support may not be provided for those pupils who most need it.

Marking: the importance of getting it right

88. Inconsistency in the quality, frequency and usefulness of teachers' marking is a perennial concern. The best marking noted during the survey gave pupils insight into their errors, distinguishing between slips and misunderstanding, and pupils took notice of and learnt from the feedback. Where work was all correct, a further question or challenge was occasionally presented and, in the best examples, this developed into a dialogue between teacher and pupil.

89. More commonly, comments written in pupils' books by teachers related either to the quantity of work completed or its presentation. Too little marking indicated the way forward or provided useful pointers for improvement. The weakest practice was generally in secondary schools where cursory ticks on most pages showed that the work had been seen by the teacher. This was occasionally in line with a department's marking policy, but it implied that work was correct when that was not always the case. In some instances, pupils' classwork was never marked or checked by the teacher. As a result, pupils can develop very bad habits of presentation and be unclear about which work is correct.

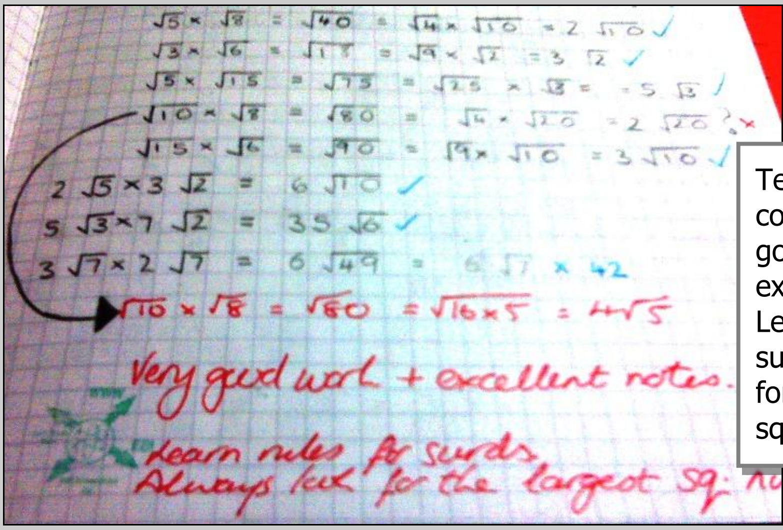
90. A similar concern emerged around the frequent use of online software which requires pupils to input answers only. Although teachers were able to keep track of classwork and homework completed and had information about stronger and weaker areas of pupils' work, no attention was given to how well the work was set out, or whether correct methods and notation were used.

91. Teachers may have 30 or more sets of homework to mark, so looking at the detail and writing helpful comments or pointers for the way forward is time consuming. However, the most valuable marking enables pupils to overcome errors or difficulties, and deepen their understanding. The following two examples illustrate this point.

Prime practice: helpful marking

Simplifying numbers written as square roots (known as 'surd form') is one of the more demanding higher tier GCSE topics. In the first illustration below, the pupil did not simplify $\sqrt{80}$ fully. The teacher demonstrates the simplification, and the helpful comment 'always look for the largest square number' relates specifically to where the pupil's solution had fallen down.

Note also that this teacher is checking work marked already by the pupil and comments on the quality of the notes made in class by the pupil.

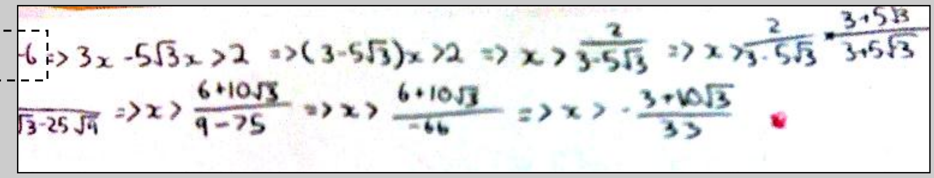


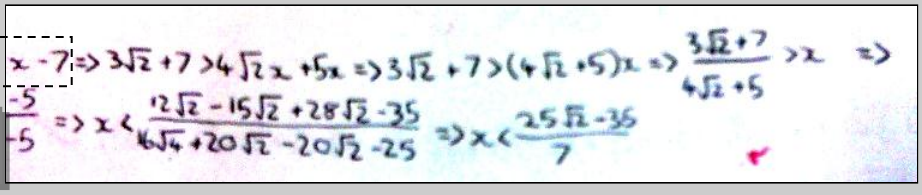
Teacher's comments: Very good work and excellent notes. Learn rules for surds. Always look for the largest sq. no.

Weaker factor: unhelpful marking

The teacher's marking and comment, 'more work is needed on this', did not help the pupil to understand the errors that arose when solving the following two challenging inequalities.

$3x - 8 > 5\sqrt{3}x - 6$

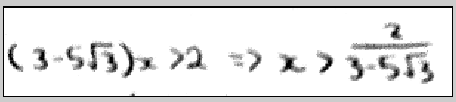




$3\sqrt{2} - 5x > 4\sqrt{2}x - 7$

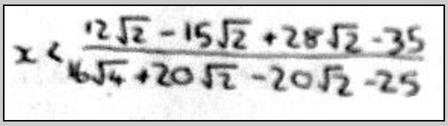
Neither of the pupil's errors was pinpointed in the marking.

In the first question, an important error occurred when the pupil divided by $(3 - 5\sqrt{3})$.



Because $(3 - 5\sqrt{3})$ is negative, x should be less than, not greater than, $2/(3 - 5\sqrt{3})$.

The pupil's error in the second question is likely to have been a simple slip. The first number in the numerator, 12√2, comes from multiplication of 3√2 by 4√2. It should be 24. Otherwise, the method was correct.



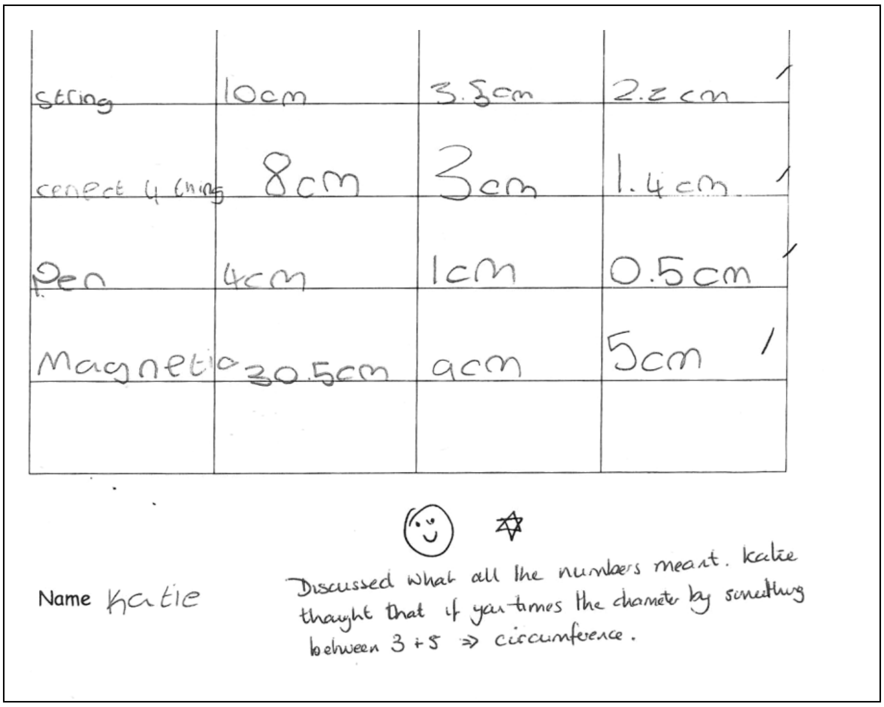
$$x < \frac{12\sqrt{2} - 15\sqrt{2} + 28\sqrt{2} - 35}{6\sqrt{4} + 20\sqrt{2} - 20\sqrt{2} - 25}$$

How might it be improved?

It is not clear whether the teacher had identified the nature of these two errors. He/she could consider making model solutions available to pupils so that they could see for themselves where they went wrong. This would also encourage their independence and focus subsequent discussion on any remaining areas of difficulty.

The teacher might have anticipated the first error. The first step in rearranging the inequality 3x – 6 > 5√3x – 4 was likely to lead to the negative expression, 3x – 5√3x, on the left hand side of the inequality. If other pupils had made the same error, it would make a good teaching point for the next lesson.

92. Examples of good annotation of pupils' work were observed in some primary schools, sometimes accompanied by photographs. The example below shows part of a Year 4 pupil's table of measurements of the circumference, diameter and radius of several objects. The teacher has recorded the pupil's generalisation from her results, 'Discussed what all the numbers meant. Katie thought that if you times the diameter by something between 3 and 5 ⇒ circumference.'



string	10cm	3.5cm	2.2cm
conect 4 thing	8cm	3cm	1.4cm
Pen	4cm	1cm	0.5cm
Magnetic	30.5cm	9cm	5cm

Name Katie

Discussed what all the numbers meant. Katie thought that if you times the diameter by something between 3 + 5 ⇒ circumference.

93. The following examples represent brief but helpful advice or questions provided by teachers in marking pupils' work.

- 'Check all reflections with tracing paper especially ones in the diagonal line y=x.'
- 'Practise adding and subtracting recurring fractions – try the A/A* booster on [online software].'
- 'Look up bearings as you've missed this work. What are the three key points to remember when using bearings?'
- 'Try this question again. What type of triangle is it?' (The pupil had previously not spotted that the unusually orientated triangle was isosceles, but redid the question correctly following the teacher's hint.)
- 'What is 20cm in mm?' asked a teacher after praising a pupil's correct work on shape. The pupil had written 200 in response. This Year 5 teacher regularly asked pupils short questions at the end of their work and they responded. The pupils explained to the inspector that they checked for the teachers' comments and questions in their mathematics and English books during register time at the start of morning school. Such good practice is not typical.

94. Some marking did not distinguish between types of errors and, occasionally, correct work was marked as wrong. For example, in marking homework on probabilities of single events, a teacher marked unsimplified fractions as wrong in exactly the same way as incorrect answers that showed misunderstanding. For instance, the probability of selecting a heart from a pack of playing cards is $\frac{1}{4}$ but a pupil's unsimplified but correct answer of $^{13}/_{52}$ was marked wrong, instead of indicating that this fraction was correct but cancels down to $\frac{1}{4}$. The same pupil's incorrect answer of $\frac{1}{4}$ for the probability of selecting a king from a pack was similarly marked wrong without any comment. The pupil might have reasoned, incorrectly, that the probability of selecting one king, knowing that a pack has four kings, is $\frac{1}{4}$ but this misunderstanding was not addressed through the marking. (The correct answer is $^{4}/_{52}$ which simplifies to $^{1}/_{13}$.)

95. At other times, teachers gave insufficient attention to correcting pupils' mathematical presentation, for instance, when $6 \div 54$ was written incorrectly instead of $54 \div 6$, or the incorrect use of the equals sign in the solution of an equation.

96. Most marking by pupils of their own work was done when the teacher read out the answers to exercises or took answers from other members of the class. Sometimes, pupils were expected to check their answers against those in the back of the text book. In each of these circumstances, attention was rarely paid to the source of any errors, for example when a pupil made a sign error while expanding brackets and another omitted to write down the '0' place holder in a long multiplication calculation. When classwork was not marked by the teacher or pupil, mistakes were unnoticed. In the example below, the pupil made a

common, but important, error by not drawing the quotient line correctly in the formula for solving a quadratic equation. Because the work was not marked, the error was not corrected and the pupil could continue to make the same mistake repeatedly in the future.

$$x^2 - 4x + 2 = 0$$

$$x = 4 \pm \frac{\sqrt{(16 - 4 x 1 x 2)}}{2 x 1}$$

$$x = 4 \pm \frac{\sqrt{8}}{2}$$

$x = 5.4$ or 2.6, which are incorrect solutions

The correct first step should have been $x = \frac{4 \pm \sqrt{(16 - 4 x 1 x 2)}}{2 x 1}$

97. The involvement of pupils in self-assessment was a strong feature of the most effective assessment practice. For instance, in one school, Year 4 pupils completed their self-assessments using 'I can …' statements and selected their own curricular targets such as 'add and subtract two-digit numbers mentally' and 'solve 1 and 2 step problems'. Subsequent work provided opportunities for pupils to work on these aspects.

98. An unhelpful reliance on self-assessment of learning by pupils was prevalent in some of the schools. In plenary sessions at the end of lessons, teachers typically revisited the learning objectives, and asked pupils to assess their own understanding, often through 'thumbs', 'smiley faces' or traffic lights. However, such assessment was often superficial and may be unreliable, as illustrated in the following case study.

Weaker factor: unreliable self-assessment of understanding

A low-attaining Year 8 class had worked on multiplying and dividing by 10, 100 and 1,000. In the work on multiplying, the pupils had completed a page of simple multiplications, mostly multiplying whole numbers by powers of 10, but also including some where they had to multiply a decimal number. One pupil who had ticked her answers right explained to the inspector, 'to multiply by 100, you add two zeros'. She went on to say that when it was a decimal you had to move the decimal point. She knew to move the point the same number of places as the number of zeros in the multiplier, so twice when multiplying by 100. However, she was unsure in which direction the point moved. In fact, she gave the answer to 4.6 x 10 as 0.46 but, because she believed that 0.46 was the same as 46, she marked her answer as correct. She thought that she understood the topic but her understanding was very shaky.

How might it be improved?

When assessing pupils' understanding at the end of such a lesson, the teacher might have asked pupils to display their answers on mini-whiteboards so that errors would be picked up immediately. Alternatively, a quick matching task that involved questions and possible wrong and right answers (say 46, 4.60, 0.46, … for 4.6 x 10) would allow misconceptions to be revealed.

99. Rather than asking pupils at the end of the lesson to indicate how well they had met learning objectives, some effective teachers set a problem which would confirm pupils' learning if solved correctly or pick up any remaining lack of understanding. One teacher, having discussed briefly what had been learnt with the class, gave each pupil a couple of questions on pre-prepared cards. She took the cards in as the pupils left the room and used their answers to inform the next day's lesson planning. Very occasionally, a teacher used the plenary imaginatively to set a challenging problem with the intention that pupils should think about it ready for the start of new learning in the next lesson.

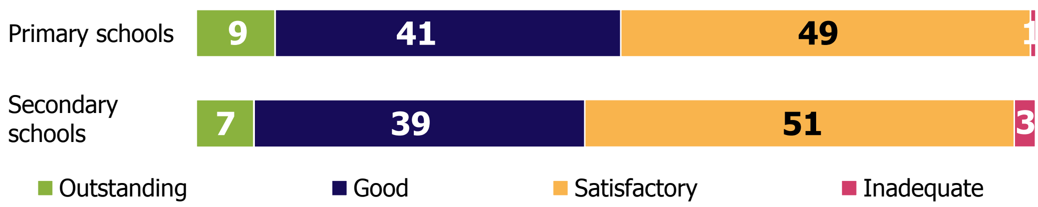
Curriculum

100. Important weaknesses in the curriculum remain. Inspectors continue to be concerned about the lack of emphasis on 'using and applying mathematics'. In addition, curriculum plans in many schools did not offer the necessary support to help teachers' tailor lessons to meet the needs of different ability groups. This section draws attention to the negative impact of early entry to GCSE on many of our pupils.

The curriculum – is it good enough?

101. Since the last survey, the secondary National Curriculum, GCSE and AS/A-level specifications, and the National Strategy frameworks have all been revised. Most schools have amended their schemes of work, some on more than one occasion. Despite this, or perhaps because of it, the mathematics curriculum was judged good or outstanding in less than half of the schools inspected (47). While it was inadequate in only seven schools, it often had important shortcomings that impeded pupils' better progress.

Figure 4: Quality of the curriculum in mathematics in the schools surveyed (percentages of schools)



Percentages are rounded and do not always add exactly to 100.

