Department for Education

Achievement of 15-Year-Olds in England: PISA 2015 National Report

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Executive summary

Introduction

The Programme for International Student Assessment (PISA), led by the Organisation for Economic Co-operation and Development (OECD), provides evidence on how the achievement and abilities of 15-year-olds varies across countries. PISA is conducted every three years, and pupils are tested in four subjects (science, mathematics, reading and collaborative problem solving), with one subject the particular focus each time. Together these data enable us to benchmark ourselves against the rest of the world, and to spot particular strengths and weaknesses in our education system.

PISA is conducted every three years and is centred around a direct assessment of pupils' science, mathematics and reading abilities. Each year one of these subjects is covered in more detail – science in 2015 – and pupils are also assessed in an innovative domain – collaborative problem solving[1] in 2015. In 2015 PISA was administered in the majority of countries as a computer-based assessment (CBA) for the first time.

Over 70 countries participated in PISA 2015, including all members of the OECD and all four countries within the United Kingdom. In England, PISA 2015 was conducted in November to December 2015, with a sample of 5,194 pupils in England from across 206 schools. The vast majority of England's participating pupils were born between September 1999 and August 2000, meaning they came to the end of primary school during 2010, and were the last cohort to take the GCSE examinations before they are reformed.

Highlights

The average science, mathematics and reading scores of pupils in England have not changed since 2006. Our 15-year-olds continue to perform significantly above the OECD average in science whilst they remain at the OECD average for mathematics. For the first time in 2015, pupils in England perform significantly, but only just, above the OECD average in reading.

Although there has been no significant change in England's absolute score, our performance relative to other countries has changed since 2012 as they improve or decline around us. The OECD average has fallen (but only significantly in science) meaning that England's reading performance is now above average despite having not changed since 2012, and our relative science position has increased compared to 2012 as other countries' average scores have dropped. Whilst performance in England has not changed there have been changes in other parts of the United Kingdom, notably declines in average science performance in Scotland and Wales.

East Asian countries continue to dominate the top positions in PISA. Singapore tops

[1] The results of the collaborative problem solving assessment will be released by the OECD in 2017.

PISA 2015 in science, reading and mathematics. Shanghai, which came top across all three subjects in 2012, has been joined in PISA 2015 by three more Chinese provinces (Beijing, Jiangsu and Guangdong) and is no longer reported as a separate entity. China (B-S-J-G) performs similar to England in science and reading. It continues to outperform England in mathematics.

Achievement in science

The average science score in England has remained consistent since 2006 and is higher than the average score of 15-year-olds in 52 countries. There are just nine countries where the mean science score is at least 10 points (four months of schooling) ahead of England, including Singapore, Japan, Estonia and Taiwan – the top science performers in 2015.

Although England's average science score has not changed since 2006, other countries have moved around us. For example, Australia and New Zealand have undergone a sustained fall in their scores since 2006 and are now at a similar level to England, having been previously ahead. The average science score has also fallen in Finland, though it remains a high-performing country. Portugal and Macao, meanwhile, are two of the few countries where there has been a statistically significant and sustained improvement in science achievement since 2006.

The comparatively high science performance of England's high-achievers is a notable strength of the English educational system; this country has some of the best young scientists anywhere in the world. There are only three countries (Singapore, Taiwan and Japan) where the top 10 per cent of pupils are more than one school term (four months of schooling) ahead of their peers in England. However, the gap between the highest and lowest achieving pupils in science is also bigger in England than in many other OECD countries.

Pupils in England achieve approximately the same scores in what PISA defines as the living scientific system (which roughly equates to biology), physics and earth and space sciences. This is similar to the situation in many of the top-performing countries.

Although boys in England have achieved a higher average score in science than girls in the past, in 2015 there is no evidence of a gender gap in performance.

Achievement in mathematics

The average mathematics score for England has remained stable since 2006. There are 18 countries where the mean score is at least a third of a year of schooling ahead of England, and 36 countries where the mean mathematics score is at least a third of a year of schooling below. The top seven ranked jurisdictions in PISA mathematics are all within East Asia. It is of note that while China are among the top seven performers; mathematics is the only subject in which China significantly outperforms England in 2015.

Although England’s average mathematics score has remained stable, a number of countries have caught England up over the last decade, including Italy, Portugal and Russia. On the other hand, the Czech Republic, Australia, New Zealand and Iceland all had higher average mathematics scores than England in 2006, but their mean mathematics score is now similar to ours. In tandem with their declining science performance, Finland, New Zealand, Australia and the Netherlands experienced substantial declines in average mathematics scores since 2006.

England’s top achievers in mathematics do not stand out in the same way as our top scientists. England has a similar proportion of high-achieving pupils as the average across members of the OECD, and our top maths performers are similarly placed internationally as we are in terms of our average performance.

Meanwhile, the relatively poor mathematics skills of England’s low-achieving pupils stands out as a weakness of England’s education system. England’s lowest achievers have mathematics skills that are significantly below the mathematics skills of the lowest achievers in several other countries. It is also notable how the bottom 10 per cent of mathematics performers in England trail those in Northern Ireland and Scotland, despite both countries having very similar average mathematics scores to England. Indeed, England has a particularly unequal distribution of 15-year-olds’ mathematics achievement. The gap between the highest and lowest achieving pupils in mathematics in England is above the OECD average and is equivalent to over eight years of schooling.

Boys continue to out-perform girls in mathematics in England (and most other countries). The mathematics skills of boys in England is, on average, around a third of a year of schooling ahead of girls. This compares to the results for reading, in which girls do better, and science where girls and boys are equal.

Achievement in reading

As is the case with science and mathematics, there is no evidence of a significant change in average reading scores in England since 2006.

There are nine countries where the mean reading score is at least a third of a year of schooling ahead of England, with the top performing countries including Singapore, Hong Kong, Canada, Finland and Ireland. By contrast, there are 41 countries where the mean reading score is at least a third of a year of schooling lower than in England.

As with the other subjects, England’s stability is in contrast to other countries which have moved around us. Some of the higher-performing countries in 2006 have experienced a decline in their reading scores, including South Korea, Finland and New Zealand, though they nevertheless remain ahead of us. Countries catching us up in 2015 include Russia and Portugal (both of which have also caught up with us in mathematics), as well as Spain.

The performance of the top 10 percent of pupils in England is relatively strong in reading. Indeed, there are relatively few countries across the world where the highest-achieving pupils have substantially stronger reading skills than those in England, and only one (Singapore) where the top performers' average score is more than 20 points above the top performers' score for England.

The gap between the highest and lowest achieving pupils in reading in England is similar to the OECD average. However, this masks some important points. In only seven countries is the spread of results (in terms of the gap between the top and bottom 10 percent of performers) greater than in England. Only one of these – New Zealand – is a top-ten country (in terms of average reading scores), whilst six of the top-ten countries have significantly smaller differences between the best and worst readers compared to England.

Boys in England continue to perform less well than girls in reading by an average of around nine months of schooling. This is not an unusual finding; there is a similar gender gap in reading skills in many other OECD countries.

Variation in scores by pupil characteristics

There is a relatively large gap in England between high and low performers. The difference between the top and bottom 10 per cent of pupils in England is over eight years of schooling in both science and maths – a larger gap than in most OECD countries. A number of factors contribute to this gap.

Differences in pupil's socio-economic background will explain some of the variation since more advantaged pupils perform better on average than their less advantaged peers. For example, in science, the gap between pupils from the most and least advantaged 25 per cent of families is almost three years of schooling. However, the size of this gap is very similar to the average across industrialised countries. Moreover, in some countries the strength of relationship between socio-economic status and achievement is much stronger than in England; e.g. China and Singapore. Yet in others, such as Hong Kong, the relationship is weaker.

Pupil performance in England also varies according to immigrant status. Pupils from immigrant backgrounds achieve lower scores than those who were born and raised in the UK. Again, England is not unusual in this respect. White pupils in England also obtain higher scores than their Black and Asian peers although White pupils from less advantaged backgrounds perform significantly lower than more advantaged White pupils.

Differences in achievement between schools

In England, there are bigger differences in achievement amongst 15-year-olds who attend the same school than there are differences in achievement between pupils who attend different schools. This is not unusual for a country with a comprehensive schooling system, with a similar finding occurring across a diverse set of countries within the OECD (e.g. Finland, South Korea, the United States). The same does not hold true in countries where academic selection into secondary schools is used, such as the Netherlands and Germany, where differences in achievement are just as big between schools as they are within schools.

Whilst differences across schools are not as large as in other countries, they do still exist. Pupils in outstanding Ofsted-rated schools perform better than their peers in schools rated as inadequate/requiring improvement. The difference in science is around two years of schooling (with similar gaps in mathematics and reading). Comparing performance across schools managed or governed in different ways, the top performing schools are independents. Their performance in science puts them level with 15-year-olds in the top-performing countries, such as Singapore. Independent school pupils are also around a year of schooling ahead of the next highest achieving group in England, converter academies, who are then around a year of schooling ahead of voluntary-aided and controlled schools. Performance is lowest in sponsored academies, where the average science score is 480 points – equal to the overall performance of countries like Italy, Hungary and Luxembourg.

When looking at school admissions policies, pupils who attend grammar schools are the top performing, with a difference of almost a year of schooling in both science and mathematics compared to their peers who attend an independent school. Yet when looking across countries, it is apparent that there is little association between the use of academic selection to assign pupils into different secondary schools and the proportion of disadvantaged pupils who manage to succeed academically against the odds. Some caution is required, however, when considering the differences in achievement between schools. In particular, as no control has been included for pupils' prior achievement, these results cannot be interpreted as providing evidence of differential pupil progress or of school effectiveness.

School management and resources

Headteachers in England are more likely to report being proactive in the management of their schools than in other countries (including those with the highest average science scores). For example, a greater proportion of headteachers in England use pupil performance data in setting their school's educational objectives than in any of the ten countries with the highest average science scores. Moreover, headteachers in England are more positive about the science resources that are available within their school than in the typical OECD or high performing country. Likewise, they are generally positive about the science equipment that their school has available. Headteachers in England are less likely to report that their staff are resistant to change.

Headteachers in England do also face a number of challenges. Almost half of secondary school pupils in England are taught in schools where the headteacher believes that staff shortages are hindering learning; this is 15 percentage points above the OECD average and the average across the 10 high-performing countries. Headteachers in England are also more likely to report problems with physical infrastructure than headteachers in other industrialised countries. Another key concern of headteachers in England is the level of absenteeism amongst their staff;

a quarter of secondary pupils are taught in schools where the headteacher believes that this is hindering pupils' learning.

There are also key challenges facing headteachers managing low performing schools (in terms of Ofsted inspections). For instance, whereas only 19 per cent of headteachers who lead an outstanding school agree that their staff do not meet individual pupils' needs, this increases to 42 per cent in schools that require improvement, and up to 77 per cent for the inadequate group. Therefore, targeting the way teachers interact with pupils could be a way to improve lower performing schools.

Pupils' experiences of their time in science classes at school, and their aspirations for the future

Secondary school pupils in England report having almost five hours of timetabled science lessons per week, which is more than the OECD average (3.5 hours) and the average across the high-performing countries (four hours). Pupils in England report around 16.5 hours per week of additional study (i.e. hours outside of pupils' regular timetable). Only two of the 10 high-performing countries (Singapore and China) report higher additional study hours.

In science lessons, pupils report a variety of activities taking place, and in general, classrooms in England appear more interactive than in high performing countries. Despite this, pupils in England are only slightly more likely to conduct investigations to test an idea, and are less likely to argue about and debate science questions and investigations.

Science teachers in England provide more regular feedback to pupils on their strengths and weakness, including specific areas they can improve, than teachers in many of the countries with the highest average scores. Within England, pupils with lower levels of achievement report receiving more regular feedback from their science teachers than pupils with higher levels of achievement.

There is more frequent low-level disruption in science classrooms in England than in the average high-performing country. There is a particularly stark contrast between science classrooms in England and science classrooms in the high-performing East Asian nations in this respect.

Most pupils in England believe that the content of their school science lessons is helping to prepare them for the future; around three-quarter agree that it will help them to get a job and that it will improve their career prospects. More than a quarter of pupils (28 per cent) in England hope to be working in a science related career by age 30. This is above the average across industrialised countries (24 per cent) and the average across high-performing countries (22 per cent).

PISA across the UK

The average science score in England (512) is significantly higher than in Northern Ireland (500) and Scotland (497). Pupils in each of these three countries achieve significantly higher science scores than pupils in Wales (485). In reading and mathematics, average scores are similar across England, Northern Ireland and Scotland, with Wales again significantly behind the rest of the UK. Whereas average scores have remained stable in England and Northern Ireland since 2006, there has been a sustained 20 point (eight months of schooling) decline in science scores in Wales. Similarly, there has been a 15 point (six months of schooling) decline in PISA mathematics scores in Scotland between 2006 and 2015.

Socio-economic inequality in 15-year-olds' science achievement, as measured by the relationship between pupil background and attainment, varies across the UK. Inequality in pupil outcomes is similar in England, Scotland and Northern Ireland. In Wales, however, the link between socio-economic status and performance in PISA is weaker. This is due to the comparatively weak academic performance of pupils from the most advantaged socio-economic backgrounds in Wales, relative to their equally advantaged socio-economic peers in England, Scotland and Northern Ireland.

Generally speaking, the proportion of headteachers reporting inadequate or poorly qualified teachers or teaching assistants was similar in the UK to the rest of the OECD, and particularly low in Northern Ireland and Scotland. Teacher supply is considered much less of a problem in Northern Ireland and Wales than it is in Scotland and England. Teachers not meeting individual pupils' needs also stands out as a particular concern to headteachers in England and Scotland, less so in Northern Ireland and Wales.

The importance of PISA to policymakers in the UK should not be under-estimated. As noted by Taylor, Rees and Davies (2013), within-UK comparisons are interesting from both an academic and education policy perspective. Yet, due to a lack of accessible and comparable national examination data, relatively few 'home international' comparisons have been conducted. PISA is an important exception. By drawing separate samples for England, Northern Ireland, Scotland and Wales, PISA allows us to make comparisons across the UK, spotlighting key differences in policy and performance since devolution, and in the broader context of what is going on in the world around us.

Chapter 1. Introduction

1. The aim of this report is to provide a first insight into how young people in England perform on the PISA science, reading and mathematics assessment in 2015. This includes comparing scores achieved by pupils in England to their peers in other countries, and investigating differences between groups of pupils and schools within England.