102. Day-to-day management of the curriculum is generally stronger than strategic leadership. Action to bring improvement tends to be reactive rather than proactive. Lack of robust evaluation of curricular developments and initiatives, including intervention programmes, and insufficient interrogation of information from monitoring activities and question-level analyses too often mean searching

questions are not asked about the effectiveness of the provision and whether all groups are benefiting equally. In particular, questions like:

- What approach was used in the teaching of a topic found difficult by all/some pupils? Did all teachers use the same approach or approaches that drew on the same conceptual models? (These have implications for professional development and guidance for staff.)
- How are different pupils affected by decisions made about setting and examination entry policies? (Some educational research suggests that setting benefits the higher sets only. Evidence underpinning this report shows that higher sets receive better teaching. It is not clear that schools' entry policies always have each individual pupil's best interests at heart.)
- How good is the mathematical progress of the nurture group/intervention groups/withdrawal groups/disabled pupils and those who have special educational needs? Are mathematical expectations high enough or are some pupils working at levels below their prior attainment and potential?
- Is the shift in primary schools to teaching some mathematics through themes and topics aiding pupils' progress? Is there coherence between planning for mathematics within themes/topics and discrete mathematics lessons? In primary and secondary schools, are cross-curricular opportunities ad hoc?

Still too little 'using and applying mathematics'

103. In the very best schools, 'using and applying mathematics' was integrated into day-to-day teaching. For example, new topics were introduced by presenting a suitable problem and inviting pupils to use their existing knowledge in innovative ways. More generally, the lack of emphasis on using and applying mathematics remained a weakness that is persistent. Activities identified in schools' documentation were too often left to the choice of individual teachers, so that not all pupils undertook them.

104. These criticisms are not new. Much the same was said in the previous report. In many secondary schools at that time, pupils' experience of using and applying mathematics was largely restricted to GCSE coursework tasks. Since then, coursework has been abolished in GCSE mathematics, with the result that the schemes of work in some of the schools gave teachers no guidance at all on teaching pupils to use and apply mathematics.

105. Using and applying mathematics reappeared in the 2007 secondary National Curriculum under the title 'key process skills' and also as 'functional mathematics', for which a separate qualification was initially intended as a 'hurdle' for grade C GCSE mathematics. It remains a compulsory part of diploma programmes and the key process skills are reflected in the most recent GCSE specifications. While the change from coursework to examination of these skills was signposted well in advance, its implementation was dogged with difficulties and many schools, even the far-sighted, struggled to make adequate

preparations. Many schools interpreted functional mathematics as problem solving in real-life situations, and treated it as a bolt-on activity rather than understanding that the development of these skills is part of behaving and reasoning mathematically, and therefore pervades good learning of mathematics.

106. At Key Stage 3, most of the schools had introduced 'rich tasks' as a periodic activity to develop and/or assess pupils' functional or key process skills. The most effective schools were moving beyond this first step towards incorporating problem solving and rich tasks throughout the curriculum.

107. In the primary schools, opportunities to use and apply mathematics were generally restricted to solving 'word problems'. Typically pupils were given sets of word problems, all of which required the same recently learnt operation or method, for example several problems all solved by using subtraction. Such practice does not promote good problem-solving skills because pupils do not have to think the approaches through for themselves.

108. Pupils were rarely given open-ended investigative activities. When they were used, the skills of using and applying mathematics were not generally specified, as in the following example.

Weaker factor: a need for guidance on using and applying mathematics

The newly qualified Year 5/6 teacher lacked experience in teaching using and applying mathematics. Nevertheless he set the pupils the 'pond borders' investigation. The learning objective was 'to be able to apply addition to solve mathematical problems'.

Two groups were working on square ponds, and one group on rectangular ponds of dimension n+1 by n. Well into the lesson, pupils were working in pairs, making the pond borders from tiles and predicting what the number of tiles for the next pond would be. 'It is going up in the four times table' was one pupil's comment.

The group working on the rectangular pond was being supported by a teaching assistant who was steering them too strongly towards sums of the form L + L + W + W + 4 for particular ponds. One boy, working independently from his peers in the group, justified his solution for a 10 x 11 pond by jotting on his mini-whiteboard:

1	10	1
11		11
1	10	1

He then wrote 10+10+10+10+1 +1+1+1+1+1 = 46.

How might it be improved?

The teacher’s inexperience meant that the learning objective did not reflect the skills and language of using and applying mathematics, such as spotting and describing patterns, making and testing rules and generalisations, but the pupils were nevertheless investigating. The boy who justified the 10x11 pond was very close to being able to make his own generalisation for such a pond, with some skilful questioning.

The teaching assistant was steering the group too much rather than asking pupils to come up with their own ideas.

The higher attaining group, which had been set a completely different investigation that proved less demanding, might have been better suited to the rectangular pond task, possibly extending to n by n+2, or n by m.

109. Reasoning and proof were not well developed in most of the secondary schools visited. Many high-attaining Year 11 pupils were not familiar with geometric proofs, for instance of the circle theorems, or using algebraic argument, in spite of the inclusion of these in current GCSE specifications. A recent GCSE examination question asked pupils to prove that ‘the sum of the squares of two consecutive integers is one greater than twice the product of the integers’ and provided an illustrative example, $9^2 + 10^2 = 181$ and $2 \times 9 \times 10 = 180$. The principal examiner’s report stated that ‘the concepts of algebraic proof were rarely demonstrated well’. This mirrors the weaknesses and gaps in pupils’ knowledge noted when inspectors scrutinised their books and practice examination papers and in discussions.

Schemes of work and the elusiveness of guidance for teachers

110. The pace of change is particularly acute in secondary schools, which helps to explain why problems with the coherence of teaching programmes arose in more than half of the secondary schools visited in the survey, compared with less than one third of the primary schools. Rarely did secondary schools’ schemes of work set out a coherent learning journey in mathematics for pupils as they progress through the school.

111. The better teaching programmes took account of the full range of ability. Nearly all the secondary mathematics lessons were taught to classes set by prior attainment. However, some schools did not have a well-defined teaching programme for each set or tier that gave guidance on how far a topic should be developed with each class of pupils, creating potential difficulties later in building subsequent learning, given that many pupils experience changes in sets and teachers. Instead, in these schools, the teachers used a single scheme of work which was based on the needs of the average pupil. While this typically included suggestions for extending high-attaining pupils or supporting low-attaining pupils, each teacher was free to interpret the guidance in a different way. This issue was prominent in the previous survey report.

112. During the period of the survey, an increasing number of schools had begun to enter pupils for GCSE in Year 10 or early in Year 11. However, not all the schools visited had done so with sufficient thought. In order to 'start GCSE in Year 9', they 'cover Key Stage 3 in two years' but, in effect, pupils move directly from their Year 8 programme to the former Year 10 programme, the previous Year 9 programme now being omitted. While this has the accidental benefit in some cases of removing some of the excessive repetition of Key Stage 3 work previously seen in Key Stage 4, it does not represent a carefully laid foundation for, and transition to, study of GCSE mathematics.

113. Perhaps surprisingly, the switch to early entry was common among schools where many pupils entered Year 7 without having reached the expected level for their age. In effect, pupils who were already a year or more behind were asked to complete their GCSE programmes a year early. While the motivational effect of preparing for an examination worked for some pupils, the negative impact on the quality of their learning in the longer term cannot be overemphasised and is discussed in depth in Part B of this report.

114. In a few secondary schools, younger, vulnerable pupils were taught by the same teacher for several curriculum subjects. This strategy aimed to ease transition to secondary school by providing curricular experiences closer to primary classrooms and to nurture pupils' confidence and self-esteem. However, teachers' expectations of pupils' academic progress were not consistently high enough, for instance a Year 7 nurture class was working on Level 2 number work when some pupils had already attained Levels 3 and 4 at primary school.

115. A few secondary schools provided a 'competency curriculum' for the younger year groups. This aims to develop pupils' learning skills effectively so that their academic progress subsequently accelerates. The teachers of this provision were often English, humanities or primary specialists. Mathematics was not often included in the group of subjects taught through the programme. The following example shows the pitfalls of weak curricular planning coupled with use of non-specialist staff who were inexperienced in teaching mathematics.

Weaker factor: inadequate curriculum planning and guidance

Year 7 pupils were following a newly introduced competency curriculum which included mathematics. A consultant had conducted learning walks and was relatively positive about the programme. However, evidence from the mathematics visit showed that pupils had learnt very little mathematics in the first term and what they were doing was not coherent. They had received no mathematics teaching for the first four weeks of the autumn term while teachers got used to delivering the competency-based lessons.

As the term progressed, leaders realised that pupils needed to develop new mathematical skills and keep others sharp. This led to the use of undifferentiated, repetitive numeracy worksheets, resulting in unsatisfactory teaching and learning. There was no proper scheme of work, only a list of topics to be covered, and a lack of liaison with the mathematics department.

Pupils occasionally worked in groups on interesting rich tasks, for instance deciding where to place a by-pass for a town. The pupils had to synthesise information about imperial and metric measures, scale drawings and maps, percentages, using large numbers – costs running to millions of pounds, for example. Because pupils' solutions showed no working, it was not possible to determine whether their mathematics was correct. Even where pupils learnt a new skill through the task, for instance how to calculate a percentage, the small number of times a percentage was calculated meant that their understanding of percentages was unlikely to be secure.

How might it be improved?

There is no quick fix. The development of pupils' mathematics knowledge, skills and understanding through thematic or other cross-curricular approaches requires medium- and short-term planning of the highest quality. Medium-term plans would need to identify the mathematical content and skills in using and applying mathematics which could be taught through each theme. Some aspects would require additional emphasis to secure pupils' skills and others might require separate teaching where the chosen themes do not lend themselves to learning some of the content or skills.

Short-term planning is needed to support teachers, particularly non-specialists, in the approaches and activities that best develop pupils' skills and understanding. Ideally, these should align with those used within the mathematics department, and provide a secure progression route to later discrete teaching of mathematics. Leaders responsible for the thematic approaches would need to work closely with mathematics leaders.

Leadership and management

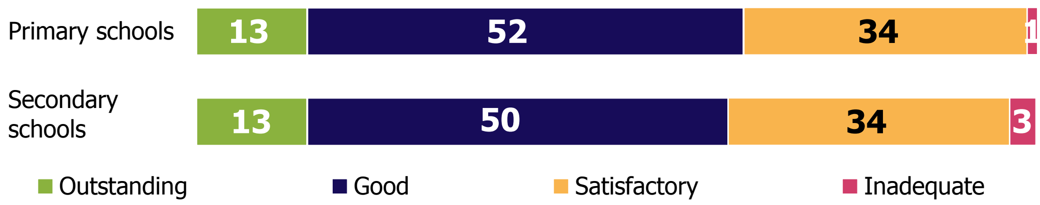
116. Changes in school performance measures since the last report have raised the profile of mathematics in secondary schools. However, the effects have not all been positive, resulting in inequitable provision for different groups of pupils; further attention is given to this in Part B.

117. This section of the report also evaluates the impact of in-school monitoring and evaluation in raising the quality of teaching and the effectiveness of leadership in ensuring that all pupils receive consistently good teaching

Overview and ethos

118. Leadership and management of mathematics in primary schools were slightly weaker than in the previous survey, when 71% was good or better.[9] By contrast, the proportion of good and outstanding leadership and management in the secondary phase increased, with changes in secondary school performance measures a key driver.

Figure 5: Quality of leadership and management in mathematics in the schools surveyed (percentages of schools)



Percentages are rounded and do not always add exactly to 100.

119. Leadership was rarely inadequate in primary schools but, in a minority, it lacked subject expertise or rigour. Both of these weaknesses impeded leaders' ability to get underneath the subject-specific aspects of teaching or the curriculum which needed improvement. In more than half of the primary schools, many of which were small, leaders tended to rely on the close working relationships between staff and informal professional dialogue to maintain or improve the quality of provision. A similar ethos was common in secondary mathematics departments.

120. The fastest improving schools and departments took nothing for granted. They monitored provision rigorously and used the outcomes to identify strengths and weaknesses, evaluated the effectiveness of actions taken, and pinpointed the next steps in driving improvement. Staff collaborated to learn from and support each other well.

The influence of performance measures

121. Leaders in the primary and the secondary schools were driven strongly to improve results in mathematics, clearly influenced by the public profile of their results and how those results are used. Since the last survey, it has become increasingly common for teachers' performance management targets to include measures of attainment and/or progress for the pupils that they teach. Thus, accountability has increased.

122. The profile of mathematics in the principal secondary attainment and progress measures has been raised since the last survey. From 2008, performance has been measured against the statutory target for the proportion of pupils gaining

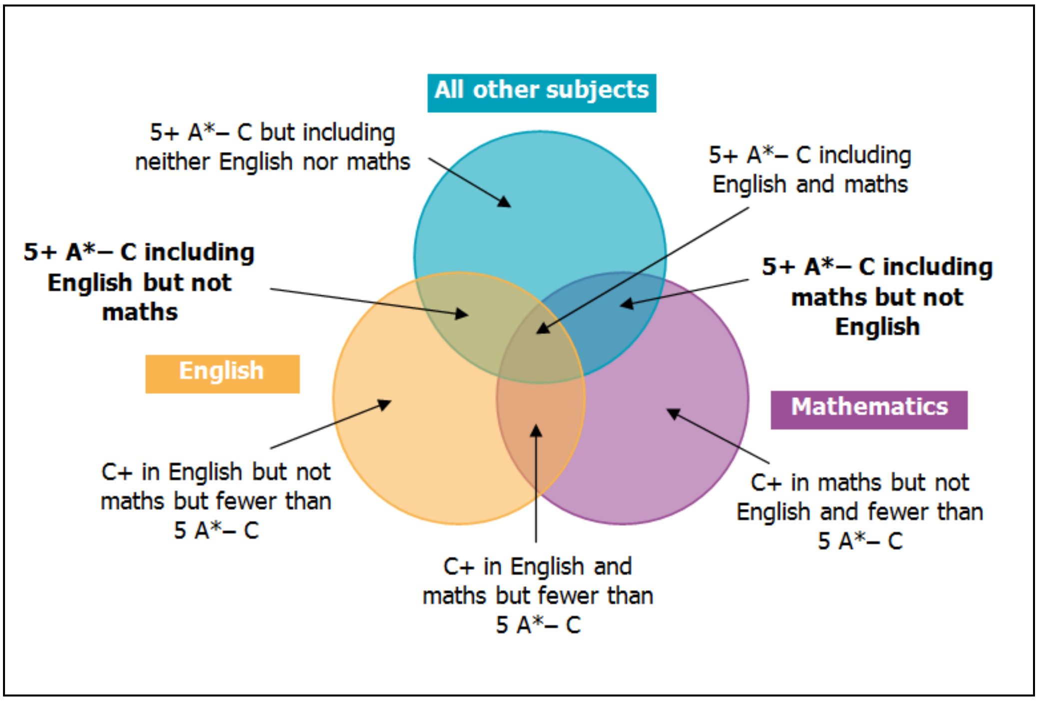
[9] In general, when judging the leadership and management of mathematics, inspectors consider the combined impact of senior staff and subject leader.

the equivalent of at least five GCSEs at grade C or better, including English and mathematics. The previous measure did not require English and mathematics to be included, and some schools that appeared quite successful on the old measure suddenly found themselves looking much weaker. Moreover, the main measure of progress was amended in 2009 to give increased emphasis to English and mathematics. This boosted the attention paid to mathematics by senior leaders.

123. Given that GCSE pass rates nationally at grades A* to C in mathematics have consistently been lower than those in English, the priority in many schools was to improve results in mathematics. Senior leaders have therefore devoted more resources to the subject and have commonly taken a more direct role in monitoring pupils' performance and looking closely at the work of mathematics departments.

124. Many of the secondary schools, especially the low attaining ones, have concentrated on those pupils likely to gain five or more GCSE A* to C grades but who are not secure in English or mathematics, represented by the sections labelled in bold font in the Venn diagram below. Similar diagrams and lists were often used to record the names of each pupil in a Year 11 cohort, and sometimes Year 10. The strategies then adopted by the schools generally depended on which part of the diagram the pupils' names were located. Not all groups were treated equally, as discussed further in Part B of this report. Those placed outside the three circles were the pupils who were expected to gain low grades in mathematics and English and fewer than five A* to C grades in other subjects. Overall, these low-attaining pupils were least often the focus of support in the schools visited.

Figure 6: A representation of schools' analysis of pupils' likely performance at GCSE



Monitoring: to check or to improve?

125. In all the schools visited, monitoring and evaluation had included lesson observations undertaken as part of the teachers' performance management. Sometimes in the primary schools, the later observations had been of lessons other than in mathematics. Senior and subject leaders' evaluation of teaching in lessons jointly observed with inspectors during the visits was generally accurate. However, leaders' judgements did not always match the evidence in schools' own observation records. These tended to paint a more positive picture of teaching principally because they had paid more attention to what the teacher did in the lesson than to how well the pupils learnt and progressed in mathematics as a consequence. The shift in leaders' attention towards the mathematical elements that promote or hinder good progression is a crucial next step for schools in raising satisfactory teaching to good and eradicating the inconsistencies in teaching within a school.

126. Nevertheless, in comparison with the previous survey, schools have got better at monitoring teaching and learning, often responding promptly to any teaching that had fallen below an acceptable standard by working closely with the teachers concerned. For more effective schools, this included satisfactory teaching. However, it was much less common to find a systematic programme to improve the quality of teaching across a department or primary school, or to ensure consistency of approach in the way that particular topics were taught. Indeed, it was not unusual to find that raising attainment and school development plans did not include specific actions to improve the quality of teaching.

127. Increasingly, subject leaders and senior staff also monitored provision through 'learning walks' (where several classes were each visited for a short time). These have the potential to provide leaders with a quick overview of teaching and learning and can be used for specific checks such as: adaptation of work to different sets/groups of pupils; consistency of approach among teachers; use of talk; and compliance with school and departmental policies, for instance on methods of calculation. However, schools' records showed that learning walks were frequently concerned with checking generic features or policy requirements such as displaying lesson objectives, having seating plans, and making 'next step' comments in marking. They rarely focused clearly on the quality and mathematical detail of learning and progress over time; for instance, how well the activities were leading to the intended learning for all pupils, and whether the approach/resources promoted understanding and made links with prior learning.

128. A further positive development has been a broadening of leaders' monitoring activities to include features such as scrutiny of pupils' work; questionnaires or interviews with staff and pupils; and checks on planning, use of homework, assessment records and the quality of marking. These activities were sometimes distributed through the school year or they were concentrated in an intensive period of review of the subject. While in most of the schools the

systems and structures were suitable, the lack of attention to mathematical detail impeded faster improvement. Sometimes a weakness was identified but then not followed up in the areas for development or linked to professional development. For senior leaders whose specialism is not mathematics, gaining an understanding of what the best mathematics education involves presents a significant challenge.

129. The best leaders inspired and supported teachers in teaching pupils to solve problems and think for themselves in mathematics. For others, to place a greater and concerted emphasis on this and other areas for professional development during observation of lessons, through scrutiny of planning and pupils' work, in mathematics meetings, and in developing guidance collaboratively with staff is necessary for a positive impact on teaching, learning and outcomes.

130. Arrangements for the leadership of mathematics in primary schools varied but have increasingly become of a collaborative nature. Sometimes, a senior leader had responsibility for the subject and, at other times, the subject leader worked alongside a senior leader, but rarely did a subject leader work entirely on her/his own. Analysis of data, lesson observations, and meetings to discuss pupils' progress were more often carried out by senior leaders, while monitoring activities such as the scrutiny of pupils' books were the responsibility of the subject leader.

131. In the secondary schools, line-management meetings, through which senior leaders provide support and hold the heads of department to account, were more frequent and rigorous than during the previous survey. They often included close and regular scrutiny of data that tracked pupils' attainment and progress. Heads of department were increasingly expected to produce subject-specific analyses, self-evaluations and action plans.

132. However, in the primary and secondary schools, senior and subject leaders too often concentrated on reacting to what monitoring information and data analyses showed, by increasing intervention or revision for instance, rather than unearthing, and then tackling, the causes of the inconsistencies and relative weaknesses in provision. This lack of mathematically informed strategic insight remains the main impediment to securing significant improvement in the longer term for many schools. For example, if the data showed that the pupils had difficulty with division or ratio, then additional support on those topics would be provided. However, the missing essential step was to review how the topics were taught in the first place and how that teaching and/or the curriculum might be improved so that pupils in the future do not struggle with them.

Developing the mathematical expertise of staff

133. Improving the consistency of teaching within a school by raising the quality of the weaker teaching is crucially important if all pupils, rather than some or most of them, are to have the opportunity of sustained good learning and progress.

One key starting point, rarely seen during the survey, is to develop guidance on agreed approaches to teaching topics or sequences of related topics. Guidance should bear in mind pupils' prior knowledge and progression to future learning, and the breadth and depth of coverage expected for each class. For instance, discussing and agreeing an appropriate algebraic method for solving simultaneous linear equations, including the cases of no and infinitely many pairs of solutions, and the graphical interpretation and representation of the equations. A department might also decide that more-able pupils should be able to solve the equations by elimination and by substitution in readiness for solving pairs of linear and non-linear equations.

134. The good practice survey found that the maintained schools had:

> '…clear, coherent calculation policies and guidance, which were tailored to the particular school's context. They ensure consistent approaches and use of visual images and models that secure progression in pupils' skills and knowledge lesson by lesson and year by year.
>
> … A crucial element is the involvement of all staff in professional development on aspects of the policy, for instance in developing progression in subtraction from the early years to Year 6. This means all the teachers and teaching assistants see how the methods in any year build on what went before and feed into what is learned later. Moreover, the policies reflect particular adaptations such as a reduction in emphasis on or removal of some interim methods, for instance 'chunking' as a method for long division. It was clear from discussions with staff and scrutiny of pupils' work that the policies are implemented consistently. In essence, the policies capture effective whole-school approaches to developing securely pupils' calculation skills, mental and written. Moreover, the schools evaluated and reviewed their policies on a regular basis.'

135. A second approach to improving consistency is to share good practice, for instance through peer observation, discussion and coaching. This approach is being fostered in primary schools involved in the Mathematics Specialist Teacher programme, but the majority of schools are not yet benefiting from this long-term investment in subject expertise.[10] The approach is also encouraged by the National Centre for Excellence in the Teaching of Mathematics.[11] Fundamental to all of this, though, is accurate information about the precise nature of the weaknesses and inconsistencies. Not all schools visited had sufficient insight into the mathematical detail of areas for development, often because monitoring focused on generic aspects of teaching and learning.

[10] Information about the Mathematics Specialist Teacher Programme is available the National Centre for Excellence in the Teaching of Mathematics (NCETM) and includes links to the individual university providers at www.ncetm.org.uk/news/33949.
[11] The National Centre for Excellence in the Teaching of Mathematics at www.ncetm.org.uk.

136. The quality of secondary subject leaders' teaching showed that many have the potential to serve as role models for other teachers of mathematics in their schools. Teaching was good or outstanding in around three quarters of subject leaders' lessons, compared with a half overall. They were more likely to take higher-attaining sets and teach in Key Stage 4 and the sixth form than their colleagues. In part, this related to the varying levels of subject expertise of the staff who taught mathematics within the school. However, it was also the case that the lowest attaining pupils needed to make the most progress and therefore required the best teaching, but too often did not receive it. This is why in-school inconsistency in the quality of teaching is such a concern. Much more needs to be done to enable all staff to teach well, regardless of the ability of their pupils.

137. In the primary schools surveyed, subject leaders did not teach noticeably better than other teachers. This relates to changes in the ways that many primary schools allocate subject leader roles: it is no longer the case that the subject leader is necessarily the most experienced and skilled teacher of mathematics within the school. Some subject leaders do not have sufficient depth of subject knowledge, or lack confidence in and/or experience of mathematics across the whole primary age range. As recommended in the previous survey report, the improvement of subject leaders' expertise in developing the quality of teaching and the curriculum across the school remains a key priority if pupils' achievement is to be raised significantly.

138. Some schools were enabling enthusiastic staff to develop their mathematics expertise through additional qualifications and courses.

Prime practice: support of a non-specialist teacher on the Mathematics Development Programme

Subject expertise in this 11–16 specialist mathematics and computing college was strong and well deployed. Twelve staff taught mathematics: eight had degrees in mathematics, science, technology or engineering subjects and three had higher education qualifications specialising in mathematics. The remaining teacher, who was regarded as an effective practitioner in her specialism of physical education, was developing her mathematics expertise through the Mathematics Development Programme at a local university.[12] Mathematics had been her second subject on her BEd course.

The teacher's confidence and expertise were being developed carefully. Initially, she taught a low set in Year 7, planning lessons jointly with the head of department. She also received support from a local authority consultant. Lesson observations by the consultant and head of department

[12] At the time of the visit, the Mathematics Development Programme was in its first year of national roll-out. The programme ceased in July 2011.

showed that things were going well so her mathematics teaching commitment was increased to two sets, still low-attaining as she was not yet confident in her own mathematics ability. The teacher explained 'I have lots of discussions with colleagues over approaches to teaching topics. My teaching is improving all the time.' This was borne out by the school's records. At the time of the visit, she was also sharing the teaching of a middle-ability Year 9 set, planning jointly with the other teacher.

The teacher explained that she was enjoying the course very much and that she was much more confident in her understanding of mathematics. In-school support extended beyond the head of department to include fortnightly meetings with the initial teacher education mentor with whom she had carried out peer observations on the topic of angles. Another teacher helped her with the use of interactive whiteboards.

139. Other examples of schools developing staff's expertise included two teachers from an alternative provision setting who were benefiting from a five-day mathematics development course at a local university. They brought ideas from their course into their teaching, which increased variety within the lessons and captured pupils' interest. A primary school invested in its staff by supporting three teaching assistants in gaining GCSE mathematics and a nursery teacher in studying for an Early Years degree.

140. Where a secondary mathematics department is not fully staffed with effective mathematics specialists, deployment presents problems, as illustrated in this case study.

Weaker factor: the challenge of staff deployment

Five of the nine teachers were mathematics specialists. Two teachers were scientists who taught a little mathematics, one was a geographer who taught mostly mathematics, and one an ICT specialist who was particularly keen to improve.

The focus on raising the proportion of GCSE A* to C grades, coupled with an identified need to raise achievement of the most able, led to the specialists teaching mostly middle and high sets in Years 9 to 11. Non-specialist and weaker teachers were generally assigned to lower sets.

This accounts for some differences in progress. The school had been successful in improving the progress of the high-attaining pupils but the progress of lower attainers and those who had special educational needs had not similarly accelerated. This is because many were taught by non-specialist or weaker teachers who secure satisfactory rather than good progress.

How might it be improved?

Having too few effective specialists is a challenge faced by many secondary schools. Part of the solution lies in raising the quality of the weaker teaching through guidance and working alongside staff in developing their expertise. Subject leaders may require additional time for this. There is no easy answer, but placing the strongest teachers with the older and more-able pupils has the danger of perpetuating the slower progress of younger and lower-attaining pupils.

141. Headteachers in schools facing the same challenge described the strategies they had adopted successfully which included: recruiting and nurturing newly qualified staff; developing enthusiastic teaching assistants or learning mentors into mathematics teachers through a school-based training route; and use of subject enhancement and development programmes. Some spoke of their worries over recruitment if challenging robustly the performance of weak practitioners, including subject leaders, led to vacancies, while others were very clear that they knew they had to 'get the right staff' even if it meant a period of temporary teaching.

142. In the most effective schools, skilled experienced staff developed the less experienced and supported the non-specialist, thereby building the department's future capacity. However, where departments were stretched and not fully staffed by specialists, and under pressure to raise GCSE results, building for the longer-term took second place. The recommendation in the previous report that mathematics departments have time to plan and work together had been adopted in only a few of the schools visited.

143. The quality of leadership and management of mathematics was a key factor in sustaining high achievement, as illustrated in the example below.

Prime practice: sustaining high performance

Close attention to mathematical detail was the hallmark of leadership of the subject at departmental and senior levels. Insightful monitoring and evaluation led to well-designed action plans. The thoughtfully designed curriculum ensured good progression throughout the school, enabling the majority of pupils to take GCSE at the higher tier. The most able pupils studied a Free-standing Mathematics Qualification (FSMQ) in additional mathematics alongside GCSE. As a result, they were well prepared for further study and subsequently made good progress at A level.

The mathematics department had a good mix of experienced, effective teachers and less experienced teachers of high potential who were being nurtured and developed by their colleagues. Thus the departmental ethos and expertise is sustained over time. Teachers used a mixture of exploration, demonstration, problem-solving and consolidation exercises. They taught with the aim of developing pupils' understanding and expected pupils to explain their thinking. As is the case with many schools, however, much of the well-established good practice in teaching is not documented.

144. To bring about long-term improvement in mathematics, schools judged satisfactory typically needed to improve the day-to-day provision. This can be a slow process and schools feel the pressure to raise attainment rapidly. However, concentrating the best teachers and the main intervention programmes in the priority year groups perpetuated underachievement further down the school. Where nothing was done to improve provision for younger pupils, the same 'emergency' tactics were required year after year because the school was continuously building underachievement. The need to get teaching and learning right first time is crucial.

Part B: Unequal learning journeys through the mathematics curriculum

145. A key message of this report is that pupils of different ages, needs and abilities receive significantly unequal curricular opportunities, as well as teaching of widely varying quality, even within the same year group and school. Differences and inequalities extend beyond the teaching: they are rooted in the curriculum and the ways in which schools promote or hamper progression in the learning of mathematics.

146. Children start school having had widely different mathematical experiences at home with family and carers, as well as in any pre-school or childcare provision. Some three- and four-year-olds can already count and recognise the digits for the first few numbers. Many are familiar with nursery rhymes and songs that involve counting up and/or down. Most have met numbers in everyday life, for instance, the number of the house or flat in which they live, ages of other members of their family, telephone numbers, and money; but discussion with family members and other adults about such numbers may have been limited. In conversation, children may have made simple comparisons using words such as more, less, taller, older. They might have enjoyed making patterns using colour and shapes. Other children, by contrast, will have had very limited mathematical experiences. The gap between what different children know and can do mathematically is present before they start learning at school.

147. Years later, when pupils leave compulsory education aged 16 years, the gap between the mathematical outcomes of the highest and lowest attainers is vast. Too often, pupils' relative start and end points align, but not always: some outstanding schools break the cycle of low attainment. The challenge, nationally, is to raise the achievement of the lower and middle attainers without suppressing that of the most able, too many of whom are also underachieving. The aim is to improve progression for all pupils, so that all are mathematically equipped for their futures. This is not simply about improving the quality of teaching, although that is a key element.

148. This section of the report explores some aspects of schools' work that contribute to this unevenness of pupils' experience. It draws upon examples of good practice that help avoid or overcome inequalities and some factors that exacerbate them.

Variables in learning mathematics: age and ability

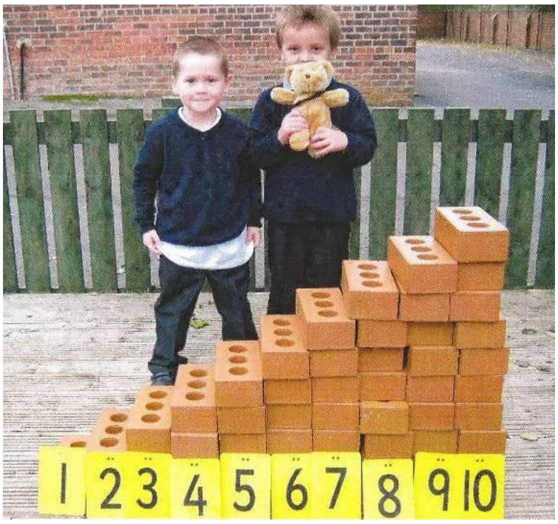
The early days

149. In Nursery and Reception classes, children typically learn through a mix of free-choice play and focused activities with adults. The best provision observed in the survey was mathematically rich and tailored to the needs of different groups of children. Adults used mathematical language and questioning effectively to develop children's vocabulary and thinking.

Prime practice: a mathematically rich Reception classroom

The teacher seized every opportunity for children to use mathematics in everyday activities. Working out daily attendance and absences of boys and girls became a shared activity, which significantly improved children's addition and subtraction skills. Similarly, every opportunity was taken to develop children's understanding and use of mathematical language.

Mathematical games proved highly engaging as children cast dice, played matching card games, rolled marbles into numbered compartments and used the computer to investigate patterns and number sequences. The stimulating outdoor environment buzzed with activity as children organised races on foot and using wheeled vehicles, for which they receive rosettes to develop a clear understanding of ordinal numbers (1^{st}, 2^{nd}, 3^{rd}…). Other children constructed stepped walls using building blocks, and learnt to count forward and back as they moved soft toys from one step to another.