2. PISA (the Programme for International Student Assessment) is a global benchmarking study of pupil performance managed by the Organisation for Economic Co-operation and Development (OECD)[2]. It provides a comparison of what 15-year-olds across the world know and can do in the core subjects of science, reading and mathematics. Additionally, contextual information collected from pupils and their school enables associations between performance and other factors, such as pupil engagement or teaching resources, to be compared between and within participating countries.

3. The inaugural PISA study took place in 2000.The study has since been conducted on a three-year cycle with an alternating focus on reading, mathematics or science. In 2015 the main focus of the assessment was science. In total, 72 countries and territories[3] participated in this round of PISA - including all OECD member states. Within this national report results are presented separately for England, Northern Ireland, Scotland and Wales (bringing the total number of countries up to 75). As Chapter 11 will reveal, diverging education policies and differing economic contexts across the four UK countries may be resulting in variation in patterns of educational achievement. Table 1.1 provides a list of all countries that took part in 2015[4].

4. This chapter introduces PISA 2015 and our analyses of the data for England. It does so by addressing the following questions:

- *What data were collected as part of PISA 2015, and how?*
- *Have there been any methodological changes since the last PISA cycle?*
- *What can PISA tell us? (And what can it not tell us)?*
- *How will the rest of the report be structured?*

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[2] The OECD is an international organisation of industrialized countries. Its mission is to 'promote policies that will improve the economic and social well-being of people around the world'.
[3] From this point forward, 'countries' will refer to countries and territories.
[4] See the OECD website for a full list of countries that have participated in each round of PISA: https://www.oecd.org/pisa/aboutpisa/pisaparticipants.htm

Table 1.1 Countries participating in PISA 2015

Albania	**Estonia**	Lebanon	Russia
Algeria	**Finland**	Lithuania	**Scotland**
Argentina+	**France**	**Luxembourg**	Singapore
Australia	Georgia	Macao	**Slovakia**
Austria	**Germany**	Macedonia	**Slovenia**
Belgium	**Greece**	Malaysia+	**Spain**
Brazil	Hong Kong	Malta	**Sweden**
Bulgaria	**Hungary**	**Mexico**	**Switzerland**
Canada	**Iceland**	Moldova	Taiwan
Chile	Indonesia	Montenegro	Thailand
China*	**Ireland**	**Netherlands**	Trinidad and Tobago
Colombia	**Israel**	**New Zealand**	Tunisia
Costa Rica	**Italy**	**Northern Ireland**	**Turkey**
Croatia	**Japan**	**Norway**	United Arab Emirates
Cyprus+	Jordan	Peru	**United States**
Czech Republic	Kazakhstan+	**Poland**	Uruguay
Denmark	**South Korea**	**Portugal**	Vietnam
Dominican Republic	Kosovo	Qatar	**Wales**
England	**Latvia**	Romania	

Notes: Table includes all countries/territories participating in PISA 2015. Members of the OECD are highlighted in **bold**. + indicates limitations with the data meaning exclusion from the report. Although there are 35 members of the OECD, 38 countries are in bold as the United Kingdom is split into four separate countries throughout this report.

* *China* refers to the four Chinese provinces that participated (Beijing, Guangdong, Jiangsu and Shanghai).

1.1 What data have been collected as part of PISA 2015?

5. In England, PISA was conducted between November and December 2015. A total of 206 schools and 5,194 pupils took part. The study was carried out on behalf of the Department for Education by England's National Centre, a consortium of RM Education, UCL Institute of Education and World Class Arena Limited. The main component of PISA is a two-hour test, which assesses the ability of the sampled 15-year-olds to address 'real life' challenges in these academic domains. This differentiates PISA from General Certificate of Secondary Education (GCSE) exams and other international pupil assessments, such as the Trends in International Mathematics and Science Study (TIMSS) that aims to measure knowledge of particular curriculum content areas of the equivalent of our year 5 and year 9 pupils. The most recent TIMSS study also took place in 2015 and the results were published in November 2016 – see Box 1.1 for further information.

Box 1.1 Differences between PISA, TIMSS and GCSEs

PISA tests pupils' skills in reading, mathematics and science; subjects that are also assessed in the Trends in International Mathematics and Science Study (TIMSS) and our national General Certificate of Secondary Education (GCSE) exams. Although there is a strong correlation between PISA scores and GCSE grades, there are also important differences in terms of patterns of pupil performance. In this box, we describe some of the key differences between PISA, TIMSS and GCSEs:

Type of skill assessed: Whereas GCSEs examine pupils' knowledge of specific content and application of specific techniques as defined by national curricula, PISA measures pupils' 'functional skills' – their ability to apply knowledge to solve problems in real world situations. This is also in contrast to other international studies, such as TIMSS, where the assessment framework is aligned to a set of content agreed by the International Association for the Evaluation of Educational Achievement (IEA) who oversee the study.

Timing: In England, the PISA tests were sat in November/December 2015 by pupils around age 15 at the beginning of year 11. This is six months before GCSE exams, which were taken in May/June 2016. The TIMSS tests were sat in May/June 2015 by pupils approaching the end of years five and nine (age 9-10 and 13-14).

Test administration mode: Whereas the PISA 2015 tests were all completed on computer, GCSEs continue to be paper-based examinations. TIMSS assessments were also paper-based in 2015.

Question style: Previous analysis of the PISA test questions found that they typically require a greater amount of reading than GCSE exams, particularly in science. In 2015, the computer-based delivery of PISA meant pupils' investigative skills were assessed for the first time in science. TIMSS questions are very similar in style to our national Key Stage 2 assessment questions.

Stakes: PISA and TIMSS are 'low stakes' tests for pupils; pupils do not receive any feedback about their performance and have little riding upon the results. In contrast, GCSEs are 'high stakes' exams, with all pupils receiving a grade that potentially has an impact upon their future educational options and career.

6. In addition to the PISA test, 15-year-olds in all participating countries completed the 'pupil questionnaire', which asked detailed information about pupils' economic and social background, attitude towards school, out-of-school activities and life satisfaction. Two additional 'ICT literacy' and 'educational career' questionnaires covered the frequency and quality of out-of-school tuition, parental involvement with homework and use of computers at home and in school. By using data from these questionnaires, this report will also provide an analysis of 15-year-olds' perceptions of teaching practice in their schools, and their aspirations and expectations for the future.

7. In all countries, headteachers of participating schools were also asked to complete a background questionnaire. This included questions regarding school resources, quality assurance processes, perceived barriers to learning and the impact of school inspections. Analysis of these data will also be presented within chapter 8 of this report.

8. All analyses presented within this report are correct as of the data received by the authors on 4th November 2016.

1.2 How was the PISA 2015 sample recruited in England? And how representative is it of the population?

9. In England in 2015, information was collected from 206 schools and 5,194 pupils reflecting official response rates of 92 per cent for schools and 88 per cent for pupils, and exceeding the strict minimum response rates required by the OECD[5].

10. A two stage survey design is used to select schools and pupils to take part in the study. Schools in England were randomly selected to be representative of the national distributions of school type (e.g. independent, academy), location and historical GCSE performance., As there are only 19 independent schools, 28 selective schools and nine 'inadequate' schools (as rated by Ofsted) in the PISA 2015 sample for England, estimates for these particular school types will be accompanied by relatively large margins of error.

11. Within each school, a simple random sample of 30 pupils who met the PISA age definition were selected to participate[6]. In England, this translated to an initially selected sample of 6,254 pupils. A total of 5,194 of these pupils completed the PISA assessment, with 704 pupils absent on the day of the test, 285 pupils excluded from

[5] The OECD requirements stipulate that the school-level response rate is at least 85 per cent, and that at least 80 per cent of selected pupils participate in the study within selected schools. See Appendix B for further details.
[6] Further details on this process can be found in Appendix B.

the sample (primarily due to Special Educational Needs[7]) and 71 pupils ineligible as they did not meet the PISA population definition.

Table 1.2 The (state school) sample participating in PISA 2015 in England

	PISA sample	State school population
FSM eligible		
No	88%	87%
Yes	12%	13%
Ethnicity		
White	79%	76%
Asian	10%	10%
Black	5%	6%
Mixed	4%	5%
Other	2%	2%
Unknown / unclassified	1%	1%
Gender		
Female	49%	50%
Male	51%	51%
English as an Additional Language (EAL)		
No	85%	84%
Yes	15%	16%
School management group		
Academy Converter	43%	48%
Academy Sponsor Led	22%	16%
Community School	18%	17%
Other	8%	8%
Free school	0%	1%
Voluntary	8%	9%
School admissions policy		
Comprehensive	93%	95%
Selective	7%	5%
Total number of pupils	**4,742**	**530,448**

Source: PISA 2015 matched database, Department for Education (2016a) and House of Commons (2016).

Notes: Figure for PISA sample based upon weighted data. Although PISA collects data from state and independent school pupils, this table refers to state school pupils only. Figures may not sum to 100 per cent due to rounding.

[7] In PISA, all countries attempt to maximise the coverage of 15-year-olds enrolled in education in their national samples. The sampling standards permit countries to exclude up to five per cent of the relevant population, for reasons such as Special Educational Needs. Of the 285 pupils excluded from the PISA sample in England, 61 per cent had a Special Educational Need.

12. Overall, there is relatively little difference in the distribution of pupils according to observable characteristics between the pupils from state-funded schools within the PISA sample and the population of pupils in state-funded schools in England (see Table 1.2). Further analysis of the characteristics of responding and non-responding pupils and schools in England can be found in Appendix B.

13. Although the PISA 2015 data for England are representative of the target population, the fact they are based upon a sample (rather than a census) means there will be a degree of uncertainty in all estimates derived using these data. To reflect this uncertainty within our analysis in this report we have included 95 per cent confidence intervals within many of the graphs to represent not just the value of the estimate, but also the interval in which we expect this value might have been had we taken a different sample of the same size[8]. For many of the demographic groups presented in Table 1.2, sample sizes in PISA are relatively small. For instance, only 224 of the pupils who completed the PISA test are of Black ethnicity. Similarly, a total of 519 pupils who took part in PISA were eligible for Free School Meals (FSM). There will consequently be quite a large degree of sampling error in the results reported for these particular sub-groups.

14. We will also state whether a difference between two estimates (e.g. in average PISA scores between two countries) is 'statistically significant' or not. This simply means that we can be 95 per cent certain that the difference between the estimates would also exist had we taken a different sample. Note that 'statistical significance' does *not* mean a difference is big, or necessarily of substantive importance. Indeed, in large samples such as PISA, even quite small differences can reach statistical significance[9].

1.3 Have there been any important changes to PISA since the last round in 2012?

15. A number of changes have been made to PISA in 2015 since the 2012 cycle. The main study used computer-based assessment (CBA), instead of the more traditional paper-based assessment (PBA), for the first time. Moreover, as PISA 2015 focussed on scientific performance, a greater number of assessment items tested 15-year-olds' competence in science than in reading or mathematics. New, interactive science questions have also been introduced, while there have also been some changes to how test questions have been scored and converted into the PISA

[8] If one were to repeat the PISA sampling process 100 times, one would expect any given estimate for England to fall between the upper and lower confidence interval on 95 occasions.
[9] The complex survey and test design of PISA makes accurate estimation of standard errors, confidence intervals, and statistical significance tests non-trivial. Throughout this report we use the *repest* package developed by analysts from the OECD (Avvisati and Keslair 2014) and implemented within the statistics package *Stata*.

proficiency scales. Pupils' collaborative problem solving skills were also tested for the first time within the PISA 2015 assessment[10].

16. There are three main implications of science being the focus of PISA 2015 when compared to the previous two cycles (when mathematics and reading were the focus of the study). First, the assessment included a greater number of science test questions. Pupils' ability in science is therefore measured with greater precision. Second, a more detailed analysis of 15-year-olds' science competency is possible. This includes a breakdown of science performance by 'cognitive' (how well pupils have mastered science skills) and 'content' (knowledge of particular scientific phenomena) domains. Finally, as the background questionnaires also focused upon science, a more detailed analysis of pupils' attitudes, expectations and beliefs about science is possible.

17. The change to computer-based assessment offers a number of administrative advantages, including efficiencies in marking, the introduction of new interactive questions, and the provision of additional information on the techniques pupils use to answer test items. It also enables the assessment of some new aspects of science that are included for the first time within the PISA 2015 science competency framework, including pupils' ability to solve problems in a simulated scientific experiment using scientific techniques.

18. A number of other technical aspects of the PISA study have changed in 2015 from previous rounds. This includes an increase in the number of 'trend' items included in the test, alterations to the statistical model used to scale the PISA scores and changes to how test questions not reached by pupils are treated. The PISA measure may also be impacted by changes to the administration of the test, or the ways in which pupils interact with the assessment items. The change of assessment mode therefore introduces a challenge in comparing performance measured by computer-based assessment with performance measured by paper-based assessment (both across cycles, and between countries who conducted the PISA 2015 assessment on computer to those that conducted the 2015 assessment on paper[11]).

19. To adjust for the change in test administration mode and to ensure that PISA 2015 scores are comparable with the scale established for the paper-based assessment, the OECD have used test questions that are not subject to large mode differences. Further details on this methodology and the impact of other technical

[10] The collaborative problem solving results are due to be released by the OECD in 2017, and are therefore not covered in this report.
[11] A total of 15 countries participating in PISA 2015 continued to use paper-based assessment: Albania, Algeria, Argentina, Georgia, Indonesia, Jordan, Kazakhstan, Kosovo, Lebanon, Macedonia, Malta, Moldova, Romania, Trinidad and Tobago, and Vietnam.

changes on the pattern of results from previous cycles are available from the OECD in the Annex of the international PISA 2015 report.

20. Finally, in May 2015 an error was identified in the layout of the PISA 2012 pupil questionnaire administered in the Welsh language. The error was not large enough to have a detectable impact on the UK's PISA 2012 results. However, it does have a small impact on estimates of overall scores and gender differences for Wales, Northern Ireland and England. As the impact is only small, this report uses the original PISA 2012 results. Annex F provides a more detailed description of the error and the revised estimates as published by the OECD in May 2015.