On special occasions, children are given £1 to spend at the local shop. With help from adults, they produce simple shopping lists to decide what they want to buy and what they can afford. This engagement in mathematics develops children's confidence, understanding and enjoyment of using mathematics in everyday life.

A good understanding of place value is considered to be of paramount importance by the school. This was supported by a wide range of practical equipment including base-10 apparatus, 100 squares, bead strings, place-value cards and number lines. Because pupils also required good instant recall of number facts, such as number bonds to 10, and, later, multiplication tables, every opportunity was taken to develop them.

150. Conversely, the weakest provision failed to exploit opportunities for children to play with numbers, measures, shapes and patterns to develop their numerical and spatial awareness. The environment lacked exciting activities and displays that would draw children into mathematical play. Talk between children and adults lacked mathematical depth, focusing instead on superficial features and praise for participation. While the most able children's progress was slowed by this, the biggest impact was on the middle and lower attainers, especially those whose home mathematical experiences were limited.

151. Most Nursery and Reception lessons ensured that all children took part in the focused adult-led activities, but less attention was paid to ensuring that children's prior knowledge was taken into account. This meant that the most able were not extending their learning while those with the weakest mathematical skills were building on shaky ground. For these children, securing their communication skills and personal, social and emotional development was often prioritised by the school as a first step towards learning. They were generally less mature: for instance, they could not maintain concentration and were reluctant to play or learn alongside other children.

152. By the end of the Reception year, national data show that pupils' mathematical skills vary widely. The most able five-year-olds can count, write, order, and calculate fluently with numbers to 20, and they can compare and describe objects and quantities. However, a small minority of children struggle to count and work confidently with single-digit numbers. Not all are therefore equally ready mathematically for Key Stage 1.

Jumping from Reception to Key Stage 1

153. Learning in Year 1 is generally quite different to learning in the Reception class. The usual primary pattern of whole-class teaching for up to an hour at a time is a sharp contrast to the typical mix of play and focused activities in Reception classes. However, an important improvement by an increasing number of schools over the last three years has been the introduction of some whole-class teaching towards the end of Reception and the retention of some 'free-flow' provision at the beginning of Year 1. This has helped to promote better transition by providing greater continuity of learning styles and environment, although not frequently securing good progress.

154. Less of the teaching in Year 1 was good or outstanding than in the other primary years. The use of assessment information from the EYFS profile was inconsistent and did not aid planning as well as it might so that pupils' early learning of mathematics was not securely built upon. In the following example, a school used this information to help group pupils in Reception and Year 1.

Prime practice: good use of assessment in the infant years

Reception children were organised into ability groups, based on observational assessments of their attainment, and they engaged in short, focused, adult-led activities each day. They also had good opportunities to develop their reasoning and problem-solving skills through child-initiated activities, indoors and outside. As a result, less than 10% of children each year fail to reach at least six points in all areas of mathematics by the end of Reception (in comparison with 74% nationally in 2011). For those not reaching this standard on transfer into Year 1, individual plans ensured that Year 1 teachers focused on aspects of the EYFS curriculum required to bring their attainment up to the expected level.

155. While the Early Learning Goals and National Curriculum Level 1 do not match exactly, the knowledge and skills of the most able children at the end of Reception resonate with aspects of National Curriculum Level 1. These children were too rarely challenged by the teaching in Year 1. A further factor that impedes pupils' progress is that many schools do not realise that their target-setting systems represent insufficient progress in Key Stage 1 and, in turn, lead to low expectations, particularly of the more able. Consequently, even where targets are met, pupils have not done as well as they should.

Primary days: squares, triangles and hexagons – which group are you in?

156. In Key Stages 1 and 2, mathematics lessons followed a similar pattern: they typically began with a starter activity. The teacher then introduced the main part of the lesson, followed by independent work when pupils of similar attainment were usually seated together. Pupils were always aware of the hierarchical nature of these groups and could explain to inspectors which group found mathematics easy or hard and whether the groups got the same or different work to do. The class was usually gathered together again for the closing plenary.

157. The starter activity was often pitched towards the middle-attaining pupils, as was the introduction to the main learning. Too often, the more-able pupils waited patiently while the teacher spent time explaining to other pupils when they were ready to start independent work. Moreover, they were often required to complete work set for the middle attainers before moving on to extension work, which sometimes involved more difficult numbers rather than more complex ideas or contexts for problem solving. Such practice can dull pupils' enthusiasm for mathematics. Only in the best lessons were the higher attainers suitably challenged throughout; for example, when pupils were set more challenging work from the outset.

158. Teachers found difficulty in planning plenary sessions that reviewed the diverse learning of all groups. Often, pupils spent time listening to other groups reporting back on their work, which was sometimes too hard for some pupils to understand and too easy for others. At other times, the pupils' explanations

were unclear, and when the teacher did not amplify key points, the plenary was not a helpful learning experience for anyone.

159. Sometimes, teachers' planning for more-able pupils drew on material for the year above, but information about this was not routinely recorded and passed on to the next class teacher and, consequently, accelerated progress was not built upon systematically. Such strategies tended to grind to a halt in Year 6, although a few schools liaised with partner secondary schools to provide additional sessions for these able pupils. Sometimes, teachers provided challenging problems or investigations for the more-able pupils, which they enjoyed and found interesting. However, such activities were rarely part of the mathematical diet of all pupils as they should be.

160. An example of good practice was provision of a different starter activity for the higher attainers, led in this case by a teaching assistant. Another approach was to ask differentiated questions. In a mixed-age Key Stage 1 class, pupils counted in their heads in 1s, 2s, 10s, or 5s, according to their group, as the teacher pointed to positions on a counting stick, and wrote their answers to her questions on mini-whiteboards. In a Year 3 class, the main activity was to create as many calculations as possible with the answer 20. This excited the pupils and enabled responses at different levels, for instance able pupils realised that subtracting any pairs of numbers that differed by 20 would work, and one pair wrote 100,000 – 99,980. Low-attaining pupils, supported by the teacher, learnt to use inverse operations to write division calculations; for example knowing 3 x 20 = 60 led to 60 ÷ 3 = 20.

161. In some classes, pupils who were lower attaining or had special educational needs and/or disabilities were supported well by teaching assistants in each phase of the lesson, for instance by providing additional verbal prompts or practical equipment in starter activities or introductory explanations. In other classes these pupils struggled to participate in whole-class elements and subsequently did not get far through the set work unless heavily supported by the teaching assistant, so their learning remained fragile. Sometimes they were set independent work that did not relate to the teacher's explanation to the whole class.

162. An increasing minority of schools were starting to place Key Stage 2 pupils in sets for mathematics, particularly in Years 5 and 6. Sometimes an extra teacher or teaching assistant was employed to teach an additional Year 6 class thereby making all the Year 6 classes smaller. The rationale behind such setting was to allow teachers to concentrate on a narrower range of attainment, especially in the run up to national tests. Rarely, however, were such strategies evaluated in terms of the gains in progress for different groups of pupils.

Secondary days: ready, get set, go – but how far?

163. A body of research has been conducted on the use of setting by attainment in secondary mathematics. Some research points to the benefits being restricted to the more-able pupils, with adverse effects on other pupils' motivation and self-confidence, including some able girls. Few schools had explored pupils' views on learning mathematics including their thoughts on how they are grouped or placed in sets and the demand of the mathematics they learn.

164. Almost all the secondary schools visited placed pupils in sets for mathematics in Years 8 to 11. A few had mixed-ability classes in Year 7, but the majority set early in Year 7, sometimes after testing all the pupils as well as, or instead of, using information from primary schools coupled with national test and teacher assessment data. Heads of department frequently bemoaned the slow transfer of assessment information from primary schools. They also commented about the number of pupils who, when tested by the secondary school at the start of Year 7, did not reach the levels they had been awarded in the Key Stage 2 test and teacher assessments. (Parallel concerns have also been expressed publically by those institutions admitting A-level and undergraduate pupils.) The focus on 'three levels of progress' had increased the schools' attention to pupils' prior attainment, and they realised that any pupil who had reached Level 4 in Year 6 would need to gain GCSE grade C to have made the expected three levels of progress. While a difference in performance might relate, at least in part, to the summer-holiday break from mathematics, it also raises questions about how secure aspects of the pupil's learning were in primary school.

165. To a large extent, the set a pupil is placed in determines the mathematics he/she will encounter and potentially caps what he/she might attain. In Key Stage 4, the set is often linked to a particular GCSE tier so, for instance, a middle-attaining group might be prepared for the foundation tier, grades G to C. The schools visited had systems to enable pupils to move up, or down, a set. However, moving up a set becomes increasingly difficult as pupils progress through the school due to higher sets' more extensive mathematical knowledge and skills. A recent trend has been the wholesale regrouping of Year 11 cohorts after the results of early GCSE entry to allow different sets to focus on particular grades or tiers.

166. Other important issues were associated with setting. All secondary schools would ideally staff all of their mathematics classes with skilful specialist teachers. Many of the schools visited struggled to do so, and therefore had to make choices. They often prioritised the staffing of key examination classes and higher-attaining sets, placing non-specialist and temporary teachers with lower sets and younger classes. Timetable constraints sometimes resulted in two teachers sharing a class, again usually of younger or less-able pupils. The extent of this varied. In one secondary school, for instance, pairs of teachers shared the teaching of all the Year 7 sets and most of the Year 8 sets. In general, this does not aid coherent progression or good-quality learning.

167. Schools rarely articulated their rationale for the deployment of teachers beyond an emphasis on maximising the performance of those pupils closest to external examinations and recognition that non-specialist teachers were unlikely to have the subject knowledge to teach higher-attaining sets. Senior and subject leaders appeared to realise, perhaps too acceptingly, that ground would need to be made up in the future if the pace of learning of younger and lower-attaining pupils was affected by weaker teaching. This is one reason why it is so important that good-quality guidance and schemes of work are available to support teachers. When talking with Key Stage 4 pupils, it was noticeable that higher-attaining pupils generally had been taught by fewer teachers in their time at the school than lower attainers at the same school. In short, a pupil's prior attainment affects the quality of teaching received, and hence the quality of his/her learning, progress and subsequent attainment.

Qualifications: who chooses what and when?

168. Examples of good reflective policy and practice have begun to emerge, as some schools realised that not all of their pupils were equally well suited to the focus on attaining GCSE grade C and, in particular, that some more-able pupils were underachieving. Indeed, this resonates with the messages in the Department for Education's recent publication, *Early entry to GCSE examinations*.[13] For the most able, some schools introduced demanding qualifications such as additional mathematics or a FSMQ which were taught alongside GCSE mathematics. The pupils took all the examinations together at the end of Year 11, with their performance at GCSE having benefited from the additional stretch they had received through the other courses.

169. A highly successful school was visited in 2011 to look at how it engaged its able mathematics pupils.[14] Problem solving and practical activities underpin the pupils' understanding.

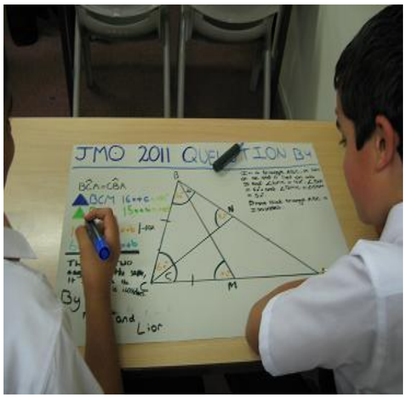
> **Prime practice: inspiring future mathematicians**
>
> In solving problems, teachers aimed to foster the attitude that pupils, even the most able, should expect to struggle and, indeed, to welcome the challenge. As the head of department explained, 'Students wouldn't give up on a computer game just because they failed to solve it first time. This persistence is needed with mathematics problems as well.'

[13] *Early entry to GCSE examinations*, Department for Education, 2011; www.education.gov.uk/publications/RSG/AllRsgPublications/Page7/DFE-RR208.

[14] *Engaging able mathematics students,* Ofsted, 2011; www.ofsted.gov.uk/resources/120114.

Pupils often solved problems in pairs or small groups and, after a solution had been discussed, they sometimes made informal posters to display their solutions.

The head of department added: 'Employers love this approach because pupils learn to solve problems, becoming more proficient at working in small teams and at communicating their ideas. Collaboration and communication are vital to solving problems in mathematics.'



Making posters to display solutions

170. Crucially, the best schools made decisions about qualifications, course options and entry policies with the best interests of individual pupils at heart. Early completion of a mathematics qualification was appropriate for some pupils, for example those in danger of disaffection or absence. Some schools had introduced AS courses for able Year 11 pupils who had completed GCSE early, but subsequent post-16 pathways were not always well thought through; for instance, whether the pupil, if successful at AS, would be able to continue with the second year of A-level mathematics in the first year of the sixth form, particularly if attending a different institution.

171. Moreover, not all of the schools appeared to recognise that a grade B performance at GCSE did not constitute the best grounding for AS/A-level mathematics, even where it represented 'expected progress' or an 'aspirational target' for the pupil. Demanding algebra topics were too often a casualty of the limited time for completing GCSE by the end of Year 10, yet essential for successful advanced-level study. As one sixth-form pupil commented, 'Hard GCSE stuff was done at the end. There wasn't much time for it.' This is echoed in principal examiners' reports from awarding bodies. For example, one on a recent unit examination stated how poorly the question 'Solve the equation $5x^2 + 14x – 24 = 0$' was answered. Typically, pupils learn to solve and practise easier quadratic equations, such as $x^2 + 4x + 5 = 0$ but have limited experience of equations with non-unitary coefficients of x^2. Moreover the technique frequently taught for the easier type of equation is not directly transferable to the harder kind.

172. The policies and practices described above are not in the best interests of the pupils' future education and employment, even if they have a motivating effect in the short term. Taking a further year over GCSE and gaining an A* grade is much more likely to provide a strong platform for further study of mathematics in the sixth form and related subjects.

173. In England, unlike the majority of high-performing countries, mathematics is not a compulsory subject for those pupils undertaking post-16 study. Thus, two years of further education leads to a different type of gap at 18 – one related to

whether mathematics has formed part of the pupil's study. This country needs more pupils to study more mathematics post-16 and at a higher level. The report of the Advisory Committee for Mathematics Education, *Mathematical Needs*, estimated that, of those pupils entering higher education each year in the United Kingdom, 333,000 would benefit from studied mathematics (including statistics) recently to a level beyond GCSE, but that only 125,000 had done so.

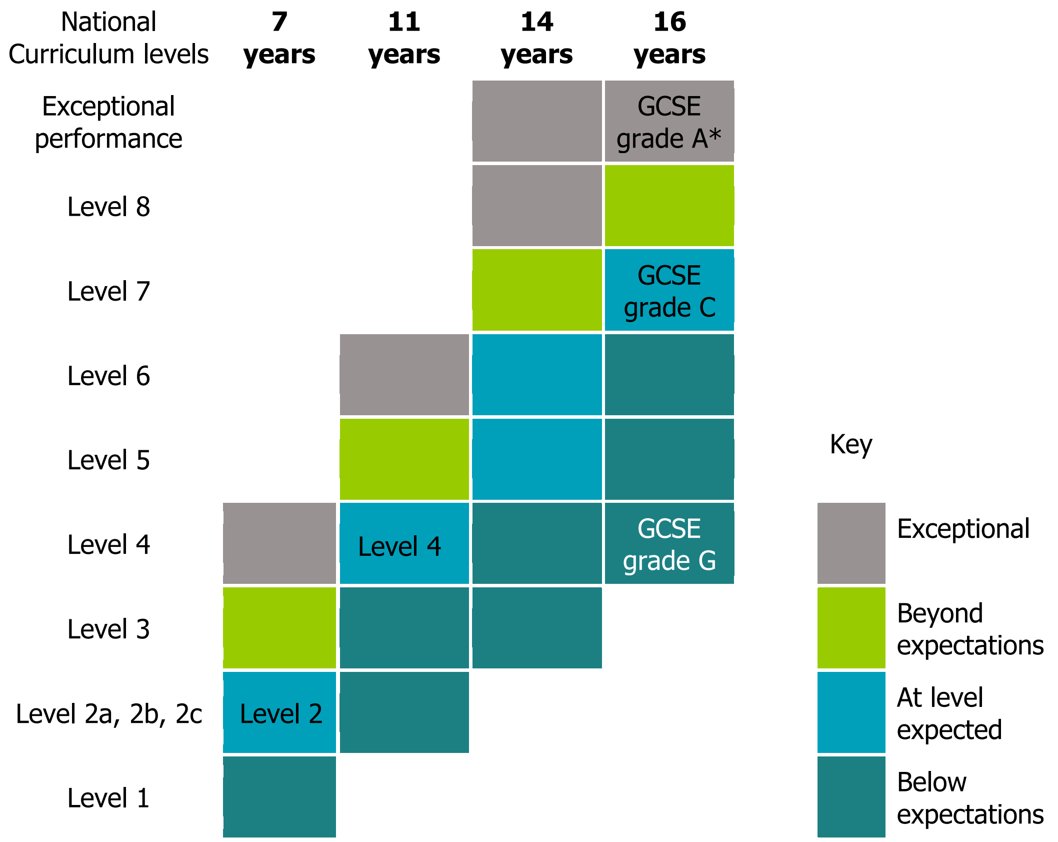
Links between attainment and the curriculum: made for measuring?

174. Mathematics in English schools is defined in statute by the EYFS framework and the National Curriculum. These comprise a set of curricular documents which have overlapping mathematical content and skills, intended to allow all pupils access and entitlement to the mathematics curriculum according to their age and developmental stage. The documents do not attempt to define a single coherent mathematical journey from 3 to 19 years. The three documents listed below, which are currently in operation, were developed and implemented at different times.

- Problem solving, reasoning and numeracy in the 2008 EYFS (EYFS profile points 1–9).
- The 1999 National Curriculum for Key Stages 1 and 2 (programmes of study broadly Levels 1–3 and 3–5, respectively).
- The 2007 National Curriculum in Key Stage 3 (programme of study broadly Levels 4–7) and Key Stage 4 (reflected in GCSE specifications for grades G–A*).

175. One factor that contributes significantly to how the mathematics curriculum is implemented in English schools is the very strong emphasis on external assessments and related performance measures. The table below compares pupils' performance at the end of each key stage and national expectations for pupils of that age.

Figure 9: pupils' performance compared with national expectations at the end of each key stage.[15]



176. The majority of pupils stay within a colour band as they move through the key stages. Although the illustration suggests that progress through the National Curriculum levels is smooth, in practice pupils' learning is uneven. In particular, the repetition of mathematical content and skills in adjacent programmes of study, reflected in schools' schemes of work, textbook series, and examination specifications, means that low attaining 16-year-olds will often have met, and struggled with, Level 4 topics in each of Key Stages 2, 3 and 4.

177. The way the programmes of study are defined allows, in theory, teachers to plan to meet each pupil's individual needs – 'made-to-measure mathematics'. However, the heavy focus on maximising the numbers of pupils who meet the expected standard at the end of each key stage has skewed the experiences of many pupils likely to meet or close to meeting the expected standard. The minority of pupils who do not meet the expected standard grows by key stage: in 2011, 10% of seven-year-olds did not reach Level 2, 20% of 11-year-olds did not reach Level 4, and 36% of 16-year-olds did not gain at least grade C at

[15] Illustration adapted from table published formerly by the Department for Children, Schools and Families.

GCSE, although only 5% of the whole cohort did not gain a GCSE qualification at grade G or better.

178. It is not uncommon for measures of achievement to have unintended consequences. At the time of the previous report, *Mathematics: understanding the score,* schools' emphases were on the key threshold measures for attainment, Level 2, Level 4, and GCSE grade C, too often to the detriment of pupils well above or below these levels/grade.[16] These emphases have been supplemented with attention to all pupils making at least the expected number of levels of progress. In practice in secondary schools, this often places the greatest focus on pupils who entered the school at Level 4 and need to reach grade C GCSE. Historical data show that progression rates vary widely, with higher-attaining much more likely to make the expected progress than average or lower-attaining ones. For instance, of the pupils who started secondary school at Level 3 in 2006, 39% reached grade D or better in 2011; from Level 4, 69% reached grade C or better; and from Level 5, 79% reached grade B or better. These disparities in progress rates are unacceptably large. In 2011, increases in progression rates from the starting points of Levels 3 and 4 reflected schools' emphases on grade C. Progression from Level 5 did not improve.

179. Despite secondary schools' focus on progress, it is nevertheless of grave concern that so many able pupils underachieve at GCSE. Too many schools were content with a grade B for their able pupils, speaking of them as 'meeting their target' and 'making expected progress'. Of those pupils who attained Level 5 at Key Stage 2 in 2006, more than 37,600 attained no better than grade C at GCSE in 2011: this represents a waste of potential and should be a cause of national concern. While some of the reasons behind this are explored in this report, one immediate implication is the impact on uptake by such able pupils to advanced-level studies of mathematics, because most pupils who elect to study and then succeed in mathematics at AS/A level had gained a grade A* or A at GCSE. A parent might legitimately ask 'How has my mathematically able child fallen back into mediocrity?' In recent years, only half of those pupils who reached Level 5 at Key Stage 2 went on to gain A/A* grades at GCSE. In order to raise the expectations of able pupils and to encourage greater uptake of advanced-level mathematics, a more ambitious measure for 'expected progress' for such pupils would be four levels of progress between Key Stages 2 and 4.

180. Pupils working below, but close to, national expectations were often at the centre of schools' efforts to raise attainment. They had often been in perpetual 'catch-up', subjected to a wide range of intervention and other strategies throughout their time at school. (See later section on intervention.) Conversely, those pupils working well below expectations, who are arguably in need of the most support and the most effective teaching, tended not to be the focus of

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[16] *Mathematics; understanding the score* (070063), Ofsted, 2008; www.ofsted.gov.uk/resources/070063.

such attention. This is also an area of grave concern, because these are the most likely pupils to leave school without a qualification in mathematics and therefore not well equipped for their future lives and work.

Planning and teaching for progression: for tomorrow as well as today

181. Good-quality lesson planning, teaching and intervention strategies helped to secure learning and progress within lessons, from lesson to lesson, and to close gaps. However, few of the schools surveyed successfully planned and taught for strong mathematical progression over time, reflected in depth of conceptual understanding and fluency in skills and problem solving for all pupils. This is a key area for development for any school wishing to improve pupils' achievement. Informal discussions and sharing of ideas between staff (teachers and teaching assistants) were useful but insufficient to promote consistency of approach and better progression.

182. The principal impediment to stronger progression was the lack of coherence in the way that topics are developed over time. In the primary schools, lesson planning was usually based on the Primary National Strategy framework, or textbooks developed in line with the framework. Because teachers often teach the same year group in successive years, they have become familiar with and confident in the topics for that class. They were less familiar with how the topics they teach fit in with the longer-term progression of that strand of mathematics, and therefore the key ideas that pupils need to understand so that later learning can be built securely. For example, the early foundations for multiplication are laid in the infant years, well before any formal methods are taught. Instant recall of tables and associated number facts, and good understanding of place value, become increasingly important as pupils move through primary school and are essential prerequisites to later success in multiplication.

183. The excellent calculation policy of one primary school, visited as part of the good practice survey, provided an overview of the development of addition, subtraction, multiplication, and division from Reception to Year 6. It also provided detailed information on progression year by year and how to use practical resources and models to develop understanding at each stage. The extracts below, taken from part of the guidance for Reception/Year 1, illustrate the clear, helpful advice provided for teachers.

Prime practice: helpful advice for teachers – an extract from a school's calculation policy

Children are encouraged to visualise and develop a mental picture of the number system and methods are explicitly taught. *Eg: put the big number in your head and count on; show me 2 fingers and 4 fingers and then count how many altogether etc.* Problem solving questions are posed and explored with class daily through adult role in continuous provision eg: (*home corner*) *Do we have enough plates for everyone? How many more do we need? (Sand) There are 5 pebbles in the wet sand and 3 in the dry. How many pebbles altogether?* Mental addition and subtraction is also explored through daily routines such as dinner register/fruit and milk and the numeracy hour. This is also how children begin to explore counting in sets of and groups. Quick ways of counting quantities are identified which is also experienced through cooking and mental maths starters.

Mathematical Challenges are available for Y1 in class daily but also given as open ended tasks in 'choosing' sessions.

Vocabulary

Is explicitly taught with lots of different terms used for the same meaning. Vocab cards are displayed and children are expected to use appropriate vocabulary when they discuss what they are doing.

Recording

Children record whole number sentences, rather than just filling in answers – this begins by modelling in YR and then using number cards to record, with practical recording by the first term in Y1. They are referred to as a number sentence and are read them back to the child to see if they 'make sense'. Children are taught that the equals sign means 'the same as' so it's like a weighing scale. Both sides have to be the same for it to be equal/balanced.

Resources and Models

Children:

- have access to practical resources that support addition and subtraction which they can decide when and how to use eg: counters, number tracks.
- are able to use models such as number tracks and number lines to support calculation
- are given calculations that demonstrate when the order of numbers matters
- know that, when counting on or back with a number line, the first move is the first count
- are given opportunities to make decisions about the 'best' way to add or subtract and to explain their strategies and why they chose them – eg: if we are adding in our heads, which number should we put there and which one on our finger?

184. Without such policies to guide primary staff and ensure consistency between teaching approaches, interim calculation methods grow a life of their own. Too many pupils were becoming bogged down in them and were not always progressing to more efficient methods. These weaknesses extended beyond the primary years. For instance, some low-attaining pupils in the secondary schools relied on repeated addition to multiply because they had never mastered multiplication tables or methods or understood place value.

185. In the secondary schools visited, planning at Key Stage 3 was drawn from various sources but mainly the Secondary National Strategy framework and textbook schemes. The three-part structure was still evident in lessons although the starter activities were less varied than at the time of the previous survey.

Following the cessation of national Key Stage 3 tests, many schools have started GCSE teaching in Year 9 after completing the scheme for Years 7 and 8. While avoiding some of the repetition that was frequently evident at the beginning of Year 10 GCSE courses, this does not reflect careful thought about a five-year learning journey or an emphasis in Years 7 and 8 on those key mathematical ideas and techniques that are essential for success at GCSE. This is a missed opportunity to secure better progression for all pupils. At the same time, enrichment activities in Year 9 have diminished in many schools, replaced too often by a relentless march towards early and repeated entry of GCSE examinations.

186. At Key Stage 4 and in the sixth form, schemes of work were rarely adapted to the particular circumstances of the school and its pupils. They were often simply the schemes provided by awarding bodies or in conjunction with textbooks. Other schemes of work were little more than a list of topics. Specific weaknesses included:

- lack of agreement among teachers in the same school or guidance in the schemes of work about the preferred ways of tackling particular topics, or the depth of treatment expected for different groups
- little clarity about how concepts were to be introduced and linked to ensure the development of understanding
- common schemes of work being provided for entire year groups, with no guidance to teachers about what was expected in each set
- few opportunities for pupils to develop their skills in using and applying mathematics or, where using and applying activities were included in the scheme, no guidance on how pupils should develop skills progressively over time
- limited use of ICT to enhance the development of conceptual understanding and pupils' enjoyment of learning.

187. Few schools provided guidance for teachers on preferred teaching approaches. Some published schemes included a teacher's guide. Teachers in many of the schools spoke of the informal discussions they had about approaches to teaching some topics, but such strategies were typically ad hoc. There was little evidence of schools developing systematic guidance for teachers on a range of topics. Sometimes, subject leaders believed that consistent approaches were being used and were surprised and disappointed to find during inspections that they were not. Scrutiny of pupils' work had become a common monitoring activity but it rarely considered consistency and appropriateness of approaches, or curriculum coverage and depth. Thus opportunities were missed to pick up weaknesses and inequalities early, and to provide support and challenge for teachers before fragile or patchy learning turned into underachievement.

188. When the schools had a stable and experienced staff, they frequently did not see the need to formalise guidance, though they had the capacity to do so.

Unfortunately, as some of the schools had found, the transition from a stable, experienced staff to one with limited experience and high turnover can be rapid. Schools with many inexperienced, non-specialist and/or temporary teachers, which would most benefit from guidance, lacked the capacity to prepare it. In these circumstances, support tended to be short term, with no scope to build for longer-term improvement. For instance, in one school less-experienced teachers received support from colleagues and a National Strategy mathematics consultant to improve their planning, but considerable variation remained between classes in the amount of work completed each lesson and in the depth of treatment of the same topic by different teachers.

189. The schools with outstanding mathematics curricula ensured systematic and progressive development of pupils' skills in using and applying mathematics. Some secondary schools were taking steps in the right direction by linking rich mathematical activities into each topic to support pupils' conceptual development and problem-solving skills, but did not always consider explicitly which process skills were being developed. Functional skills tasks, often seen as 'real-life mathematics', tended to focus on the topic used to solve the problem rather than the problem-solving approach itself.

190. The following table shows how one school's well-organised Key Stage 3 scheme of work was structured to include all the key elements. The resources, including ICT, and suggested starters helpfully pointed teachers towards particular approaches, coupled with useful ideas for extension and investigative activities. The scheme was not, however, supplemented by guidance about progression in different aspects of mathematics.

Figure 10: Headings used in a school's Key Stage 3 scheme of work

National Curriculum Level	Set	Learning objectives (title of unit; teaching hours)	Resources	ICT, historical and cultural links	Extension and investigation	Suggested starters

The scheme included a note about the fortnightly Cognitive Acceleration in Mathematics Education (CAME) lessons and a range of periodic assessment tasks. Although the development of pupils' skills in using and applying mathematics was not explicit within the scheme's learning objectives, the assessment tasks gave all pupils the chance, for instance, to:

- solve word problems in a range of contexts (Level 4)
- identify the necessary information to solve a problem (Level 5)
- break down a complex problem into simpler steps, choosing and using appropriate and efficient operations and methods (Level 5).

191. The primary schools visited were increasingly seeking to incorporate mathematics in meaningful ways within themed or topic work. However, the planning for this was generally ad hoc rather than systematic with new learning in mathematics rarely introduced through topic or theme work. In one effective

school, a poster on the staffroom wall showed the next term's topic in the centre. Teachers had added suggestions for mathematical elements, creating a spider diagram. The headteacher explained that, during the next staff training day, the teachers would develop the mathematical component for each year group and marry the topic planning with the day-to-day teaching of mathematics, thereby strengthening pupils' learning and avoiding unnecessary repetition.

192. Many of the schools were careful to ensure that intervention sessions did not happen at the same time each week for individual pupils, so that they did not always miss a music lesson, for instance. Schools that intervened promptly to tackle a misconception, difficulty or gap that was slowing a pupils' progress often made use of break and lunch times, form and assembly times. One primary school, for example, had recently introduced a system of early morning support by teaching assistants for pupils who had had a difficulty in the previous day's lesson, with the aim of overcoming the stumbling block before the next lesson. Another worked with small groups of pupils who were likely to find a new concept difficult in advance of the whole-class teaching to review the essential pre-requisite knowledge and skills. A feature of the stronger practice was speedy, focused intervention when pupils faltered, to ensure that misconceptions were overcome; however, a crucial element missing too often was the reflection on why the pupil had the difficulty in the first place and how teaching might be improved to secure understanding straight away.

193. The mathematical needs of secondary pupils who attended alternative provision were not always considered well enough. In one school, for example, the pupils who attended college were taught in various, but mainly lower, sets for most of their mathematics lessons. They were then grouped together for a weekly catch-up lesson to make up for the lesson they missed when attending college. The catch-up teacher liaised with the pupils' regular teachers. However, in the lesson observed, the needs of individual pupils were not met well, particularly those of a more-able pupil. In the following example from a different school, the majority of lessons were being missed by a pupil.

Weaker factor: missing mathematics lessons

Three Year 11 pupils at one school were studying diploma courses at college. One of these pupils received only one of three mathematics lessons each week in school, and she was struggling. She explained to the inspector that pupils from other schools who attended her diploma course did not miss any lessons because their schools had constructed the timetable to avoid that.

How might it be improved?

Ideally, it would be better if fewer or no lessons were missed but arranging a whole timetable around a small number of pupils is not likely to be possible in a large school. The head of department felt that the pupil's needs were being met through one-to-one support. However, in the observed lesson, the pupil did not understand the topic being taught and said she had missed earlier work on it by being at college. The timing of such support was important as it needed to occur before the next lesson, which could be difficult if the next lesson followed the college day, but then the pupil could possibly have been taught in advance of the college day. It would also be important to ensure that the pupil's work was organised well to align the one-to-one support work with that from her usual mathematics lessons.