1.4 What can PISA tell us? (And what can it not tell us?)

21. PISA provides comparative evidence on the 'functional ability' of 15-year-olds in three specific subjects. It allows one to describe the distribution of 15-year-olds' abilities in the subjects that PISA tests, how this compares across countries, and how such skills vary by demographic group. For instance, PISA can be used to address questions such as 'how big is the difference in the science performance of 15-year-olds in England and the highest performing countries' and 'is the relationship between socio-economic status and achievement stronger in England than in other members of the OECD'?

22. PISA can also be used to establish the *correlation* between academic achievement and a range of potential explanatory factors. This includes pupils' attitudes, expectations and beliefs, school-level factors (e.g. school resources and management strategies) and system-level characteristics (e.g. amount of school autonomy). It is therefore a useful benchmarking tool that can help teachers, schools and policymakers understand the relative strengths and weaknesses of young people at a particular point in their development.

23. Increasingly, PISA also provides important contextual information about other aspects of pupils' lives. For instance, in addition to testing pupils' skills, PISA 2015 also includes data on their ambitions, anxieties, social interactions, and life satisfaction. Together, this can direct government and educators towards the areas and groups in the most need of assistance.

24. Despite these strengths, PISA also has limitations. It is therefore important to clearly state what these data, and the analysis presented in this report, can and cannot reveal.

25. PISA scores are the culmination of all the factors influencing 15-year-old pupils' skills throughout their early life. This will include schools (both primary and secondary) and government education policy. Yet it will also encompass the time

and monetary investments made by parents, young people’s attitudes and motivation, early lifetime conditions e.g. attending pre-school, macro-economic forces (e.g. economic prosperity, inequality) and a host of other factors. Consequently, it is not appropriate to treat PISA as a direct indicator of the ‘quality’ of England’s schools. Moreover, due to the host of factors influencing pupils’ test scores, some of which cannot be observed within the data, PISA can typically only identify correlations between variables, rather than establishing *causation*. However, what PISA can provide is a descriptive account of how the distribution of 15-year-old pupils’ skills vary by school-level characteristics (e.g. by school inspection rating). It also provides contextual information on issues such as school organisation and administration.

26. Additionally, PISA is a cross-sectional survey, providing a snapshot of pupils’ skills at one point in time. It therefore does not provide any information about the *progress* young people make during their time at school. Consequently, it is not possible to establish whether secondary schools in any particular country facilitate more academic progress than others.

27. Finally, PISA scores can increase or decrease for many substantive reasons; changing economic conditions, changing demographics due to immigration, shifts in attitudes towards education and out-of-school parental investments, for example. It is therefore not possible to attribute change in a country’s performance as direct evidence for or against any particular national policy (or set of policies). Trends in PISA results should therefore not be taken as providing robust evidence as to the direct impact of any previous or on-going educational reform.

1.5 Which countries should we compare England to?

28. There are several possible countries (or groups of countries) that it might be particularly useful to compare to England. One common choice is the OECD average; the average outcome amongst the 35 members of the OECD. This has the benefit of considering England’s outcomes relative to the benchmark of other industrialised countries; those with a level of resources that are at least broadly comparable to our own. As Table 1.1 illustrates the OECD is now quite a diverse group in itself and also excluding a number of countries with high levels of academic achievement, such as Singapore and Hong Kong.

29. Another possibility is to compare England to a set of ‘high-performing’ countries (however ‘high-performing’ may be defined). These countries are of obvious interest to policymakers, given their high levels of achievement. Yet focusing solely upon this group is not always the most relevant as many lessons can be drawn from similarly performing countries too.

30. One could choose to compare England to other countries where achievement levels have risen or declined substantially over a sustained period of time. This may provide a better way of identifying countries that have initiated change in educational outcomes, and therefore in identifying policies that could then be tested in England. However, identifying exactly what has led to change in a countries' performance is a notoriously difficult task.

31. Finally, one may try to compare outcomes in England to other 'comparable' countries. This could be, for instance, other parts of the UK, other English-speaking countries, countries with a similar education system, or of a similar population size. The benefit of this approach is that at least some of the factors which complicate international comparisons – such as differences in language or culture – may be at least partially ruled out. However, there are limitations to this approach as well, such as reducing the number of comparators to a small group of countries, while a number of potential explanations for any cross-national variation that occurs in the results are still likely to remain.

32. Each choice of who to compare England against therefore has both its benefits and advantages. With this in mind, throughout this report we will use a number of different comparators for England, including:

- The average across the 35 members of the OECD.
- The 10 countries with the highest average PISA scores; for most comparisons, this will refer to high performance in the science domain. (We label these the 'H10' countries throughout the report).
- Countries where the average score is above 450 points (in most comparisons this will be in respect to the science domain).
- The other three countries that make up the United Kingdom. These comparisons will be the specific focus of Chapter 11.

1.6 How will the rest of the report be structured?

33. The remainder of this report will be structured as follows. **Chapters 2 to 5** will focus upon comparisons of England's performance in the PISA science, mathematics and reading assessment. As science was the focus of PISA 2015, a detailed comparison of performance across content and cognitive domains will be presented for this particular subject in chapter 3. Each chapter includes information on the distribution of pupils' test scores, an overview of how average performance in

England has changed over time[12], and how this compares to a selection of other countries.

34. **Chapter 6** moves on to the association between PISA scores and key demographic characteristics. We start by investigating the link between socio-economic background and performance in England, and how this compares to other countries. A similar analysis is then performed for differences in achievement between migrants and natives. The final sub-section then focuses upon differences by ethnicity, including the performance of the White working class.

35. In **chapter 7**, we turn to differences in performance within England at the school level. Following the structure of the previous chapter, it documents how average scores vary by a set of school-level characteristics. This includes differences by school management type (e.g. academies, independent schools), admissions policy (e.g. grammar, comprehensive) and Ofsted inspection rating.

36. **Chapter 8** focuses upon the views of headteachers in England, as captured by their responses to the PISA school questionnaire. This includes an analysis of headteachers' management styles, the factors that they believe to be hindering instruction within their school, and if they feel that their school is adequately resourced. The views of headteachers in England are first compared to the views of headteachers in other countries, in order to provide an international comparative context for the results. We then explore variation in headteachers' responses within England, focusing upon differences between those leading schools with different Ofsted ratings, and between different types of school. In doing so, chapter 8 will highlight what headteachers in England believe to be the most significant barriers to learning within their schools.

37. Investigation of pupils' responses to the PISA background questionnaire follows in **chapter 9**, with an emphasis upon how they view science teaching within their school. England is compared internationally in terms of the frequency different learning activities occur within their science lessons, and the amount of feedback that they receive about their performance. Attention is also paid to how much time 15-year-olds in England spend learning science each week compared to other subject areas, both inside and outside of school.

38. Previous research has illustrated the important role young people's aspirations play in shaping their future[13]. **Chapter 10** therefore investigates the

[12] Although the PISA study began in 2000, the UK did not meet the strict data requirements of the OECD in the first two waves (2000 and 2003). Comparisons of PISA scores for England can therefore not be made before 2006.

[13] Morgan (2005).

aspirations and expectations of 15-year-olds in England, and how this compares to the aspirations of young people in other parts of the world. As science is the focus of PISA 2015, particular attention is paid to the proportion of young people in England who aspire to a Science, Technology, Engineering or Mathematics (STEM) career, and the extent to which they believe that their school science lessons are relevant for their educational and occupational future. We also investigate 15-year-olds' plans regarding higher education, including the proportion who believe they will obtain at least an undergraduate degree, and the institution they hope to attend. For each of these topics, the situation in England is first placed into an international comparative context, before further investigation of within-country differences between certain demographic groups (including gender and socio-economic status).

39. The **final chapter** focuses upon differences in outcomes between the four constituent countries of the United Kingdom. This includes how test scores vary across the UK, and whether gender and socio-economic gaps are bigger in certain parts of the UK than others. It concludes by exploring differences between England, Northern Ireland, Scotland and Wales in pupils' and headteachers' responses to the background questionnaires. This includes whether there are differences in headteachers' views on the factors hindering instruction within their school, and in describing the amount of time 15-year-olds spend studying science compared to other subject areas.

Chapter 2. Achievement in science

- On average, young people in England score 512 on the PISA 2015 science test. England's score has remained broadly stable over the past decade since 2006 (when the average for England was 516 points).
- England is among the high performing OECD countries for science (having scored above the OECD science average every year since 2006). England maintained this performance in 2015, scoring significantly higher than the OECD average of 493.
- Science was England's top PISA subject in 2015, with15-year-olds scoring higher in science (on average) than in either reading or mathematics. This was also the case in 2012.
- Whilst England has shown no material improvement in their score since 2006, it is notable that very few other countries have managed to substantially increase their scores over the same period. In fact, several other countries (including Finland, New Zealand and Australia) have seen their average science score decline by 10 points or more. There has been a sharp drop in average science scores in a number of high-performing countries between 2012 and 2015, including Finland, Hong Kong and South Korea.
- England has a greater proportion of top-performing pupils in science (12 per cent) than the average across members of the OECD (8 per cent). England's top-performing pupils are amongst the world's best 15-year-olds in science.
- Whilst the strong performance of high-achievers has helped to maintain England's position in PISA science, there remains significant inequality in science performance in England. The gap between the highest and lowest achieving pupils in science (at 264 points) is bigger in England than the average across industrialised countries (247 points). This is equivalent to more than eight years of schooling.
- Improving the basic science skills of low-achieving pupils is likely to be key to any future improvement in England's average science scores.

Box 2.1 Methods for interpreting differences between countries

1. **Country rankings**. This is where countries are placed in ranked order by a particular statistic (e.g. average scores) and the position of England is then compared to other countries. Although easy to communicate, this approach has at least three limitations; 1). First as PISA is based upon a sample rather than a census, we cannot be certain about the exact position of any given country. Consequently, two identical countries could end up with quite different rank positions (e.g. 20th versus 30th) simply due to sampling error; 2) rank order provides no information about the size of the achievement gap between countries; 3) the position of a country may change over time due to a change in the number (or selection) of countries taking part.
2. **'Statistically significant' differences**. One way to account for the fact PISA is a sample is to report whether differences are 'statistically significant'. In the report we therefore state whether there is a 'significant' difference between countries when we are almost certain that any difference between results is not due to sampling error. This overcomes one limitation of country rankings outlined above, but does not address the others including the magnitude of the difference between countries. Indeed, in large sample studies such as PISA, even relatively modest differences between countries can be reported as 'statistically significant'.
3. **Effect size differences.** Differences between countries can also be interpreted in terms of an effect size. This refers to differences between countries in terms of magnitude. An advantage of this approach is that it retains some information about differences in achievement between England and any given country of interest. Moreover, in large samples such as PISA, effect size differences of important magnitude will also typically be statistically significant.

Throughout this report, a combination of the second and third methods listed above will be used. When reporting average PISA scores, countries will be divided into five groups, based upon the number of test points they are ahead or behind England. This will also be expressed in terms of 'months of schooling' differences, following the OECD's rule of thumb that 30 test points is approximately equal to one additional year of schooling (see Appendix D for further details):

Group 1: These are countries with a mean score at least 20 points ahead of England (ahead by eight months of schooling)

Group 2: Mean score between 10 and 20 points (between four and eight months of schooling) ahead of England

Group 3: Mean PISA score within 10 points (four months of schooling) of England

Group 4: Mean score between 10 and 20 points (between four and eight months of schooling) below England

Group 5: Mean score between 20 and 30 points (eight to 12 months) below England

A star (*) will then also be placed by any country with a mean score

1. Ensuring sufficient scientific literacy amongst young people is important for England's economic prosperity, well-being and growth[14]. As the OECD states:

> '*societies will therefore require a cadre of well-educated scientists to undertake the research and the scientific technological innovation that will be essential to meet the economic, social and environmental challenges which the world will face*'[15].

It is therefore important to consider how the science proficiency of 15-year-olds in England compares to 15-year-olds elsewhere in the world. This chapter does so by answering the following research questions:

- *What is the mean science score in England, and how does this compare to other countries?*
- *How have average science scores in England changed over time? How does this compare to other countries?*
- *What proportion of pupils in England reach each science achievement level?*
- *How do the science scores of the highest achieving pupils in England compare to other countries?*
- *How do the science scores of the lowest achieving pupils in England compare to other countries?*
- *How big is the gap between the pupils with the strongest and weakest science skills? How does England compare to other countries in this respect?*
- *How big is the gender gap in science scores?*

2.1 What is the mean science score in England, and how does this compare to other countries?

2. The average scores of the top-performing countries are significantly ahead of England's mean score of 512. Singapore leads the way (556), followed by Japan (538), Estonia (534) and Taiwan (532). The average science score in these countries is estimated to be at least two terms of schooling (20 test points) higher than in England. These countries are included in panel (a) of Table 2.1.

3. Three East Asian economies (Macao, Hong Kong and Vietnam), one European country (Finland) and one English-speaking member of the OECD (Canada) sit within a second group which are between 10 and 20 test points higher than England.

[14] World Bank (2003).
[15] OECD (2013).

4. China, South Korea, New Zealand and a total of six European nations (including the Netherlands and Germany) are all within 10 points of England's average score, which are displayed in panel (c). Differences of this magnitude are equivalent to less than four months of schooling, and (with the exception of Ireland) are not significantly different from the mean score for England.

Table 2.1 Mean science scores

(a) Countries more than 20 points ahead of England

Country	Mean	Country	Mean
Singapore	556*	Estonia	534*
Japan	538*	Taiwan	532*

(b) Countries between 10 and 20 points ahead of England

Country	Mean	Country	Mean
Finland	531*	Vietnam	525*
Macao	529*	Hong Kong	523*
Canada	528*		

(c) Countries within 10 points of England

Country	Mean	Country	Mean
China	518	Australia	510
South Korea	516	Germany	509
New Zealand	513	Netherlands	509
Slovenia	513	Switzerland	506
England	512	Ireland	503*

(d) Countries between 10 and 20 points behind England

Country	Mean	Country	Mean
Belgium	502*	United States	496*
Denmark	502*	Austria	495*
Poland	501*	France	495*
Portugal	501*	Sweden	493*
Northern Ireland	500*	Czech Republic	493*
Norway	498*	Spain	493*
Scotland	497*		

(e) Countries between 20 and 30 points behind England

Country	Mean	Country	Mean
Latvia	**490***	**Wales**	**485***
Russia	**487***	**Luxembourg**	**483***

Source: PISA 2015 database.

Note: Bold font along with a * indicates mean score significantly different from England at the five per cent level. Countries highlighted in red not significantly different from England. Table does not include countries where the average science score is more than 30 points lower than in England.