It is not clear whether the pupil had realised that following the diploma course would affect her mathematics lessons, and whether she would still have chosen to study the diploma.

194. Schools generally had informal systems to enable pupils to catch up with work missed through absence, whether through illness, attending withdrawal groups or other school activities. When asked about catching up with work after illness, the majority of pupils said that their teacher usually helped them in the next lesson once the class was working and that their friends explained the methods to them. Pupils also said that their teachers were willing to give them extra help outside lessons if they were still unsure.

GCSE, early entry, and readiness for mathematics post-16

195. Progression through and beyond GCSE is a concern. Despite rises in GCSE and AS/A-level results, and the increasing numbers studying the subject at AS/A level, important weaknesses in the quality of teaching and learning remain in too many schools and these impede pupils' depth of understanding and readiness for the next stage of education or work. There is too much short-term focus on teaching to, and practising of, GCSE examination-style questions. Attention to understanding is all too often replaced by memorising and replicating the steps in a method.

196. The use of early GCSE entry is spreading. The report, *Early entry to GCSE examinations,* showed that it increased from 5% in 2007 to 25% in 2010 and it has continued to rise.[17] However, the full extent of early entry to GCSE examinations is under-represented by these figures as they relate to those pupils completing the qualification rather than just entering individual units. Those figures are much higher because they include all those pupils who resit units until the end of Year 11, striving to improve their grades or reach grade C, and who therefore do not count as 'early entry'. Recently, an additional tactic in a few schools has been the use of two awarding bodies to give pupils even more chances of gaining a grade C. Despite scheduling terminal examination papers in the summer on the same morning/afternoon, schools are able to

[17] *Early entry to GCSE examinations,* Department for Education, 2011; www.education.gov.uk/publications/RSG/AllRsgPublications/Page7/DFE-RR208.

exploit the flexibility of examination arrangements. This is easier to do than in the past but increases the examination burden on pupils.

197. In a few schools, pupils had stopped studying mathematics on gaining grade C in Year 10 or early in Year 11, when not all had attained their potential. Such practice raises concerns about possible negative implications for uptake and success in advanced-level studies of mathematics, and whether enough consideration was always given to each pupil's aspirations and future pathway, as illustrated in the following example.

Weaker factor: the negative impact of stopping mathematics in Year 11

A Year 12 pupil was struggling in his mathematics AS lesson. The class were working on solving quadratic equations by factorisation. In discussion with the inspector, the sixth-former explained that he had been advised to drop mathematics after passing his GCSE early at grade C to allow him to attend extra English lessons and focus on securing grade C in his English resit in the summer of Year 11. This meant that he had not studied very much higher tier GCSE material, particularly algebra. He had therefore not met factorisation of quadratic equations before, unlike the rest of the class who had taken the higher tier GCSE. This was impeding his progress on the pure mathematics units of the AS course. The school's GCSE strategy seriously disadvantaged this pupil.

How might it be improved?

The additional support for the pupil's English GCSE could have taken place outside his mathematics lesson time. Greater consideration should have been given to the pupils' desire to study mathematics A level in the sixth form.

198. A principal concern is that pupils are not being adequately prepared by their Key Stage 4 experience. This can lead to poor retention and success rates on AS mathematics courses. A contributory factor is the reduction in demand on the higher tier GCSE following the switch from three to two tiers of entry which has led to less A* and A material being assessed on the papers. Some of the schools did not cover the full specification for higher level, or covered certain topics only superficially. They did not invest the time required to develop conceptual understanding and fluency in topics such as algebra, trigonometry and graph work, which are so important for sixth-form study. For these reasons, pupils entered early for GCSE in Year 10 were often ill equipped for A-level study and, for those who did not gain an A* grade, may have achieved a grade below their potential. Nationally, very few pupils who attain grade C at GCSE go on to study and succeed at AS/A level, and the majority of those with grade B GCSE struggle to reach the higher grades at AS/A level.

199. Some able pupils in the schools surveyed had taken GCSE early at the foundation tier, which placed a ceiling of grade C on their achievement, and then did not progress successfully to the higher tier. A full two-year (or even three-year) GCSE programme might have led them to achieve higher grades and provided a better foundation for advanced study of a range of subjects that draw on mathematics as well as mathematics itself.

200. Particularly unhelpful pathways for those wishing to progress to AS/A-level study were to take GCSE mathematics in Year 10, followed in Year 11 either by no mathematics or GCSE statistics alone. This created a gap in learning, particularly in those topics so fundamental to advanced-level study.

201. When challenged by inspectors about the above practices, leaders sometimes referred to pupils meeting their target grades or making the expected progress from Level 4/5 to grade C/B. Occasionally teachers or pupils themselves explained that they had no interest in continuing with mathematics post-GCSE, because they were aiming to study other subjects or follow careers that do not use or require mathematics. They did not always appreciate the importance of mathematics in some subjects, the humanities and sciences for example. Occasionally, in the 11–16 schools in particular, the quality of advice given to pupils about options for studying mathematics post-16 was inadequate.

202. In the most effective schools, more-able pupils were prepared well for progression to advanced study because they were given more challenging work than was strictly necessary for GCSE. The GCSE specification was covered fully, and taught in an interconnected way with extra emphasis on key topics for progression, such as algebra, trigonometry, functions and graph work. Pupils regularly tackled challenging work that went beyond the routine exercise, for example in the form of extension questions that involved twists on the standard approach; harder examination-style questions; material from mathematics challenges; and opportunities to use and apply mathematics.

203. The transition from Year 9 was smooth, with pupils already highly competent in number work, basic algebra and geometry, and the beginnings of topics such as quadratic equations and trigonometry. Older pupils gained appreciation of the interconnectedness of mathematics, because teachers made regular links between GCSE topics and future topics that would arise at A level. They were encouraged to consider A-level mathematics and further mathematics because the teachers promoted further study in a variety of ways, emphasising the value of mathematical thinking and the extra benefit of further mathematics.

204. Where satisfactory teaching dominated, pupils often experienced mathematics as a series of apparently unconnected topics, because teachers missed opportunities to make links. For example, they learnt to solve simultaneous linear equations algebraically and later by a graphical method, without any connection being made, so that pupils did not appreciate that the algebraic solution was also the point of intersection of the two straight lines. Teachers typically introduced a new topic by working through one or two straightforward

examples. Some gave tips on ways of avoiding common errors. Pupils relied on memorising methods, because teachers emphasised emulating the worked examples rather than why the methods work. Most of the teacher's questions required factual answers only.

205. High-attaining pupils were usually well motivated and prepared to tackle areas of weakness, but they were not always sure how to do so. Some lacked confidence in using important skills like algebraic manipulation, handling fractions, completing trigonometric calculations and plotting graphs, because they did not get enough practice in working through progressively harder exercises. Some pupils presented their work idiosyncratically because teachers did not provide guidance on accurate mathematical presentation. Consequently, they were ill-prepared for studying mathematics at A level.

206. A common, but less consistently effective entry pattern was to take GCSE in Year 10 or early in Year 11, and then spend the remainder of Year 11 either preparing to retake GCSE or to take a FSMQ or AS mathematics. In very high-attaining schools, where whole classes were involved, taking higher tier mathematics in Year 10 followed by a FSMQ or additional mathematics in Year 11 worked well. However, taking AS mathematics in Year 11 can cause problems for the pupils, and for schools and colleges, if progression routes to the second year of A level are not planned carefully. In a few schools, pupils who had progressed to degree courses with a significant mathematical content had reported back that they had found it helpful to have studied further mathematics, at least to AS level.

207. By contrast, in less effective schools, pupils did not cover the full GCSE specification, or they tackled some topics in a superficial way. This sometimes happened because pupils began the course in Years 10 or 9 with a new GCSE textbook, and worked though it from the beginning, spending time repeating topics already covered in earlier years. As a result, there was not always enough time to cover the full specification. More-able pupils typically completed more exercises than those in lower sets, but the majority of the work was routine. The emphasis was on passing GCSE, which was often taken in Year 10 or early in Year 11, rather than gaining the highest grades. Pupils were sometimes offered a FSMQ, a 'bridging course', or were 'accelerated' to AS even from B or C grades. Pass and completion rates were variable in the schools visited and low where progression post-GCSE had not been well enough thought through.

208. The table below shows comments, typical of the range of views, made by pupils who were studying AS/A-level mathematics at a sixth-form college about their Key Stage 4 courses. Most were positive about additional courses, as long as they were taught well. One pupil noted the drawback of not studying any pure mathematics (such as algebra) during Year 11 and another commented on the lack of depth of GCSE study.

Figure 11: Sixth-form pupils' reflections on their experience of mathematics courses studied in Key Stage 4

Pupils who completed GCSE mathematics in Year 10	
Course studied in Year 11	View on preparedness of Key Stage 4 pathway for AS/A level.
Statistics GCSE	Harder in the pure AS maths areas. It made statistics a lot easier since I had studied it for whole year, but hadn't revised C1 or C2 (the pure mathematics units) for at least a year before coming to college ... so quite hard!
FSMQ (Level 3)	The FSMQ rekindled my otherwise dwindling interest in maths. I have had very little trouble in maintaining my GCSE skills through to A-level, as most were still necessary for the FSMQ.
FSMQ (Level 3)	I think doing FSMQ additional maths really helped me settle into AS level maths as I was given an insight to some of the concepts and was ready for AS level maths after doing it.
Additional mathematics	It made it harder as I forgot most GCSE things by the time I got to college and I was fed up with the additional maths which was taught poorly.

Pupils who completed GCSE mathematics in Year 11	
Course studied alongside GCSE in Year 11	View on preparedness of Key Stage 4 pathway for AS/A level.
FSMQ (Level 3)	Taking my maths GCSE in June helped me to prepare for AS maths because I could still remember most of what I'd learnt. I also did my FSMQ level 3 exam in June which I found was more beneficial for me for AS level maths than GCSE.
Additional mathematics	I actually took my last GCSE exam at the end of Year 11. But was taught additional maths during Year 11. Personally, I feel having done additional maths helped a huge amount in Year 12 as I already had a basic idea of most of the topics covered.
None	I think the timing of my GCSE was fine. However we did not learn the fundamental stuff that would prepare us for AS level in as much detail. (E.g. quadratics and graphs.)
None	I think it is the grade of the maths that is achieved at GCSE that affects the introduction of AS level maths rather than the timing of the exam.

209. Two large, outstanding sixth-form colleges were visited in spring 2011. They were very successful for a number of reasons, not all of them easily replicated in schools' sixth forms. Both had large departmental teams of experienced, knowledgeable teachers who typically taught several AS/A-level mathematics and further mathematics groups each year, building up considerable expertise in pedagogy and in preparing pupils for the relevant examinations. The majority of pupils on the courses had gained at least grade A at GCSE and many had

also studied a FSMQ or additional mathematics. The following case studies illustrate some of the strengths at each college.

Prime practice: high-quality provision at two sixth-form colleges

At the first college:

The schemes of work provide a clear guide to staff and the department is well organised for teaching resources, including use of ICT. Teachers have high expectations, expect pupils to want to understand, and provide plenty of exercises and problems to ensure that they secure their learning.

The team is well led in a collegiate style, with lots of formal and informal discussion of teaching and learning among staff. Support for pupils is very well organised. The department provides a rich learning environment for mathematics, with good displays and the use of visiting speakers through the mathematics society.

At the second college:

Pupils learn well through lots of practice, including plenty of homework, with the expectation that they will seek help from the various mathematics 'clinics' and the virtual learning environment, in advance of the due date. Marking is thorough and regular. Pupils tackle regular 'exam-style' questions during the course so they can test themselves at examination standard. The college aims to cover the material with plenty of time to spare for revision and past papers. Provision for e-learning includes a Moodle site which includes interactive resources and a subscription to online AS and A-level resources for pupils to access at home or in college. There are home licences for pupils' use of graph-plotting software and a suite of PowerPoint revision sessions.

The college accepts pupils at A level with grade B and even grade C GCSE, but gives clear guidance about the risks involved, even with the college's higher than national progression rates from these grades.

Intervention: better diagnosis, no cure

210. The drive to raise attainment at ages 11 and 16 and to increase progress between Key Stages 1 and 2, and 2 and 4, has increased the emphasis that schools place on intervention. The previous survey report, *Mathematics: understanding the score*, noted:

> 'Evidence suggests that strategies to improve test and examination performance, including 'booster' lessons, revision classes and extensive intervention, coupled with a heavy emphasis on 'teaching to the test', succeed in preparing pupils to gain the qualifications but are not equipping them well enough mathematically for their futures.'[18]

211. Since the previous survey, intervention and other strategies aimed at raising attainment in tests and examinations have become more widespread and increasingly sophisticated. The range of strategies used by schools visited more recently and those visited at the beginning of the survey showed clear differences. In 2008, the schools usually provided revision or booster classes for pupils in Years 6, 9 and 11 and focused particularly on those pupils at risk of narrowly missing the key threshold targets. In many cases, intervention was in response to results, and sometimes analysis, of practice tests/examinations. Systematic tracking of pupils' progress was evident in some schools at that time.

212. By 2011, almost every school visited had information systems to record pupils' attainment on a half-termly or termly basis in most or all of the year groups in the school. Individual targets set in mathematics were usually based on pupils' prior attainment and national data on progress rates, sometimes taking contextual factors into account. The information systems allowed the schools to monitor each pupil's progress towards his or her target following regular collection of assessment data.

Intervention and tracking

213. Intervention based on tracking individual pupils' progress against their targets depended on the accuracy of teachers' assessment of pupils' attainment and appropriately challenging targets. Where these were inaccurate, the systems were flawed, which allowed some pupils to slip through the net.

214. Primary schools often based targets for good progress on two thirds of a National Curriculum level per year, aligned to a correspondingly ambitious target for attainment at the end of Key Stage 2. Tracking of pupils' progress at Key Stage 1 was less well developed than at Key Stage 2. Expectations for pupils' progress were sometimes too low because the model of a half or two thirds of a National Curriculum level per year does not work in Key Stage 1. A better rule of thumb would be one whole level per year. The schools did not commonly base Key Stage 1 targets on the EYFS profile scores, instead concentrating tracking in Year 2, based on assessments made during Year 1. However, one outstanding school visited identified targets during Reception for Key Stage 1 and Key Stage 2 then revised them in Year 3 if there was the potential to raise the challenge further. This school started intervention in

[18] *Mathematics; understanding the score* (070063), Ofsted, 2008; www.ofsted.gov.uk/resources/070063.

Reception for those below age-related expectations and checked their progress every half term.

Intervention to improve results

215. A major factor in pupils' achievement at Key Stage 2 remained the intervention provided for those who were at risk of not reaching Level 4. Schools monitored closely the attainment of Year 6 pupils and, increasingly, Year 5 pupils, to identify those who might need this support. In a minority of schools, the concentration on this group of pupils led to higher and lower attainers not reaching their full potential. More generally, the shift towards analysis of each pupil's progress has contributed to the slightly higher proportions attaining Level 5.

216. In a minority of secondary schools, a heavy focus on Key Stage 4 groups meant that home-grown underachievement was not being tackled in Key Stage 3. This locked the school into a cycle of extensive intervention, revision and other strategies that would be unsustainable in the long term.

217. The recommendation from the 2008 report that schools should 'identify and tackle underlying weaknesses in teaching that lie at the source of pupils' gaps in knowledge or difficulties in learning mathematics, thereby reducing reliance on short-term intervention strategies' remains a key step for schools towards building long-term sustainable improvement.

218. Over the last three years, schools' systems for setting performance targets and tracking pupils' progress have become established features of their work. Improvements noted during the survey included teachers' greater involvement in assessing and tracking each of their pupils' attainment. Through this, and question-level analysis of assessments, the primary teachers have become more precise in identifying the topics for intervention and have increasingly recognised the importance of pinpointing and overcoming pupils' misconceptions as soon as possible. The teachers were also identifying curricular targets for pupils, although these were often not demanding enough for the higher attainers. In a few exceptional cases, systematic analyses and evaluation of impact have led to improved provision: through increased focus of support and intervention, and changes to the way concepts that pupils found difficult have subsequently been introduced.

219. Similar analyses in secondary schools tended to lead to the identification of areas for pupils to concentrate on during revision. However, they were rarely used to raise questions about the quality of teaching of the topic in the first place. Instead, teachers' efforts went into supporting intervention and revision provision, which intensified as each set of examinations approached. As one head of department observed, 'We are finding it really hard to support three cohorts (Years 9, 10 and 11) at the same time with revision classes and intervention.'