5. It is also notable how England performs significantly higher than many of the Scandinavian countries (Norway, Sweden, Denmark) in PISA science, as well as several other industrialised countries, such as France, Spain and the United States. Scotland and Northern Ireland are also within panel (d), where the average science score is between 10 and 20 points lower than in England. The average score in Wales is, on the other hand, between 20 and 30 points lower than in England, sitting within panel (e).

6. It is important to note that Table 2.1 does not include any country with an average science score more than 30 points below the score for England. Results have therefore not been presented for 35 countries, including some members of the OECD, (such as Italy, scoring at 481). The average science score for England is also more than 30 points ahead of several Eastern European countries, such as Hungary (477), Croatia (475) and Slovakia (461). A full set of average scores, including all participating countries, is provided in Appendix E and the online data tables.

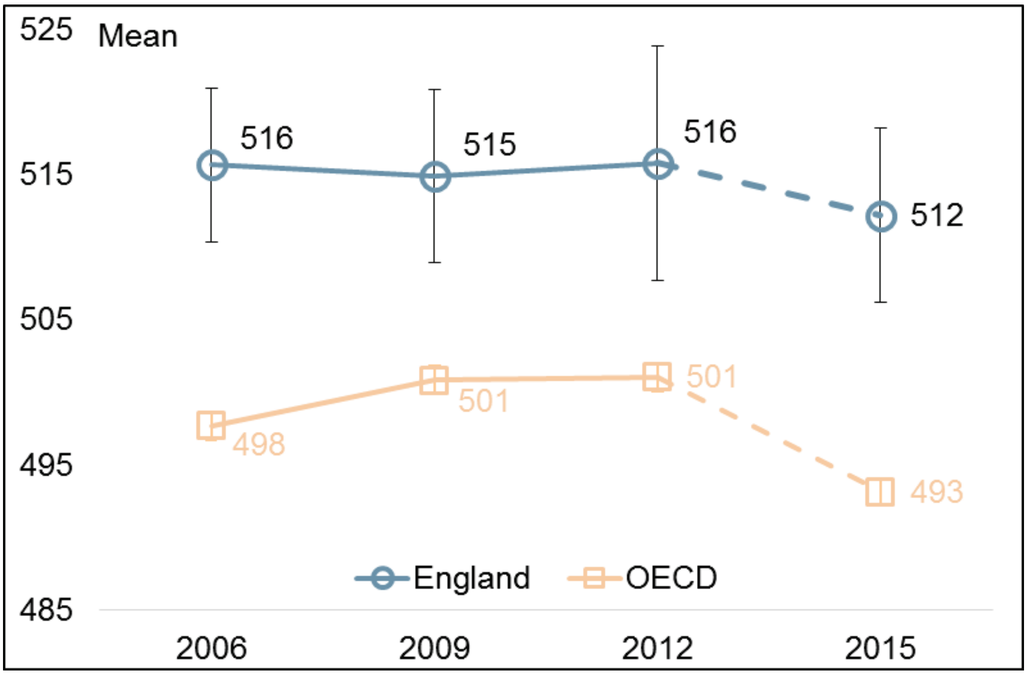
Key point

On average, 15-year-olds in England score 512 in the PISA science assessment. Of the other 70 participating countries, 15-year-olds perform at least 10 PISA points higher than England in nine other countries, and at least 10 test points lower than England in 52 countries (including Scotland, Northern Ireland and Wales).

2.2 How have average science scores in England changed over time?

7. There is no evidence of any significant increase or decrease in average science scores in England over the last decade, with the trend remaining broadly stable as illustrated by Figure 2.1 below. The average science score in England in 2015 (512) is not significantly different from the mean score in 2012 (516), 2009 (515) or 2006 (516).

Figure 2.1 Mean science scores for England between 2006 and 2015



Sources: Bradshaw et al. (2007), Bradshaw et al. (2010), Wheater et al. (2014), PISA 2015 database.

Note: The dashed line between 2012 and 2015 refers to the introduction of computer based testing. Thin line through each data point refers to the estimated 95 per cent confidence interval. OECD average based upon the 'AV09' results presented in the OECD international results Table I.2.4a. See Appendix F for further information on trends in performance over time.

8. There has been a general downturn in performance across countries since 2006; those with a mean PISA 2015 science score above 450 experienced, on average, a six-point decrease in their average score and very few countries have improved their science scores over this period. Of countries with a mean science score above 450 points[16], Portugal has experienced the greatest increase, improving by a statistically significant 27 test points. Macao, Israel and Norway are the only other countries with a greater than 10 point (four months of schooling) gain. In contrast, several other countries have seen a more than 20 test point (eight months of schooling) decline, including Finland, Wales and the Czech Republic. Further details are provided in panel (a) of Table 2.2.

[16] A total of 26 low performing countries have been excluded.

Table 2.2 The five fastest improving and declining countries in science

(a) PISA 2006 to 2015

Country	From	To	Change
Portugal	474	501	**+27***
Macao	511	529	**+18***
Israel	454	467	+13
Norway	487	498	**+12***
United States	489	496	+7
Czech Republic	513	493	**-20***
Wales	505	485	**-20***
Hungary	504	477	**-27***
Slovakia	488	461	**-28***
Finland	563	531	**-33***

(b) PISA 2012 to 2015

Country	From	To	Change
Portugal	489	501	**+12***
Taiwan	523	532	+9
Sweden	485	493	+9
Macao	521	529	+8
Singapore	551	556	+4
Ireland	522	503	**-19***
Lithuania	496	475	**-20***
South Korea	538	516	**-22***
Poland	526	501	**-24***
Hong Kong	555	523	**-32***

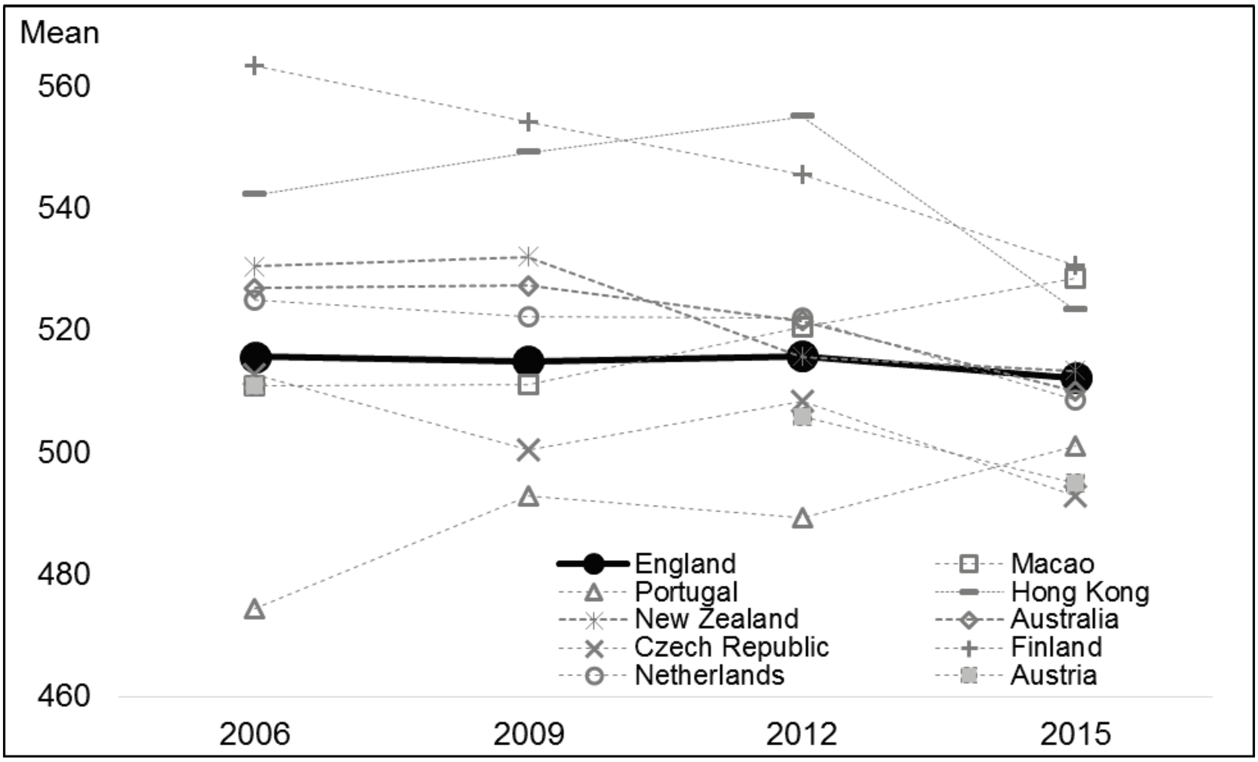
Source: PISA 2015 database.

Note: Figures illustrate the change between cycles in the mean PISA science score. Table restricted to only those countries with a mean score above 450 in the PISA 2015 science test. Bold font with a * indicates change statistically significant at the five per cent level. Figures in the ‘change’ column may not equal the difference between the ‘from’ and ‘to’ columns due to rounding.

9. A similar pattern emerges when considering change since the last PISA cycle conducted in 2012. Again, the average science score across countries has dropped, with an average decline of around eight test points between 2012 and 2015 amongst countries with a mean score above 450. Only in Portugal is there evidence of a statistically significant increase in mean science scores. On the other hand, a statistically significant fall in the mean score has occurred in several countries, with a more than 20-point decline in Hong Kong, Poland and Ireland. These are the results presented in panel (b) of Table 2.2.

10. Overall, countries with mean scores around and above England have mostly remained stable or declined over the last decade. New Zealand (530), Australia (527) and the Netherlands (525) had a higher average score than England in 2006, but differences between these countries are not statistically significant in 2015. Likewise, whereas Austria (511) and the Czech Republic (513) were similar to England in 2006, their mean score has since declined by around 15 test points, down to 495 and 493 respectively. Notable exceptions to this pattern are Macao and Singapore. Average science scores in England were similar to the former in 2006 (516 versus 511), yet whereas England's average score has remained stable, the average score in Macao has improved by around half a year of schooling to 529. Figure 2.2 provides results for a selection of countries, with further details in Appendix F.

Figure 2.2 Long-term trends in science scores across countries



Source: OECD international data Table I.2.4a.

Notes: The average three-year trend in science scores is statistically significant in all countries except England. No data available for Austria in 2009. Further details are provided in Appendix F.

Key point

There has been no statistically significant change in England’s average science score since 2006. In contrast, there has been a statistically significant downward trend in average science scores amongst some of the highest-performing countries, including in Finland, Australia, New Zealand, and the Netherlands between 2006 and 2015. Portugal and Macao are two notable exceptions where there has been a sustained increase over this period.

2.3 What proportion of pupils in England reach each science achievement level?

11. Although two countries may have similar average science scores, there could be marked differences in the distribution of pupils’ performance. There may, for instance, be important differences between these countries in their share of ‘top-performing’ pupils and the proportion of ‘low-achievers’. This matters from a policy perspective as a country’s share of high-level skills is ‘*critical for the creation of new knowledge, technologies and innovation and therefore an important determinant of economic growth and social development*’[17].

12. Similarly, if a country has a large proportion of low-achieving pupils, it suggests that the education system may not be equipping some young people with the basic science skills they need to function adequately in later life. This sub-section therefore focuses upon the proportion of 15-year-olds in England who reach each of the PISA science levels, with a particular focus upon the proportion of ‘low-achievers’ and ‘top-performers’.

13. In order to describe the distribution of pupils’ performance, the OECD divides the PISA science scale into different achievement levels. These range from Level 1b (very low levels of achievement) through to Level 6 (very high levels of achievement). Table 2.3 provides a description of these achievement levels, along with an explanation of the types of tasks they correspond to. Throughout this report, ‘low-achievers’ refers to pupils scoring below PISA Level 2, while ‘top-performers’ score at PISA Level 5 or above.

[17] OECD (2009).

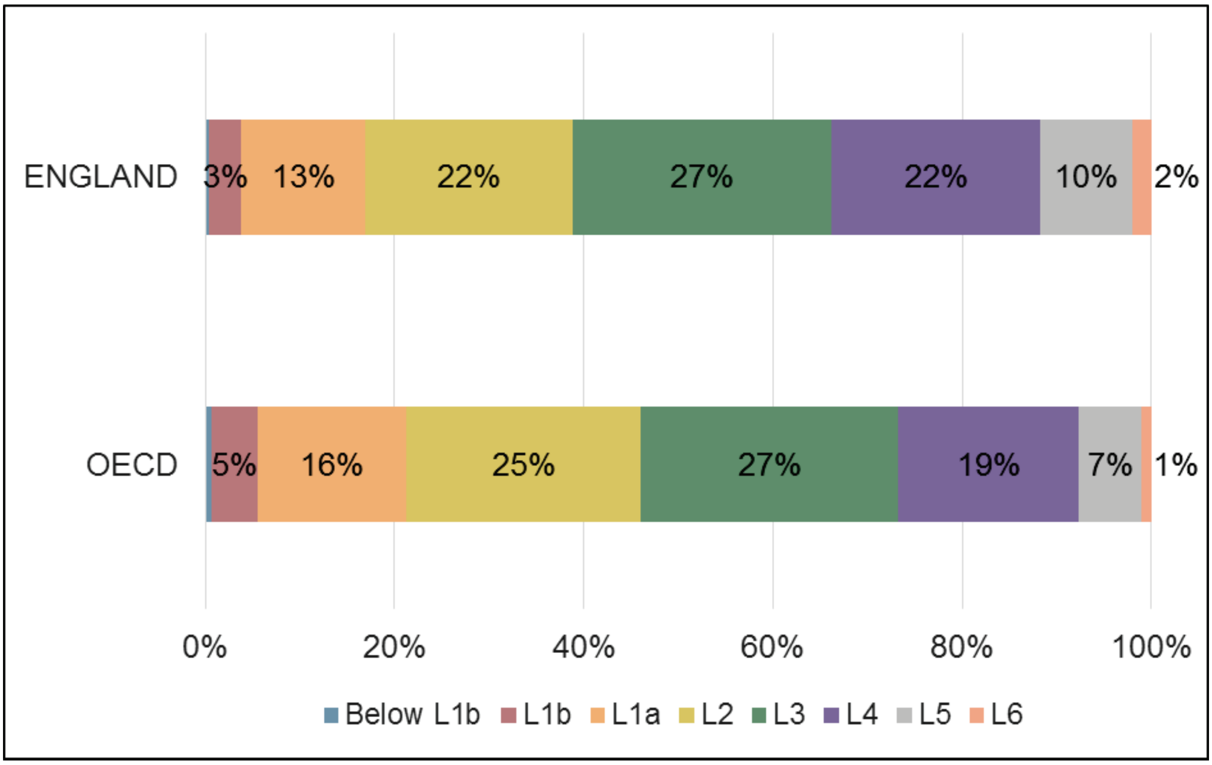
Table 2.3 The PISA science proficiency levels

Level	Description of the science proficiency levels
Level 6	Pupils consistently provide explanations, evaluate and design scientific enquiries and interpret data in a variety of complex situations. They draw appropriate inferences from different data sources and provide explanations of multi-step causal relationships. They can consistently distinguish scientific and non-scientific questions, explain the purposes of enquiry, and control relevant variables in a given scientific enquiry. They can transform data representations, interpret complex data and demonstrate an ability to make appropriate judgments about the reliability and accuracy of any scientific claims. Level 6 students consistently demonstrate advanced scientific thinking and reasoning requiring the use of models and abstract ideas and use such reasoning in unfamiliar and complex situations.
Level 5	Pupils use their knowledge to provide explanations, evaluate and design scientific enquiries and interpret data in a variety of situations. They draw inferences from complex data sources, in a variety of contexts and can explain some multi-step causal relationships. Generally, they can distinguish scientific and non-scientific questions, explain the purposes of enquiry, and control relevant variables in a given scientific enquiry. They can transform some data representations, interpret complex data and demonstrate an ability to make appropriate judgments about the reliability and accuracy of any scientific claims. Level 5 students show evidence of advanced scientific thinking and reasoning requiring the use of models and abstract ideas and use such reasoning in unfamiliar and complex situations.
Level 4	Pupils use their knowledge to provide explanations, evaluate and design scientific enquiries and interpret data in a variety of given life situations of mostly medium cognitive demand. They can draw inferences from different sources, in a variety of contexts and can explain causal relationships. They can distinguish scientific and non-scientific questions, and control variables in some but not all instances. They can transform and interpret data and have some understanding about the confidence held about any scientific claims. Level 4 students show evidence of linked scientific thinking and reasoning and can apply this to unfamiliar situations.
Level 3	Pupils can provide explanations, evaluate and design scientific enquiries and interpret data in some given life situations. They are able to draw a few inferences from different data sources, in a variety of contexts, and can describe and partially explain simple causal relationships. They can distinguish some scientific and non-scientific questions, and control some variables in a given scientific enquiry. They can transform and interpret simple data and are able to comment on the confidence of scientific claims. Level 3 students show some evidence of linked scientific thinking and reasoning, usually applied to familiar situations.
Level 2	Students use their knowledge to provide explanations, evaluate and design scientific enquiries and interpret data in some familiar life situations of low cognitive demand. They are able to make a few inferences from different sources of data, in few contexts, and can describe simple causal relationships. They can distinguish some simple scientific and non-scientific questions, and distinguish between independent and dependent variables in a given scientific enquiry. They can transform and describe simple data, identify straightforward errors, and make some valid comments on the trustworthiness of scientific claims.
Level 1a	Pupils use a little knowledge to provide explanations, evaluate and design scientific enquiries and interpret data in a few familiar life situations that require a low cognitive demand. They use a few simple sources of data, in a few contexts and can describe some very simple causal relationships. They can distinguish some simple scientific and non-scientific questions, and identify the independent variable in a given scientific enquiry. They can partially transform and describe simple data and apply them directly to a few familiar situations.
Level 1b	Pupils demonstrate a little evidence of scientific knowledge to provide explanations, evaluate and design scientific enquiries and interpret data in a few familiar life situations of low cognitive demand. They are able to identify straightforward patterns in simple sources of data in a few familiar contexts and can offer attempts at describing simple causal relationships. They can identify the independent variable in a given scientific enquiry. They attempt to transform and describe simple data and apply them directly to a few familiar situations.

14. England has fewer ‘low-achievers’ (17 per cent) than the average across members of the OECD (21 per cent). Specifically, in England, less than one per cent of 15-year-olds achieve below Level 1b, three per cent reach Level 1b, while 13 per cent of 15-year-olds reach PISA science Level 1a (see Figure 2.3). Analogous figures for the average across OECD members are one per cent (below Level 1b), five per cent (Level 1b) and 16 per cent (Level 1a). For comparison, in PISA 2006, 17 per cent of pupils in England achieved a PISA score below Level 2, compared to an OECD average of 20 per cent.

15. England also has more high-achievers in science than the average across OECD countries. For instance, around one-in-eight (12 per cent) pupils in England reach one of the top two science levels, compared to an OECD average of just one-in-twelve (eight per cent). For comparison, in PISA 2006, 14 per cent of pupils in England reached PISA Level 5 or Level 6, compared to an OECD average of nine per cent.

Figure 2.3 The per cent of pupils in England reaching each science level

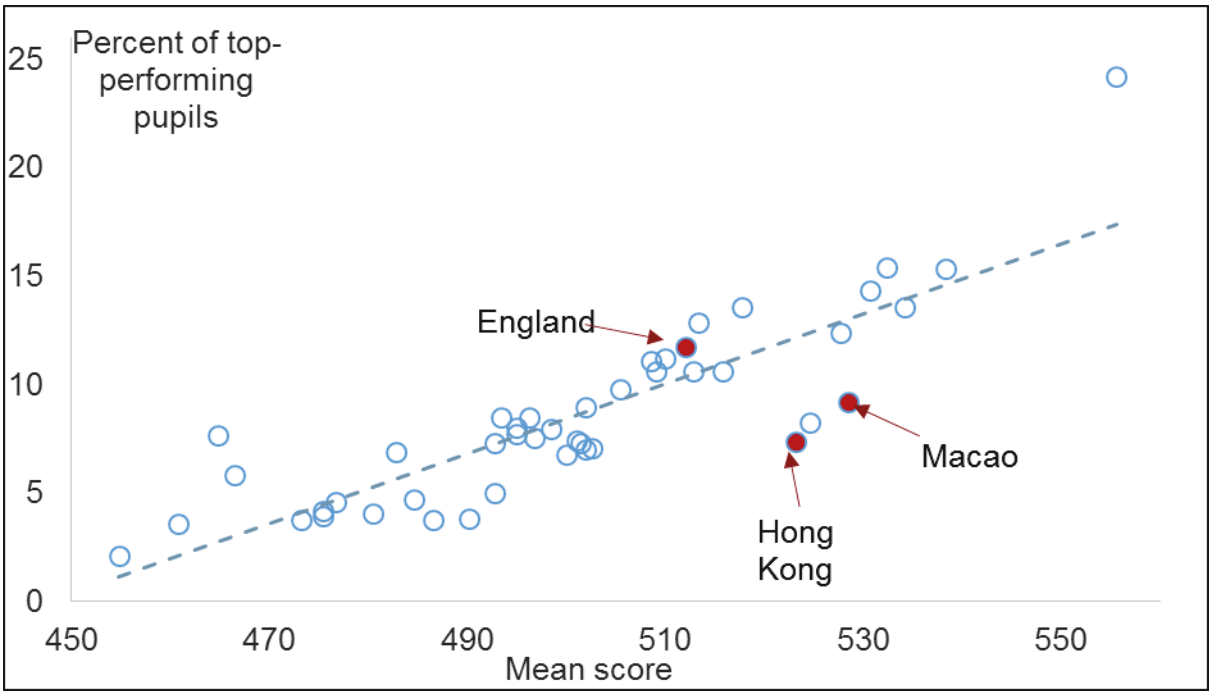


Source: PISA 2015 database.

16. England is a country with a greater proportion of high science achievers (12 per cent) than one would expect given its mean score of 512, and a larger percentage of high-achieving pupils than some countries with the highest average science scores. This is illustrated by Figure 2.4, where England sits above the dashed ‘line of best fit’. In this respect, it is particularly interesting to compare

England to Hong Kong and Macao. Although these two East Asian economies have a significantly higher mean science score than England (523 and 529 respectively) the proportion of pupils who reach PISA Level 5 or Level 6 is lower; seven per cent in Hong Kong and nine per cent in Macao compared to 12 per cent in England.

Figure 2.4 The per cent of top-performing science pupils compared to mean science scores: a cross-country analysis



Source: PISA 2015 database.

Notes: The sample of countries included in this figure has been restricted to those with a mean science score above 450.

17. High-achieving pupils in England tend to come from more advantaged socio-economic backgrounds, be White or Mixed ethnicity and attend selective or independent schools. Only four per cent of FSM pupils in England are high-achievers in science, compared to 12 per cent of non-FSM pupils. The top-performing pupils are also more likely to be White (12 per cent) or of Mixed ethnicity (12 per cent) than either Black (three per cent) or Asian (seven per cent). Finally, England's high-achieving 15-year-olds are disproportionately clustered within selective state (32 per cent) and independent (23 per cent) schools, as compared to comprehensive state schools (nine per cent). Further details are presented in Table 2.4.

Table 2.4 The characteristics of England's top-performing pupils in science

Group	Category	Per cent	Confidence interval	
			Lower	Upper
Gender	Girls	11%	9%	13%
	Boys	12%	10%	14%
FSM eligible	Not FSM	12%	10%	14%
	FSM	4%	2%	6%
Ever FSM	Never FSM	13%	11%	15%
	Ever FSM	4%	3%	5%
Immigrant status	UK Born	13%	11%	15%
	Parent(s) foreign born	9%	4%	13%
	Pupil foreign born	8%	4%	12%
Ethnicity	White	12%	10%	14%
	Asian	7%	3%	10%
	Black	3%	0%	7%
	Mixed	12%	5%	18%
	Other	9%	0%	17%
School admissions policy	Comprehensive	9%	8%	11%
	Independent	23%	18%	28%
	Selective	32%	23%	41%

Notes: PISA 2015 database.

Notes: Figures refer to the per cent of top-performing pupils in each group in England.

Key point

England has a greater proportion of high-achieving pupils in science (12 per cent) than the average across members of the OECD (eight per cent), which is also slightly higher than other countries with a similar average score. These pupils are more likely to be White or Mixed ethnicity and are disproportionally clustered in selective state or independent schools.

2.4 How do the science scores of the *highest* achieving pupils in England compare to other countries?

18. The previous sub-section highlighted how England has a greater proportion of high-performing pupils in science than the average across members of the OECD. We now provide further insight into this issue by comparing the scores of England's highest achieving pupils internationally, and considering how the performance of this group has changed over the last decade. Table 2.5 therefore presents the value of the 90th percentile of the science achievement distribution for England. (A percentile is a measure used in statistics indicating the value below which a given percentage of observations fall. For example, the 90th percentile is the value below which 90 per

cent of observations may be found). As per section 2.1, countries have been divided into different groups depending upon how far ahead or behind England they are, but now in terms of the 90th percentile.

Table 2.5 The 90th percentile of science scores

(a) Countries more than 20 points ahead of England

Country	90th percentile
Singapore	**683***

(b) Countries between 10 and 20 points ahead of England

Country	90th percentile	Country	90th percentile
Taiwan	**655***	**Japan**	**655***

(c) Countries within 10 points of England

Country	90th percentile	Country	90th percentile
Finland	**651***	Australia	639
China	649	Netherlands	638
Estonia	648	Slovenia	636
New Zealand	647	Germany	636
Canada	644	South Korea	636
England	642	Switzerland	632

(d) Countries between 10 and 20 points behind England

Country	90th percentile	Country	90th percentile
Macao	**630***	**Vietnam**	**624***
Belgium	**629***	**France**	**623***
United States	**626***	**Hong Kong**	**622***
Sweden	**625***	**Norway**	**622***

(e) Countries between 20 and 30 points behind England

Country	90th percentile	Country	90th percentile
Austria	**621***	**Czech Republic**	**618***
Portugal	**620***	**Malta**	**618***
Scotland	**619***	**Ireland**	**618***
Poland	**619***	**Denmark**	**617***
Northern Ireland	**618***	**Luxembourg**	**615***

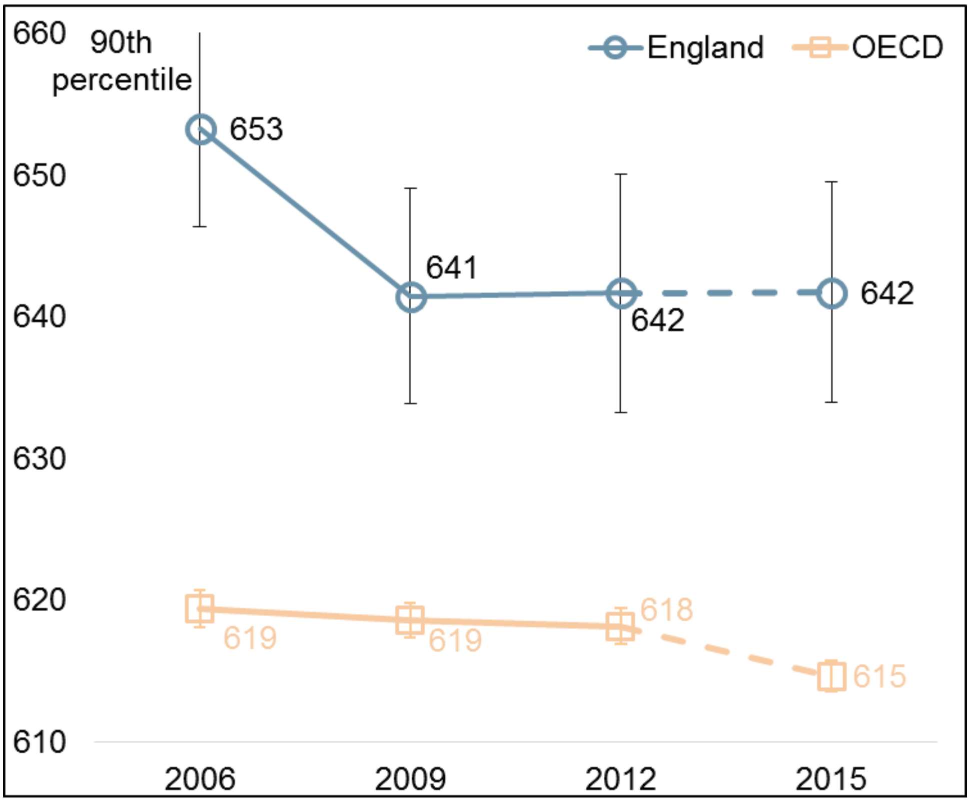
Source: PISA 2015 database.