220. The scope of intervention in the secondary schools varied, with some intervening with all those at risk of underachievement and others still focusing mainly on pupils at risk of narrowly missing the Key Stage 4 threshold target of five or more GCSEs at A* to C including English and mathematics. The most equitable practice focuses on all pupils who are underachieving.

Prime practice: intervention for all who need it

Intervention and revision contributed significantly to pupils' success in examinations. Pupils were divided into key groups: low to middle ability girls who had underachieved previously; underachieving boys; poor attenders; those on track to meet the five A*to C threshold; and a group who were making secure progress whatever their starting points.

All groups received support and encouragement relevant to their needs. In this school, intervention was about the achievement of individuals rather than simply those on the C/D borderline.

Weaker factor: inequality in intervention

The school's leaders credited much of the improvement in A* to C results in mathematics to improved intervention programmes, such as grade boosters, extra revision and generous out-of-lesson support offered by teachers. The main focus of intervention was on the C/D borderline. The most able were self-motivated to succeed and often exceeded their targets. However, too many pupils were gaining F grades when they had the potential for D or E grades. These pupils were the least confident and self-motivated.

How might it be improved?

See the previous example of prime practice!

Intervention to improve learning

221. In contrast with much of the secondary practice observed, the nature of intervention in primary schools has shown a marked improvement since the previous survey. Increasingly many schools had shifted substantially away from concentrating solely on test-focused support for Year 6 pupils at risk of not achieving Level 4; the focus was now on earlier remediation in pupils' specific areas of weakness in all year groups to overcome pupils' difficulties and prevent them from falling significantly behind their peers. For example, a Year 4 pupil who had behavioural and learning difficulties had transferred from another school. She received daily one-to-one support; in the observed session the focus was on number bonds and rounding to 10 using a range of resources including enjoyable ICT games. She had settled quickly and had made good progress from Level 1b to Level 2a in six months.

222. The use of targeted intervention to help pupils of all ages has been accompanied by teachers' increased use of tracking data and greater accountability. During regular 'pupil progress meetings', for instance, teachers and senior staff discuss how well each pupil is doing; identify those who are falling behind; and make decisions about suitable additional support for them in class as well as through interventions outside lessons.

223. Key Stage 1 pupils at risk of underachieving were receiving more intervention than seen in the previous survey, particularly those in danger of not reaching Level 2, but higher attainers were not effectively and consistently challenged. The schools used tracking better to identify those who needed help and, in the best practice, were specifying it more precisely. Evaluation of the impact of intervention has showed a marked improvement in terms of gains made in National Curriculum sub-levels, but not as effectively or frequently in assessing the pupils' degree of understanding or whether misconceptions have been overcome. Where programmes such as 'Every Child Counts' and 'Numbers Count' were used effectively, pupils overcame their misconceptions and the school used information about its pupils' misconceptions to adapt teaching for subsequent cohorts. The funding for one-to-one tuition and use of materials that assisted teachers in diagnosing pupils' misconceptions and supporting individuals, have helped schools to develop a more customised approach to intervention programmes.

224. Part of the move away from pre-test intervention organised by the Year 6 teachers or senior staff, is the changing role of primary teaching assistants. It is extending beyond general classroom support to responsibility for delivering interventions, working with the teacher in planning work, assessing impact and discussing individuals at half-termly meetings to evaluate every pupil's progress. Sometimes teaching assistants receive training to improve their skills and specialise in specific interventions. There has been a move away from nationally designed intervention programmes towards support that is more sharply tailored to individual need. Where the teaching assistant and teacher arrange support more informally, it is not as systematic.

Prime practice: a well-resourced intervention session with pupils who had special educational needs and/or disabilities

Three Year 1 pupils who had special educational needs worked with a teaching assistant on achieving their individual education plan target. The school has placed increased emphasis on the development of life skills for these pupils. In this session, they were engaged in buying items up to a value of 20p using the correct coins. The activity was well resourced. Pupils chose to buy from a colourful array of priced toys. With sensitive support from the teaching assistant, pupils were learning to use different coins to match the price correctly. They were encouraged to check each other's calculations, which ensured they were actively involved in the process all the time. One pupil was anticipating a cost before his turn. When the teaching assistant asked him to choose a priced item, he already had the correct coins set out on the table. The teaching assistant explained that this pupil had made remarkable progress and would not require prolonged intervention of this nature.

225. As intervention programmes have become widespread, expertise is being developed.

Prime practice: what works well with small group interventions in secondary schools?

A former National Strategy consultant worked part-time for a local authority on intervention with Year 11 pupils in several National Challenge schools. Each school adopted different models for intervention (for example, extracting pupils from mathematics lessons or from something else; grouping pupils according to identified weaknesses or not).

In the observed session, she had clearly developed a relationship of trust with the group of five pupils, which allowed confidence and enjoyment to be built and ensured that they were relaxed about sharing work and misconceptions with each other. She involved all the pupils in identifying mistakes and teaching each other, thus developing their understanding and confidence in a secure environment. Her 'Why?', 'How?', 'What if?' questions ensured that they thought deeply about what they were learning.

Her observations on this work were as follows.

- Group size is key. More than six to eight pupils and the 'sharing' possibilities outlined above are lost.
- Intervention is at its most powerful when it gives pupils the chance to explain their thinking, and through this to develop their understanding
- Intervention teachers need to be very carefully selected. 'All singing and dancing' teaching is not called for and would have the danger of undermining the pupils' usual teacher.
- Pupils also need to be carefully selected, so not giving the intervention teacher a group of for example, 18 pupils; the most disruptive pupils; eight pupils while their peers are enjoying their 'maths computer lesson'; or pupils of widely varying mathematical needs.
- Crucially, the process needs to be driven by senior management, especially in relation to the choice of pupils. They have a right to understand why they have been selected and to see the process as a positive one – not that they are 'thick'.

226. In some instances, intervention teachers and teaching assistants did not receive sufficient information about the particular areas of a pupil's difficulty. In the example below, the quality of one-to-one provision had not been checked by leaders.

Weaker factor: a mismatch between need and provision

At Key Stage 3, one-to-one sessions ran for 10 weeks. An observed session with a teacher and a Year 8 girl involved a timed multiplication tables test followed by practice on multiplication and division of decimals by 10, 100, … However, the target identified by the girl's usual mathematics teacher was to work on 'worded questions especially long multiplication and long division'. The next target area was to be algebra. The intervention teacher explained that she liked to check pupils' Year 6 number work as she has found that some Year 7 pupils were weak on it. This did not explain why she was doing number work with the Year 8 pupil.

How might it be improved?

The intervention teacher should have worked with the girl on the type of problems clearly identified by her usual teacher. The next target area, algebra, was vaguely specified, and a discussion between the girl's usual teacher and the intervention teacher about the particular topic and difficulties could have helped to ensure that this teaching resource was used effectively. Monitoring of this provision should have quickly picked up such a mismatch and set clear expectations for future sessions.

Notes

This report is based predominantly on evidence from inspections of mathematics between January 2008 and July 2011 in a range of maintained schools in England. The sample of 320 schools was selected from a cross-section of schools geographically and by institutional type, including academies and specialist mathematics and computing colleges. No school judged inadequate in its last whole-school inspection was included in the sample.

Inspectors visited 160 primary schools for a day each and 160 secondary schools for two days. Between them, they observed more than 470 lessons in primary schools and 1,200 in secondary schools. Ofsted's framework for inspection changed in September 2009. Prior to that date, judgements made during lesson observations placed learning with teaching, and progress with attainment. Since then, learning and progress have been judged together, with separate judgements on teaching and attainment. For the purpose of analysing the grades from lessons for this report, the changes made little difference in practice as the grades for teaching, learning and progress were almost always the same. This is because the most important element for judging teaching is its impact on learning and progress.

During the visits, inspectors gathered evidence through activities including:

- observations of lessons and intervention sessions
- scrutiny of pupils' work and discussions with groups of pupils

- discussions with senior and subject leaders, with teachers whose lessons were observed, with teaching assistants and other support staff, and occasionally with others such as local authority staff, consultants and governors.
- analysis of documentation such as assessment information, schemes of work, policies and other management documentation, information about intervention strategies and the professional development of staff in mathematics.

The report is also informed by evidence gathered during good practice visits to 10 primary schools during May and June 2011 as part of a separate survey which focused on effective practice in the teaching of early arithmetic. Further good practice visits were conducted to one primary and one secondary school, a sixth-form college and a college of further education. No judgements on lessons observed or other aspects of provision from any of the good practice visits are included in the proportions quoted throughout the report.

The report also draws on evidence related to mathematics from whole-school inspections during the same period. Further sources of evidence include the Annual Reports of Her Majesty's Chief Inspector and other reports published by Ofsted including *Finnish pupils' success in mathematics; Tackling the challenge of low numeracy skills in young people and adults*, and the previous mathematics survey report, *Mathematics: understanding the score*. Details of these publications are given in the Further information section below. The evidence was also informed by discussions with those involved in mathematics education, including teachers and pupils, subject leaders and senior staff in schools, academics, policy makers and others within the wider mathematics community.

The attainment and progress data cited in this report are drawn principally from validated RAISEonline reports and from statistical first releases, which are published by the Department for Education. Maintained schools have access to their individual RAISEonline reports and comparative national data at www.raiseonline.org. Statistical first releases can be found at www.education.gov.uk/rsgateway/underlyingdata.shtml.

Further information

Publications by Ofsted

Mathematics: understanding the score (070063), Ofsted, 2008; www.ofsted.gov.uk/resources/070063.

Finnish pupils' success in mathematics (100105), Ofsted, 2010; www.ofsted.gov.uk/resources/100105.

Good practice in primary mathematics: evidence from 20 successful schools (110140), Ofsted, 2011; www.ofsted.gov.uk/resources/110140

Tackling the challenge of low numeracy skills in young people and adults (100225), Ofsted, 2011; www.ofsted.gov.uk/resources/100225.

Other sources

Advisory Committee on Mathematics Education (ACME)

www.acme-uk.org.

ACME's purpose is to enable an effective and constructive partnership between government and the mathematics community. It aims to provide an authoritative, credible, balanced and coherent position, which inevitably does not always represent the diverse views that might exist across the mathematics education community. ACME's latest project is to provide advice on the development of a course for pupils who do not currently take A-level mathematics but will, in the future, need to continue with mathematics post-16. The link below is to the reports from ACME's project on mathematical needs:

www.acme-uk.org/news/news-items-repository/2011/6/launch-of-the-acme-mathematical-needs-project.

Cognitive Acceleration in Mathematics Education (CAME)

www.cognitiveacceleration.co.uk.

CAME draws on the research of Jean Piaget and Lev Vygotsky and focuses on questioning, collaborative work, problem solving, independent learning and challenge. It uses a selection of challenging classroom tasks which emphasise 'big ideas' or conceptual strands in mathematics.

Department for Education (DfE)

www.dfe.gov.uk.

The department's website provides links to information on many aspects of mathematics education, for instance on the current National Curriculum and its review.

Department for Business, Innovation and Skills (BIS)

www.bis.gov.uk.

BIS aims to support sustained growth and higher skills across the economy. Its website includes links to the science, technology, engineering and mathematics network (STEMNET) whose aim is to ensure that all schools and colleges have access to information about STEM subjects and career opportunities. It runs a STEM Ambassadors programme through which volunteers with a STEM background work with schools, teachers and pupils to stimulate and inspire their interest in these subjects.

Further Mathematics Support Programme

www.furthermaths.org.uk.

The Further Mathematics Network provides support for teachers and pupils of advanced-level mathematics and further mathematics, providing tuition in further mathematics for those pupils who would benefit from studying it but would not otherwise have the opportunity to do so.

Mathematical careers

www.mathscareers.org.uk.

This recently established website provides information for young people of all ages, from Key Stage 3 to graduate level, who are interested in finding out about careers and opportunities that an education in mathematics can present. It covers a range of queries and careers including mathematics, statistics, engineering, medicine, finance, computer graphics and forensic science. It also contains information for teachers, parents, careers advisers and employers.

Mathematics Specialist Teacher programme

www.ncetm.org.uk/news/33949.

Information about this programme is available from the National Centre for Excellence in the Teaching of Mathematics (NCETM) and on the websites of individual university providers.

The programme stemmed from a recommendation in the Independent review of mathematics teaching in early years settings and primary schools, DCSF, 2008; http://publications.education.gov.uk/default.aspx?PageFunction=productdetails&PageMode=publications&ProductId=DCSF-00433-2008.

National Association of Mathematics Advisers (NAMA)

www.nama.org.uk.

Membership of NAMA is open to advisers, inspectors, consultants, and providers of advice, inspection and guidance within the field of mathematics education. The association is dedicated to promoting high-quality mathematical education in the United Kingdom.

National Centre for Excellence in the Teaching of Mathematics (NCETM)

www.ncetm.org.uk.

The NCETM was launched in June 2006. It is responsible for enhancing professional development across mathematics teaching in all settings and with learners of every age and promotes collaboration between teachers. The web portal is the gateway to the breadth of the centre's national activity. A wide range of information and links is provided, for example to online courses, self-evaluation tools, support for subject leaders, publications and details of forthcoming events.

Nuffield Foundation

www.nuffieldfoundation.org/education.

The Nuffield Foundation aims to influence education policy and practice, ensuring that all young people develop the understanding and skills required to play an informed role in society. It supports research and its translation into policy and practice. The Nuffield Foundation's mathematics teaching and learning projects provide free resources for teachers. Recent research reports on international perspectives of school mathematics include:

Values and variables: Mathematics education in high-performing countries, Nuffield Foundation, 2010; www.nuffieldfoundation.org/values-and-variables-mathematics-education-high-performing-countries.

Is the UK an outlier in upper secondary maths education?, Nuffield Foundation, 2010; www.nuffieldfoundation.org/uk-outlier-upper-secondary-maths-education.

Key understandings in mathematics learning, Nuffield Foundation, 2009; www.nuffieldfoundation.org/key-understandings-mathematics-learning.

Primary and secondary National Strategies

Following the end of the National Strategies' contract on 31 March 2011, a number of key and popular teaching and learning resources were updated and adapted to enable users to access the content archived by the National Archives. Note that the interactive functionality and features previously available on the National Strategies website are not available on the archived versions. The links below are to the primary and secondary mathematics sections of the archived materials.

http://webarchive.nationalarchives.gov.uk/20110809091832/http://www.teachingandlearningresources.org.uk/primary/mathematics.

http://webarchive.nationalarchives.gov.uk/20110809091832/http://teachingandlearningresources.org.uk/secondary/mathematics.

Qualifications and Curriculum Development Authority (QCDA)

QCDA closed on 31 March 2012 as part of the government's wider education reforms. The National Curriculum assessments function is now performed by the Standards and Testing Agency. Archived materials can be found on the DfE's website.

Office of the Qualifications and Examinations Regulator (Ofqual)

www.ofqual.gov.uk.

Ofqual is responsible for maintaining standards, improving confidence and distributing information about qualifications and examinations. It regulates general and vocational qualifications in England. Information about changes to modular GCSE examinations is available at:

www.ofqual.gov.uk/news-and-announcements/130-news-and-announcements-press-releases/820-ofqual-confirms-changes-to-gcses.

Royal Society

www.royalsociety.org.

Science and mathematics education 5–14, Royal Society, 2010; www.royalsociety.org/education/policy/state-of-nation/5-14.

The Royal Society, the national academy of science of the UK and the Commonwealth, established ACME in 2002 with support from the Joint Mathematical Council and funding from the Gatsby Foundation. The Royal Society's 2010 report, *Science and mathematics education 5–14*, raises concerns about the lack of mathematics specialists in primary and early secondary mathematics teaching.

Subject associations

There are many subject associations in mathematics, some of which are listed on the NCETM's portal at www.ncetm.org.uk. These include the Association of Teachers of Mathematics (ATM) www.atm.org.uk and The Mathematical Association (MA); www.m-a.org.uk.

Teaching Agency (TA)

www.education.gov.uk/get-into-teaching.

The Teaching Agency, formerly the Training and Development Agency, is responsible for initial teacher training in England. The website provides information on the different options for training.

United Kingdom Mathematics Trust (UKMT)

www.ukmt.org.uk.