Note: Bold font with a * indicates significantly different from England at the five per cent level. Countries shaded in red not significantly different from England. Table does not include countries where the 90th percentile of the science proficiency distribution is more than 30 points below England.

19. Nurturing high-level science skills seems to be an area of particular strength of our education system; the top 10 per cent of 15-year-olds in England are amongst the highest performing pupils in science anywhere in the world. In PISA 2015, the top-performing 10 per cent of 15-year-olds in England achieved a score of 642 test points or more. Singapore is the only country where the top 10 per cent of pupils achieve a science score more than 20 points above the value for England, and only Japan and Taiwan are between 10 and 20 points higher. On the other hand, there are 56 countries where the highest-achieving pupils score at least 10 points lower than the highest achieving pupils in England.

20. The performance of the highest-achieving pupils in England has remained broadly stable since 2006, with no statistically significant increase or decrease. In particular, the highest-achieving 10 per cent of pupils obtained a science score above 653 in 2006, 641 in 2009, 642 in 2012 and 642 in 2015. Further details are provided in Figure 2.5.

Figure 2.5 The 90th percentile of science scores between 2006 and 2015



Sources: Bradshaw et al. (2007), Bradshaw et al. (2010), Wheater et al. (2014), PISA 2015 database.

Note: The dashed line between 2012 and 2015 refers to the introduction of computer based testing. Thin line through each data point refers to the estimated 95 per cent confidence interval. Confidence intervals do not include link error for comparing changes over time. OECD average based upon the 'AV09' results presented in the OECD international results Table I.05.SCIE. See Appendix F for further information on trends in performance over time.

21. A statistically significant decline has occurred in a number of countries where the 90th percentile was previously similar or higher than in England. This includes Hong Kong (655 points in 2006 to 622 in 2015), Finland (673 to 651) and New Zealand (667 to 647). Macao is, on the other hand, one of the few countries that is close to England in Table 2.5 where the performance of the top 10 per cent has increased in science over the last decade, from 611 in 2006 to 630 in 2015.

Key point

England's top-performing pupils have consistently been amongst the world's most skilled 15-year-olds in science since 2006. This is in contrast to Hong Kong, Finland and New Zealand, where there has been a significant decline.

2.5 How do the science scores of the *lowest* achieving pupils in England compare to other countries?

22. Whilst the average science score across all pupils in England is 512, the bottom 10 per cent of performers score 378 points or below, which is lower than in many of the top-performing countries. In East Asian countries, the performance of low-achieving pupils is stronger than in England; there are five where the lowest-achievers are more than 20 points ahead (Vietnam, Macao, Hong Kong, Japan and Singapore) and a further two where they are more than 10 points ahead (Taiwan and South Korea) although this is not statistically significant in the latter. A notable exception is China, where the cut-off score for the bottom 10 per cent is very similar to England. Outside of East Asia, only in Estonia (416), Finland (402) and Canada (404) do low-achieving pupils perform significantly better than in England in PISA science. Table 2.6 provides further insight.

Table 2.6 The 10th percentile of science scores

(a) Countries more than 20 points ahead of England

Country	10th percentile	Country	10th percentile
Vietnam	**428***	**Japan**	**412***
Macao	**420***	**Singapore**	**412***
Estonia	**416***	**Canada**	**404***
Hong Kong	**413***	**Finland**	**402***

(b) Countries between 10 and 20 points ahead of England

Country	10th percentile	Country	10th percentile
Taiwan	**395***	South Korea	388

(c) Countries within 10 points of England

Country	10th percentile	Country	10th percentile
Ireland	387	Germany	376
Slovenia	386	New Zealand	374
Poland	384	Spain	374
Denmark	383	Switzerland	373
Latvia	382	Scotland	372
Northern Ireland	379	Netherlands	372
Russia	379	Australia	372
Portugal	379	Norway	370
England	378	Wales	368
China	377	United States	368

(d) Countries between 10 and 20 points behind England

Country	10th percentile	Country	10th percentile
Czech Republic	**367***	**Croatia**	**360***
Austria	**365***	**Italy**	**359***
Belgium	**364***		

(e) Countries between 20 and 30 points behind England

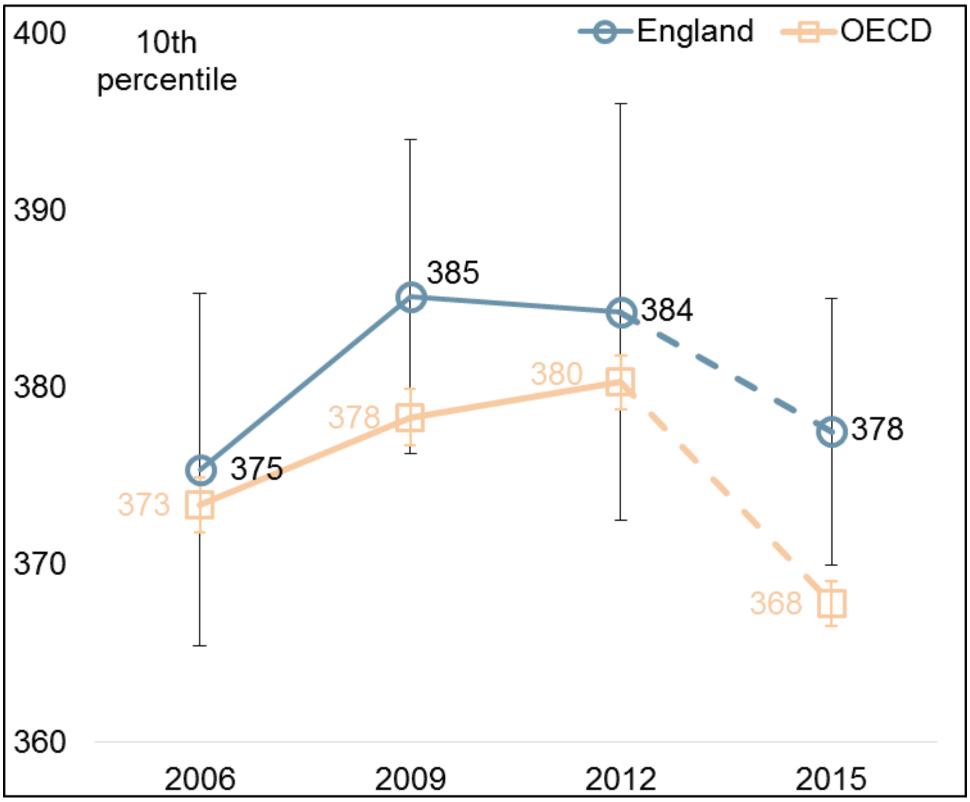
Country	10th percentile	Country	10th percentile
Lithuania	**357***	**Iceland**	**354***
Sweden	**357***	**Luxembourg**	**351***
France	**355***		

Source: PISA 2015 database.

Note: Bold with a * indicates significantly different from England at the five per cent level. Countries shaded in red not significantly different from England. Table does not include countries where the 10th percentile of the science proficiency distribution is more than 30 points below England.

23. The trend in the science performance of the bottom 10 per cent of pupils in England has remained stable over time. The lowest-achieving pupils in England obtained a score below 375 in 2006, 385 in 2009, 384 in 2012 and 378 in 2015. Differences between 2006 and 2015, presented in Figure 2.6, are not statistically significant.

Figure 2.6 The 10th percentile of science scores for England between 2006 and 2015



Sources: Bradshaw et al. (2007), Bradshaw et al. (2010), Wheater et al. (2014), PISA 2015 database.

Note: The dashed line between 2012 and 2015 refers to the introduction of computer based testing. Thin line through each data point refers to the estimated 95 per cent confidence interval. Confidence intervals do not include link error for comparing changes over time. OECD average based upon the 'AV09' results presented in the OECD international results Table I.2.4b. See Appendix F for further information on trends in performance over time.

24. Countries with scores similar to England have also either experienced a stable trend or decline since 2006. With the exception of Japan (396 to 412), there are few countries with a similar or higher science score than England where the science score of the lowest achieving pupils has substantially improved. Yet countries such as Australia (395 to 372), New Zealand (389 to 374), Finland (453 to 402) and the Netherlands (395 to 372) have seen a pronounced and statistically significant decline in the performance of lowest 10 per cent of 15-year-olds between 2006 and 2015.

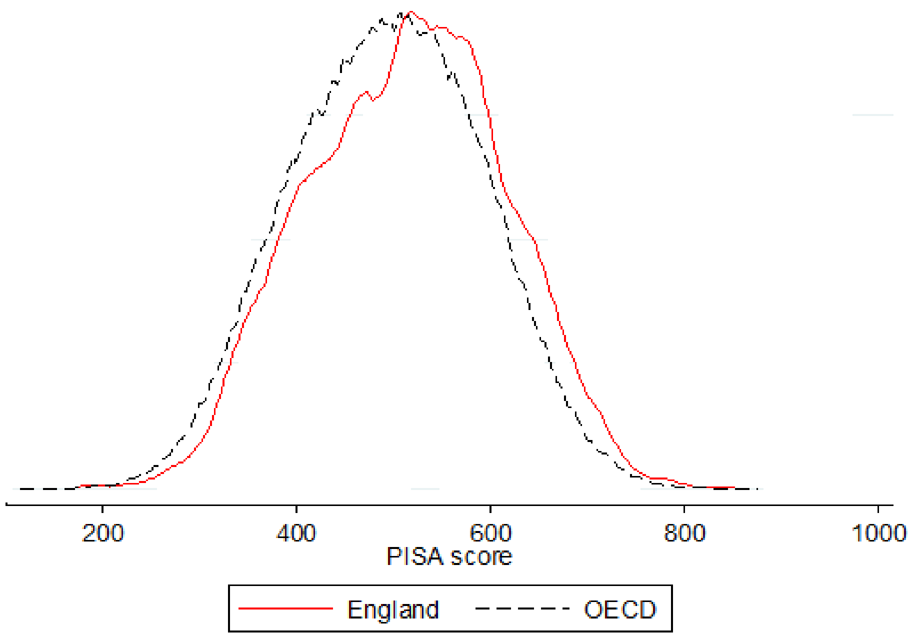
Key point

There has been no change in the science scores of the lowest achieving pupils in England between 2006 and 2015. The science scores of the lowest achieving pupils in Australia, New Zealand, Finland and the Netherlands have declined over the last decade, while they have risen in Japan.

2.6 How big is the gap between the pupils with the strongest and weakest science skills?

25. Figure 2.7 compares the distribution of science scores in England (solid red line) to the average across OECD countries (dashed black line). The distribution for England is generally to the right of the OECD average, reflecting England's higher average science scores. The difference between England and the OECD average is also somewhat smaller in the lower tail of the distribution (e.g. between 300 and 400 points) than in the upper tail (e.g. around 700 points). Throughout this report, our favoured measure of the spread of pupil performance is the gap between the highest and lowest performing pupils in each country, as captured by the difference between the 10th and 90th percentiles of the PISA achievement distribution[18].

Figure 2.7 The distribution of PISA scores in England compared to the OECD average

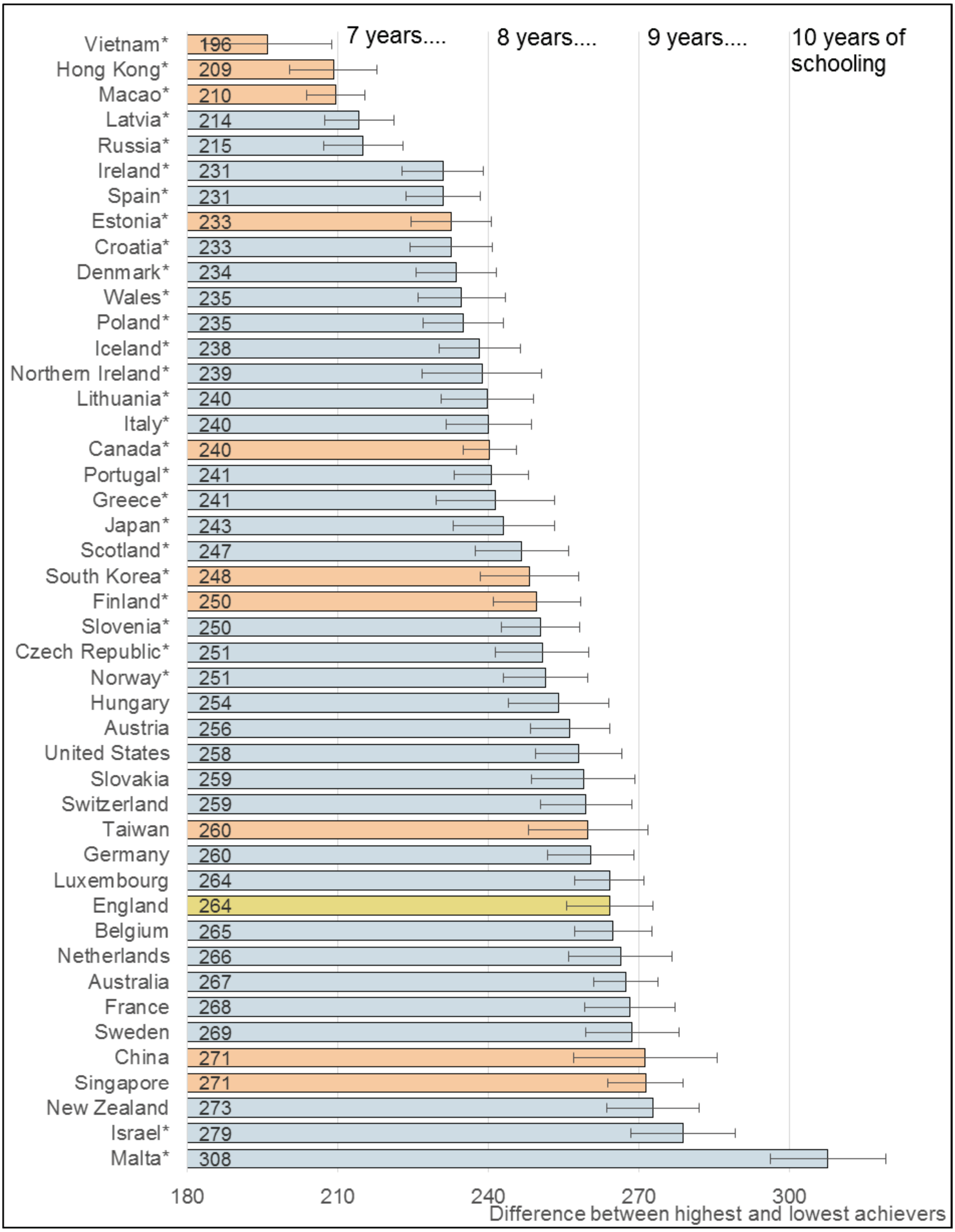


Source: PISA 2015 database

Notes: Distributions produced using the first plausible value only. Bin widths of 10 points are used for England and two points for the OECD average.