This registered charity organises mathematics challenges and enrichment activities for schools and colleges.

Annex A: Schools visited

Primary schools	Local authority
Abbey Park Junior, Infant and Nursery School	Calderdale
Albert Village Community Primary School	Leicestershire
Alderman Bolton Community Primary School	Warrington
Ashfield Primary School	Leeds
Astmoor Primary School	Halton
Audley Junior School	Blackburn with Darwen
Balgowan Primary School*	Bromley
Batley Parish Church of England Voluntary Aided Junior Infant and Nursery School	Kirklees
Bedonwell Junior School	Bexley
Beechcroft Infant School	Swindon
Blackboys Church of England Primary School	East Sussex
Blurton Primary School	Stoke-on-Trent
Broadwater Primary School	Kent
Bromley Heath Infant School	South Gloucestershire
Broomwood Primary School	Trafford
Brownlow Fold Primary School	Bolton
Brumby Junior School	North Lincolnshire
Burraton Community Primary School	Cornwall
Calton Junior School	Gloucestershire
Calveley Primary School	Cheshire East
Cannon Lane Junior School	Harrow
Castlefort Junior Mixed and Infant School	Walsall
Charborough Road Primary School	South Gloucestershire
Cheetham CofE Community School*	Manchester
Chiseldon Primary School	Swindon
Clifton Primary School	Cumbria
Colwich CofE (C) Primary School	Staffordshire
Coombe Hill Junior School	Kingston upon Thames
Corpus Christi Catholic Primary School	Birmingham
Crane Park Primary School	Hounslow
Curry Mallet Church of England Primary School	Somerset

Dairy Meadow Primary School	Ealing
Dean Field Community Primary School	Calderdale
Deighton Gates Primary School	Leeds
Dorchester St Birinus Church of England School	Oxfordshire
Dr Radcliffe's Church of England School	Oxfordshire
Dry Sandford Primary School	Oxfordshire
East Harptree Church of England VC Primary School	Bath and North East Somerset
Eastlands Junior School	Nottinghamshire
Edwards Hall Primary School	Southend-on-Sea
English Martyrs' Catholic Primary School	Sefton
Garboldisham Church Primary School	Norfolk
Gaskell Community Primary School	Bolton
Gastrells Community Primary School	Gloucestershire
Glenfrome Primary School	Bristol, City of
Great Chesterford Church of England Voluntary Aided Primary School*	Essex
Great Sankey Primary School	Warrington
Green Lane Primary and Nursery School	Kingston-upon-Thames
Greenleaf Primary School	Waltham Forest
Harden Primary School	Bradford
Harlyn Primary School	Hillingdon
Harpur Mount Primary School	Manchester
Helme Church of England Voluntary Aided Junior and Infant School	Kirklees
Hemingbrough Community Primary School	North Yorkshire
Hermitage Primary School	Cheshire East
Hever Church of England Voluntary Aided Primary School	Kent
Heybrook Primary School	Rochdale
Highworth Combined School and Nursery	Buckinghamshire
Holme Slack Community Primary School	Lancashire
Holy Rood Catholic Primary School	Hertfordshire
Holy Trinity CofE Primary School, Sunningdale	Windsor and Maidenhead
Holy Trinity CofE Primary School	Barnet
Horrabridge Community Primary School	Devon
Huntley Church of England Primary School	Gloucestershire

Kings Court Primary School*	South Gloucestershire
King's Ford Junior School	Essex
Kirkland and Catterall St Helen's Church of England Voluntary Aided Primary School	Lancashire
Langtree Community School and Nursery Unit	Devon
Laygate Community School	South Tyneside
Leeds and Broomfield Church of England Primary School	Kent
Leftwich Community Primary School	Cheshire West and Chester
Leigh Westleigh Methodist Primary School	Wigan
Longridge St Wilfrid's Roman Catholic Primary School	Lancashire
Lostock Hall Primary School	Cheshire East
Lyminster Primary School	West Sussex
Mapplewell Primary School	Barnsley
Meadow Primary School	Cambridgeshire
Meadowbrook Primary School	South Gloucestershire
Meadows Primary School	Staffordshire
Middle Barton School	Oxfordshire
Moss Hall Infant School	Barnet
Nazeing Primary School	Essex
Nether Alderley Primary School	Cheshire East
Newbridge Junior School	Portsmouth
Newtown Church of England Voluntary Controlled Primary School	Hampshire
Norcot Early Years Centre	Reading
Northern Primary School	Lancashire
Old Bank Junior Infant and Nursery School	Kirklees
Oreston Community Primary School*	Plymouth
Our Lady of Lourdes RC School	Barnet
Our Lady of the Rosary Catholic Primary School, Bristol	Bristol City of
Over Kellet Wilson's Endowed Church of England Primary School	Lancashire
Overleigh St Mary's CofE Primary School	Cheshire West and Chester
Park Brow Community Primary School	Knowsley
Park Junior School	Gloucestershire
Parrett and Axe Church of England Voluntary Aided Primary School	Dorset
Pennine Way Primary School	Cumbria

Redcliffe Early Years Centre	Bristol City of
Reeth Community and Gunnerside Methodist Primary Schools*	North Yorkshire
Rose Green Infant School	West Sussex
Sacred Heart RC Primary School	Islington
Saint Charles' Catholic Primary School, Measham	Leicestershire
Sandling Primary School	Kent
Scotts Park Primary School	Bromley
Seaford Primary School	East Sussex
Sessay Church of England Voluntary Controlled Primary School	North Yorkshire
Seven Fields Primary School	Swindon
Seymour Road Primary School	Manchester
Shakespeare Junior School	Hampshire
Snowsfields Primary School	Southwark
Southville Primary School	Bristol, City of
Spaxton CofE Primary School	Somerset
Spring Grove Junior Infant and Nursery School	Kirklees
SS Peter and Paul Catholic Primary School, Mawdesley	Lancashire
St Aldhelm's Church of England Primary School	Somerset
St Anne's and St Joseph's Roman Catholic Primary School, Accrington	Lancashire
St Benedict's Church of England Voluntary Aided Junior School	Somerset
St George Church of England Primary School	Bristol, City of
St Giles CofE (Aided) Primary School	Derbyshire
St John's Church of England (VA) Combined School, Lacey Green	Buckinghamshire
St Joseph's Catholic Primary School	Southwark
St Joseph's Stockport Catholic Primary School	Stockport
St Keyna Primary School	Bath and North East Somerset
St Mary's Church of England Primary School	Devon
St Mary's Roman Catholic Primary School, Radcliffe	Bury
St Nicholas's Catholic Primary School	Liverpool
St Peters Church of England Combined School, Burnham	Buckinghamshire
St Peter's CofE (C) Primary School	Staffordshire
St Philips Marsh Nursery School	Bristol City of

St Richard’s RC Primary School	Manchester
St Saviour’s Church of England Junior School	Kent
St Thomas More Roman Catholic Primary School	Hertfordshire
St Thomas of Canterbury Catholic Primary School	St. Helens
St Winifred’s Roman Catholic Primary School, Stockport	Stockport
Stanhope Primary School	Ealing
Stanley Primary School	Blackpool
Tattingstone Church of England Voluntary Controlled Primary School	Suffolk
Temple Guiting Church of England School	Gloucestershire
Thames View Junior School	Medway
The Leys Primary School	Barking and Dagenham
The Priory Primary School	Sandwell
The Skegness Seathorne Primary School	Lincolnshire
The William de Yaxley CofE Aided Junior School	Cambridgeshire
Thomas Hickman School	Buckinghamshire
Thornhill Primary School	Islington
Tredworth Infant School	Gloucestershire
Tunstead Primary School	Norfolk
Urmston Junior School	Trafford
Utkinton St Paul’s CofE Primary School	Cheshire West and Chester
Watchetts Junior School	Surrey
Waycroft Primary School*	Bristol, City of
Wharncliffe Side Primary School	Sheffield
Whitfield and Aspen School	Kent
Willaston CofE Primary School	Cheshire West and Chester
William Byrd School	Hillingdon
Woodlea Junior School	Lancashire
Wrekin View Primary School	Telford and Wrekin
Yeading Junior School	Hillingdon
Yeo Moor Primary School	North Somerset
York Road Junior School and Language Unit	Kent

Secondary schools	**Local authority**
Abbot Beyne School	Staffordshire
Alderbrook Leading Edge School and Arts College*	Solihull

Aldworth Science College	Hampshire
Alperton Community School	Brent
Alumwell Business and Enterprise College	Walsall
Anthony Gell School	Derbyshire
Archbishop Temple School, A Church of England Specialist College	Lancashire
Arden School*	Solihull
Bartholomew School	Oxfordshire
Bishop Heber High School	Cheshire West and Chester
Blackminster Middle School	Worcestershire
Broadland High School	Norfolk
Broadwater School	Surrey
Broomfield School	Enfield
Burlington Danes Academy	Hammersmith and Fulham
Calthorpe Park School	Hampshire
Cardinal Griffin Catholic High School	Staffordshire
Cardinal Hume Catholic School*	Gateshead
Carnforth High School	Lancashire
Carr Manor High School	Leeds
Castle View School	Essex
Chailey School	East Sussex
Charles Burrell High School*	Norfolk
Chelmsford County High School for Girls*	Essex
Chesterton Community College*	Cambridgeshire
Christ's Church of England Comprehensive Secondary School	Richmond upon Thames
Church Stretton School	Shropshire
Copleston High School*	Suffolk
Cottenham Village College*	Cambridgeshire
Cranbourne Business and Enterprise College	Hampshire
Cullompton Community College	Devon
Dame Alice Owen's School*	Hertfordshire
Darrick Wood School*	Bromley
De Ferrers Specialist Technology College*	Staffordshire
Denbigh School*	Milton Keynes
Droitwich Spa High School and Sixth Form College	Worcestershire

Elthorne Park High School	Ealing
Enfield Grammar School*	Enfield
Fairfield High School*	Halton
Faringdon Community College	Oxfordshire
Fernwood School*	City of Nottingham
Fortismere School	Haringey
Framwellgate School Durham*	Durham
Friern Barnet School	Barnet
Garstang High School : A Community Technology College*	Lancashire
Gaynes School Language College*	Havering
Glebelands School	Surrey
Glyn Technology School	Surrey
Greendown Community School*	Swindon
Grey Court School	Richmond upon Thames
Guru Nanak Sikh Voluntary Aided Secondary School*	Hillingdon
Hazelwick School	West Sussex
Hebburn Comprehensive School	South Tyneside
Hedingham School and Sixth Form	Essex
Helsby High School	Cheshire West and Chester
Heston Community School	Hounslow
Highams Park School*	Waltham Forest
Highcliffe School*	Dorset
Highworth Grammar School for Girls*	Kent
Hillcrest School A Specialist Maths and Computing College and Sixth Form Centre*	Birmingham
Holly Hall Maths and Computing College*	Dudley
Holy Family Catholic High School, Carlton	North Yorkshire
Honley High School	Kirklees
Hornby High School*	Lancashire
Huntington School	York
Idsall School	Shropshire
Impact Alternative Provision	Sefton
Isleworth and Syon School for Boys	Hounslow
John Taylor High School*	Staffordshire
King Edward VI Camp Hill School for Boys*	Birmingham

King Edward VI School*	Warwickshire
Kingsbrook Business and Enterprise School*	Northamptonshire
Kingsford Community School	Newham
Kingsmead Community School*	Somerset
Ladymead Community School*	Somerset
Lammas School and Sports College	Waltham Forest
Lea Valley High School	Enfield
Light Hall School Specialist Mathematics and Computing College*	Solihull
Little Ilford School	Newham
Loreto High School Chorlton	Manchester
Manchester Mesivta School	Bury
Manshead CofE VA Upper School	Central Bedfordshire
Methwold High School*	Norfolk
Mexborough School	Doncaster
Midhurst Grammar School*	West Sussex
Monk’s Walk School	Hertfordshire
Mount Carmel Roman Catholic High School, Hyndburn	Lancashire
Mount St Joseph: Business and Enterprise College	Bolton
Nicholas Chamberlaine Technology College	Warwickshire
Ninestiles School*	Birmingham
Our Lady’s Convent Roman Catholic High School	Hackney
Park High School*	Harrow
Parkside Community School	Derbyshire
Paulet High School	Staffordshire
Pewsey Vale School*	Wiltshire
Pleckgate High School Mathematics and Computing College	Blackburn with Darwen
Purbrook Park School	Hampshire
Quarrydale School*	Nottinghamshire
Queensbury Upper School	Central Bedfordshire
Ridgewood High School	Dudley
Rock Ferry High School*	Wirral
Rodillian School	Leeds
Roundwood Park School*	Hertfordshire
Royton and Crompton School	Oldham

Saint Cecilia’s, Wandsworth Church of England School	Wandsworth
Saint Joan of Arc Catholic School	Hertfordshire
Samuel Whitbread Community College	Central Bedfordshire
Sandhurst School	Bracknell Forest
Sedgehill School	Lewisham
Shenley Brook End School*	Milton Keynes
Simon Langton Girls’ Grammar School	Kent
Sir William Ramsay School*	Buckinghamshire
Slough Grammar School*	Slough
St Bede’s Catholic School	North Lincolnshire
St Benedict’s Catholic High School	Cumbria
St Bernard’s Catholic Grammar School	Slough
St Bernard’s Catholic High School	Cumbria
St Columbas Catholic Boys’ School	Bexley
St John Fisher Catholic Comprehensive School	Medway
St Mary’s Catholic College	Blackpool
St Mary’s Catholic High School	Wigan
St Olave’s and St Saviour’s Grammar School	Bromley
St Paul’s Catholic School	Milton Keynes
St Thomas More Catholic High School, A Specialist School for Maths & ICT	Cheshire East
Stokesley School	North Yorkshire
Stratford School*	Newham
Tabor Science College	Essex
Test Valley School	Hampshire
The Brooksbank School*	Calderdale
The Castle School	South Gloucestershire
The City Academy Bristol	Bristol City of
The Commonweal School*	Swindon
The Cooper School	Oxfordshire
The Deanery Church of England High School and Sixth Form College	Wigan
The Derby High School	Bury
The Douay Martyrs Catholic School	Hillingdon
The Ecclesbourne School*	Derbyshire
The Gartree Community School	Lincolnshire

The Harvey Grammar School	Kent
The Howard School	Medway
The King Alfred School	Somerset
The Kingsway School	Stockport
The Marlborough Church of England School	Oxfordshire
The Mountfitchet Mathematics and Computing College	Essex
The Neville Lovett Community School and Continuing Education Centre	Hampshire
The Nottingham Emmanuel School	Nottingham
The Sholing Technology College	Southampton
The Sydney Russell School	Barking and Dagenham
The West Somerset Community College*	Somerset
Thirsk School & Sixth Form College	North Yorkshire
Tudor Grange School*	Solihull
Tweedmouth Community Middle School	Northumberland
Wallasey School	Wirral
Wallingford School*	Oxfordshire
Watford Grammar School for Boys*	Hertfordshire
Westfield Middle School	Bedford
Whitmore High School	Harrow
William Beamont Community High School	Warrington
Wisewood School and Community Sports College*	Sheffield
Wrockwardine Wood Arts College	Telford & Wrekin

Focused good practice visits

Greenhead College	Kirklees
Hills Road Sixth Form College	Cambridgeshire
Woodside Primary School	Shropshire

* The provider has closed or converted to an academy since the time of the visit.

Schools visited for the survey, *Good practice in primary mathematics*

Independent schools	Location
Dragon School	Oxford
Froebel House Preparatory School	Hull
Ranby House School	Retford

St Joseph's School	Launceston
St Olave's School and Clifton Pre-Preparatory School	York
Terra Nova School	Holmes Chapel
The Cedars School	Reading
The Manchester Grammar School (Junior Dept)	Manchester
Town Close House Preparatory School	Norwich
Winterfold House School	Kidderminster

Maintained schools	**Location**
Ark Academy	Wembley
Coxhoe Primary School	Durham
Grafton Primary School	London
Heversham St Peter's CofE Primary School	Milnthorpe
Lanesfield Primary School	Wolverhampton
Lyminge Church of England Primary School	Folkestone
Mead Vale Community Primary School	Weston-Super-Mare
St Bernadette's Catholic Primary School	Stockport
St Margaret Ward Catholic Primary School	Sale
St Thomas More Roman Catholic Primary School	Chatham