[18] We have also investigated educational inequality in PISA using the standard deviation as an alternative metric. The cross-country correlation between the standard deviation and the 90th to 10th percentile gap is 0.999; almost identical cross-country patterns are observed whichever measure is used.

Figure 2.8 The difference between the highest and lowest achievers in science

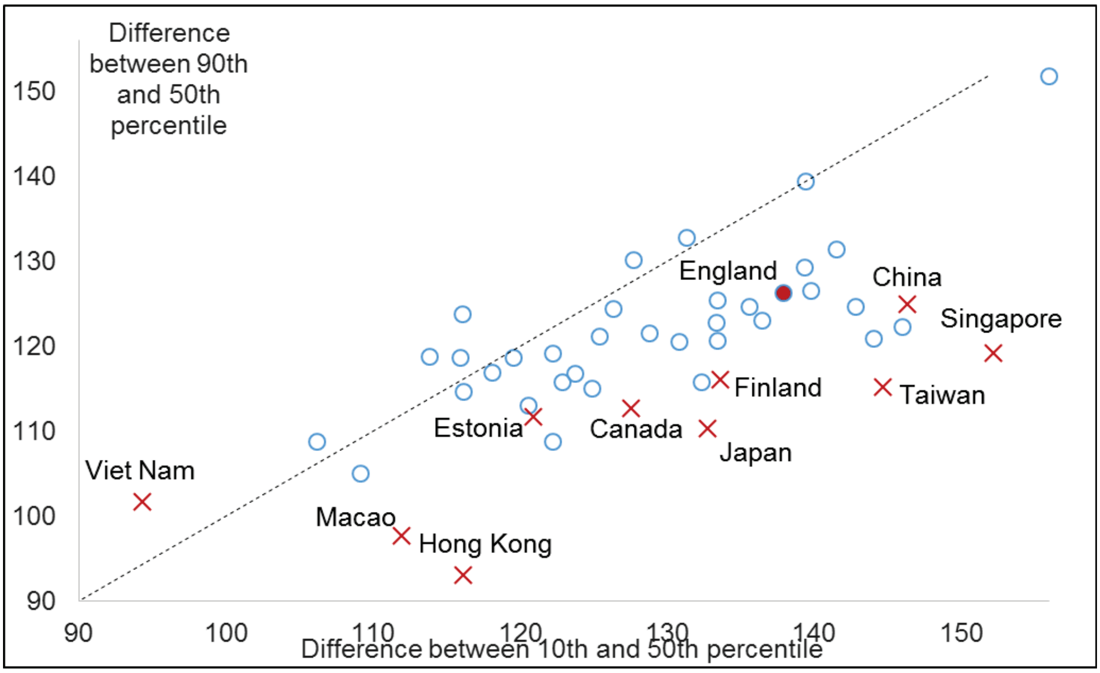


Source: PISA 2015 database.

Note: * indicates statistically significant differences compared to England at the five per cent level. Figure only includes countries where the mean science score is above 450. High-performing countries in science highlighted in orange. Thin line through the centre of each bar refers to the estimated 95 per cent confidence interval.

26. The spread of science achievement is larger in England than in other OECD countries. The gap between the top and bottom 10 per cent of pupils in this country is 264 points (almost nine years of schooling) compared to an OECD average of 247 points (just over eight and a quarter years of schooling). Indeed, only in Malta and Israel is the gap significantly greater than in England, while there are 26 countries with a mean score above 450 points where the distribution in science achievement is significantly lower. This includes a number of countries with a higher average science score than England, including Canada, Finland and South Korea. Figure 2.8 illustrates the spread of results in England compared to other countries within the top and bottom halves of the performance distribution.

Figure 2.9 A comparison of the 90th to 50th percentile and the 50th to 10th percentile across countries



Source: PISA 2015 database.

Notes: Dashed diagonal line refers to where the difference between the 90th and 50th percentile is equal to the difference between the 10th and 50th percentile. Figure only includes countries where the mean science score is above 450. Red crosses refer to the 10 countries with the highest average science scores.

27. In England and most other countries, the spread of pupil performance amongst the lowest performers is greater than that amongst the highest performers (i.e. countries tend to sit below the 45 degree line in Figure 2.9). In England, the difference between the bottom 10 per cent and the median pupil is 138 test points; around 12 test points higher than the difference between the median pupil and the top 10 per cent (126 test points). Finally, countries with the highest average science scores differ markedly in terms patterns of the spread in results. For instance, countries like Vietnam and Hong Kong have comparatively small differences

between low, average and high-achieving pupils, while Singapore and China these gaps are as large (or, in some dimensions, larger) as in England.

Key point

England stands out as a country with a comparatively large difference between the highest and lowest achieving pupils in science. In most countries, including England, the gap between the lowest achieving pupils and the average pupil is bigger than the gap between the average pupil and the highest achievers. Some high-achieving countries have a comparatively small gap between high and low-achievers (e.g. Vietnam and Hong Kong) while in others the difference is large (China and Singapore).

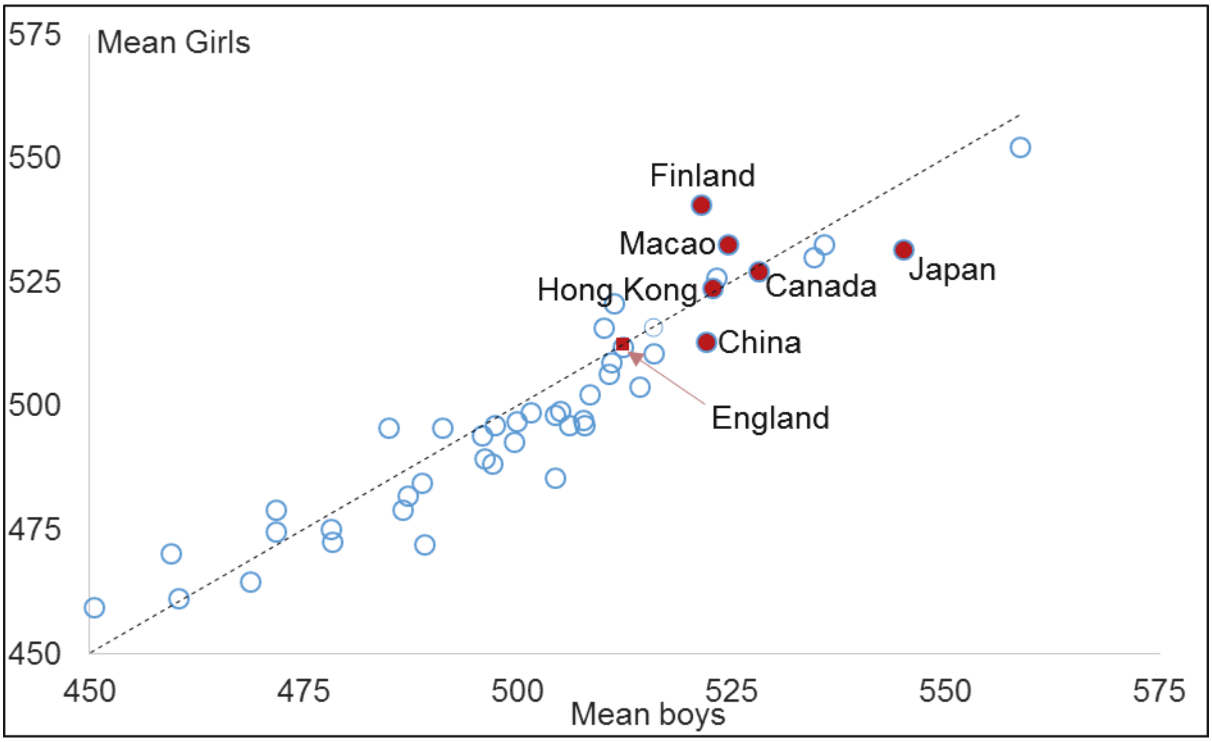
2.7 How big is the gender gap in science scores?

28. In England, boys and girls achieve almost exactly the same average score on the PISA science test (512 for both boys and girls) in 2015. This is somewhat different to the pattern observed for science GCSEs, where a higher proportion of girls (72 per cent) entered for science GCSEs achieve A*-C grades than boys (67 per cent)[19]. It is nevertheless consistent with recent findings from the 'Trends in International Mathematics and Science Study' (TIMSS), which also finds no difference in average science scores between boys and girls in year 9 (although boys perform significantly better than girls amongst our year 5 pupils). Each of these assessments differ in terms of the knowledge and skills that are being measured, and also the impact they will have on a pupils' future learning, which may explain the different patterns observed (see Box 1.1 for further details).

29. England is typical in having no gender difference in 15-year-olds' science skills. In most countries the difference in boys' and girls' test scores is less than 10 points and does not reach statistical significance. There is also little evidence of a consistent pattern emerging across the 10 countries with the highest average science scores. For instance, in Finland and Macao girls achieve significantly higher average science scores than boys, while in China and Japan the opposite holds true; scores are higher for boys than for girls. Yet in others (e.g. Canada and Hong Kong) the situation is very similar to England, with almost no difference in science achievement by gender. Figure 2.10 provides further details.

[19] Department for Education (2016b: Table S1). Figures for 'any science'.

Figure 2.10 Average science scores of boys and girls across countries



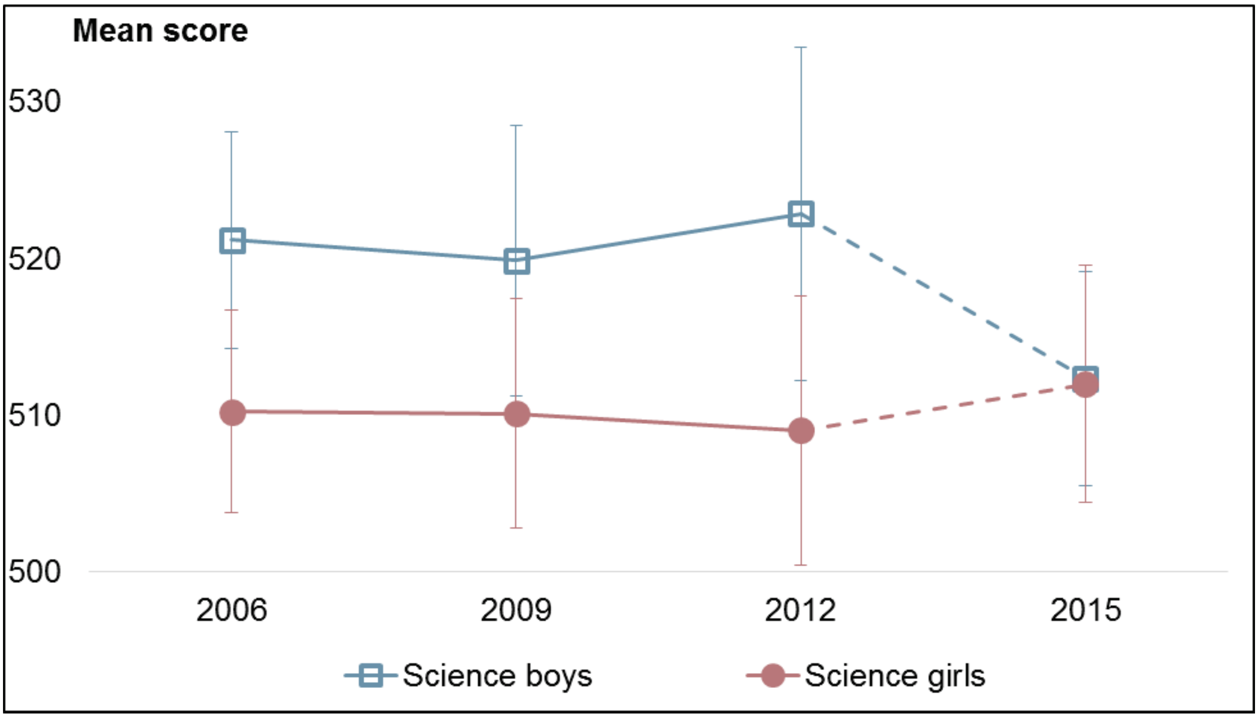
Source: PISA 2015 database.

Note: Sample of countries restricted to those with a mean science score above 450 points. Dashed line illustrates where the mean score for boys and girls is equal.

30. The gender gap in science, which was present in England in previous PISA cycles, has now disappeared. Between 2006 and 2012, the average science score for boys was consistently around 10 points higher than the average for girls. Yet, in PISA 2015, there is no gender difference in science performance.

31. Figure 2.11 reveals that this is mainly due to around a 10-point fall in the average science score for boys in 2015, bringing them into line with the average score for girls. However, the change between 2006 and 2015 is *not* statistically significant for either boys or girls. As a result, there are a number of possible explanations for this result, including sampling error, the move to computer-based assessment, alterations made to the PISA science framework, changes to the PISA scaling models, as well as the possibility of a genuine decline in the average science score of boys.

Figure 2.11 Average science scores for boys and girls in England since 2006



Sources: Bradshaw et al. (2007), Bradshaw et al. (2010), Wheater et al. (2014), PISA 2015 database.

Note: Dashed line refers to the introduction of computer based testing in 2015. Thin line through each data point refers to the estimated 95 per cent confidence interval. See Appendix F for further information on trends in performance over time.

Key points

Boys and girls in England achieved around the same average score on the PISA 2015 science test. This is in contrast to the findings from previous PISA cycles where boys in England have performed significantly above girls.

Chapter 3. Achievement in different aspects of scientific literacy

- PISA draws a distinction between different topics in science. These are the 'physical system' (which measures knowledge about matter, motion and forces), the 'living system' (which pertains to cells, organisms, humans), and the 'earth and space science system' (looking at earth's history, the earth in space, and the universe).

- Pupils in England achieve equally as well across the 'living', 'physical' and 'earth and space' science systems in 2015.

- In each of these scientific systems, there are only eight countries achieving a significantly higher average score. It is relatively common for a country to have equal scores across the three scientific systems – including in many of the high-achieving countries.

- The PISA 2015 test also examines skills in three core scientific competencies: 'interpreting data and evidence scientifically', 'evaluating and designing scientific enquiry' and 'explaining phenomena scientifically'.

- Pupils in England are equally strong across these three areas. This is also true within many of the highest performing countries.

- The PISA test also attempts to measure separate types of scientific knowledge: 'content knowledge' and 'procedural and epistemic knowledge'.

- Pupils in England are equally able in content knowledge and procedural and epistemic knowledge, which is not unusual compared to other countries. It is of note that in some of top-performing countries (e.g. Taiwan, Finland), the gap between content knowledge and procedural/epistemic knowledge is more pronounced.

1. In the previous chapter, our focus was pupils' overall achievement in science, however, proficiency in science is formed of several interlinking components, with the potential for 15-year-olds to have stronger skills in certain areas of this subject and weaker skills in others. Do pupils in England have a particularly good understanding of one aspect of science relative to others? This chapter examines such issues by considering pupils' proficiency across the eight PISA science sub-domains.

2. In order to provide a more detailed insight into the content of the PISA test, the latter half of the chapter turns to analysis of exemplar science questions. We also provide some descriptive evidence on how pupils in England performed on these tasks, relative to 15-year-olds in other parts of the world.

3. In summary, this chapter will address the following questions:

- *Do pupils in England demonstrate the same proficiency across the PISA 'physical', 'living' and 'earth and space' science systems? How does England compare to other countries in this respect?*
- *How do average scores vary in England across three core scientific competencies: 'explaining phenomena scientifically', 'evaluating and designing scientific enquiry' and 'interpreting data and evidence scientifically'?*
- *How does pupils' knowledge of scientific content compare to their knowledge of scientific processes and procedures? Is this similar to the situation in other countries?*
- *Are there gender differences in pupils' performance across the science sub-domains?*
- *What types of questions were pupils asked as part of the science test? What proportion of pupils in England answered these exemplar items correctly?*

4. When interpreting the results presented in this chapter, readers should note that the eight science sub-domains have been divided into three broad groups:

- *Scientific systems (physical, living and earth and space sciences)*
- *Scientific competencies (explaining phenomena scientifically, evaluating and designing scientific enquiry, and interpreting data and evidence scientifically)*
- *Scientific knowledge (content knowledge, and procedural and epistemic knowledge).*

The PISA 2015 test has been designed to allow comparisons to be made *within* these three broad groups. For example, average scores can be compared across physical and living science systems, or between content knowledge and procedural/epistemic knowledge. Comparisons should not be made, however, between sub-domains that fall within different groups; it is not possible to directly compare the mean score for the 'living' system to the mean score for the 'explaining phenomena scientifically' competency, for example.

3.1 Do pupils demonstrate the same proficiency across the PISA science systems?

5. Science is a broad term used to encapsulate many different topics. For instance, in the English education system, a clear distinction is made between specific areas such as physics, chemistry and biology, with pupils being able to complete separate GCSEs and A-Levels in these particular fields. PISA also draws a distinction between different topics in science, based upon the OECD definition of different scientific systems. These are the 'physical system', the 'living system', and the 'earth and space science' system. Details on the types of topics each of these covers can be found in Table 3.1, with further information available within the PISA 2015 science framework[20].

Table 3.1 Content of the PISA science 'systems'

Physical systems	Living systems	Earth and Space systems
Structure and properties of matter	Cells	Structures of the Earth
Chemical changes of matter	Organisms	Energy in the Earth
Motion and forces	Humans	Change in the Earth
Energy and its transformation	Populations	Earth's history
Interactions between energy and matter	Ecosystems	Earth in space
	Biosphere	The Universe

Source: OECD (2016:26)

6. In all three scientific systems, pupils in England perform comparatively well internationally. There are only eight countries achieving a significantly higher average score than England in each of the three domains (Singapore, Japan, Estonia, Taiwan, Finland, Macao, Canada and Hong Kong) with further details provided in Appendix G. The mean score for the living system (512) in England is also very similar to the mean score for either the physical (512) or earth and space science (513) systems.

7. England's similar score in living, physical and earth and space sciences is similar to some of the very highest achieving countries (e.g. Singapore, Japan, Taiwan). For instance, in Singapore, Japan, Taiwan, Canada and Hong Kong, the difference between average physical, living and earth and space science scores is usually less than five test points. Finland and Macao are two exceptions amongst the top-performers, with a lower score in living sciences than the other two domains.

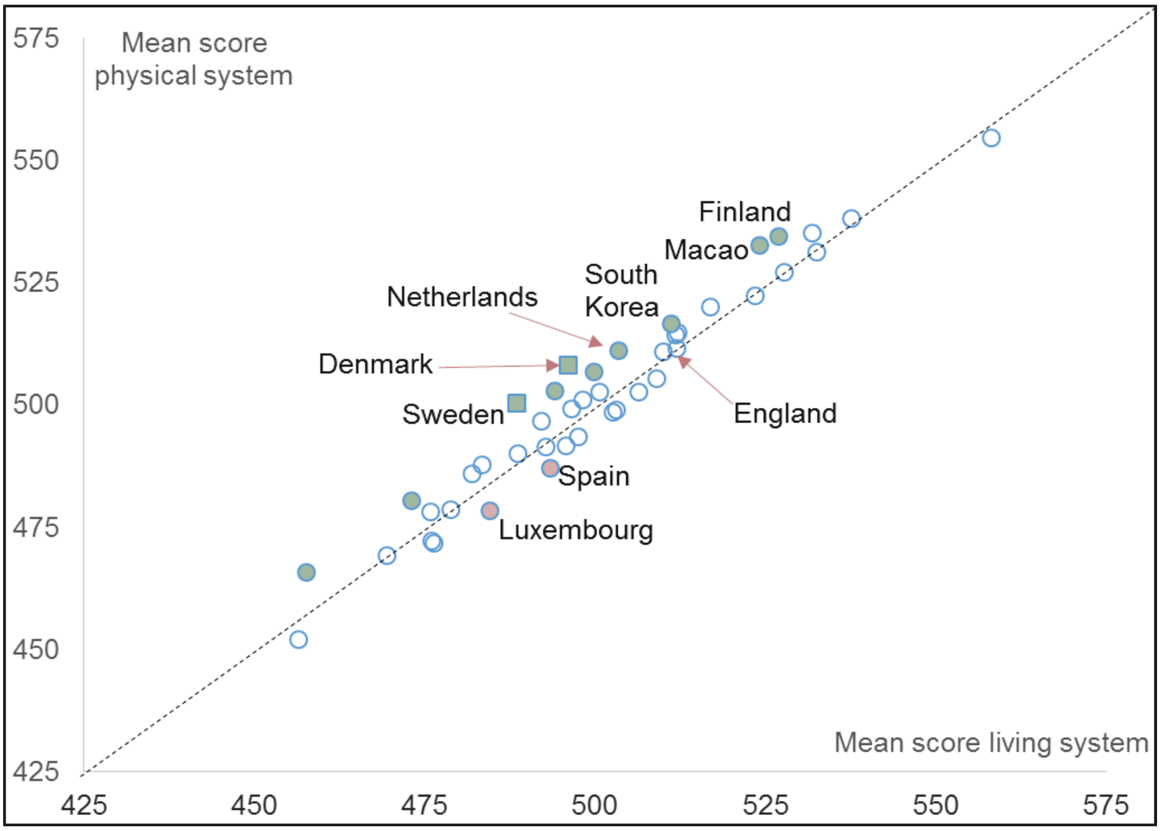
[20] See OECD (2016).

Estonia is also an exception in this group, with a substantially lower average score for living sciences (532) than for earth and space sciences (539) systems. These results are presented in Figure 3.1 and Appendix G.

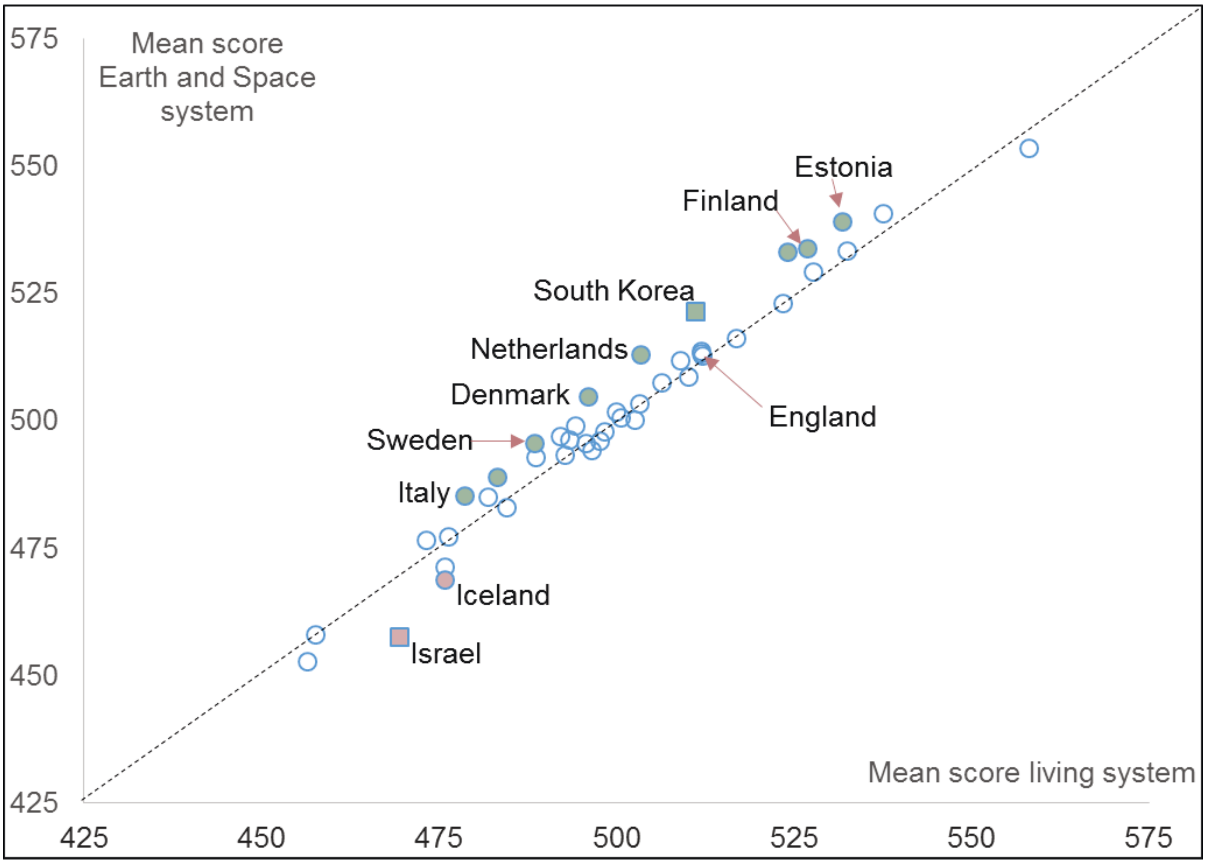
8. Several other OECD countries exhibit the same pattern of achievement as England and have similar average scores across the three scientific systems. This is especially true across all the other countries that form the UK. Prominent exceptions include Denmark, the Netherlands and Sweden, where average scores tend to be lower in the living scientific system than in either physical or earth and space sciences. More generally, there are relatively few red shaded data points below the 45 degree line in Figure 3.1. This indicates that in most countries the living science system is not a particular strength of pupils, in common with England.

Figure 3.1 Average scores across the 'scientific systems' sub-domains

(a) Living versus physical system



(b) Living versus earth and space science system



Notes: Figure only includes countries with an average score above 450 points on the overall PISA science scale. Filled circular markers indicate a difference of at least five points across the different PISA sub-domains. Filled square markers indicate a difference of at least 10 points. Red shading indicates living system score is higher; green that the score on the other domain is higher. Further details are provided in Appendix G.

Key point

There are only eight countries where pupils achieve significantly higher average scores than England in either the living, physical or earth and space sciences. Pupils in England achieve similar scores across the three PISA scientific systems.

3.2 How do average scores vary across the scientific 'competencies' measured by PISA?

9. For pupils to be able to understand and engage in critical discussions about science, they need to be able to demonstrate proficiency in three core scientific competencies. The PISA 2015 test examined pupils' skills in these three areas, which can be summarised under the following headings:

- *Explaining phenomena scientifically*. Pupils' ability to recall knowledge of a particular aspect of science, and to then use that knowledge to explain some phenomena (e.g. why antibiotics do not kill viruses). This includes the use of such knowledge to make predictions of what is likely to occur in a particular real-world situation.

- *Evaluate and design scientific enquiry*. This captures pupils' ability to identify questions that could be explored in a scientific study, to propose ways of explaining a question using a rigorous scientific method and to evaluate the quality of scientific investigations that have been conducted. This could also include an evaluation of how scientists ensure reliability of data and the generalisability of their findings.
- *Interpret data and evidence scientifically.* Pupils' ability to understand the strengths and limitations of a scientific investigation, and how the reliability of the evidence may vary depending upon the source. This captures young people's understanding of uncertainty in science, the quality assurance processes needed to ensure reliability and objectivity, and to distinguish arguments based upon evidence from other considerations.

A summary of the skills each of these competencies encapsulates can be found in Table 3.2.

Table 3.2 The scientific competencies examined in the PISA 2015 assessment

Explain phenomena scientifically	Evaluate and design scientific enquiry	Interpret data and evidence scientifically
Recall and apply scientific knowledge	Identify questions explored in a scientific study	Transform data into different representations
Identify, use and generate explanatory models	Distinguish questions that could be explored scientifically	Analyse and interpret data to reach appropriate conclusions
Make and justify predictions	Propose and evaluate ways of exploring a question scientifically	Identify assumptions, evidence and reasoning in texts
Explain implications of scientific knowledge for society	Evaluate how scientists ensure reliability, objectivity and generalisability of data and explanations	Distinguish arguments based upon theory and evidence from other considerations
Offer explanatory hypotheses		Evaluate evidence from different sources (e.g. journals, newspapers)

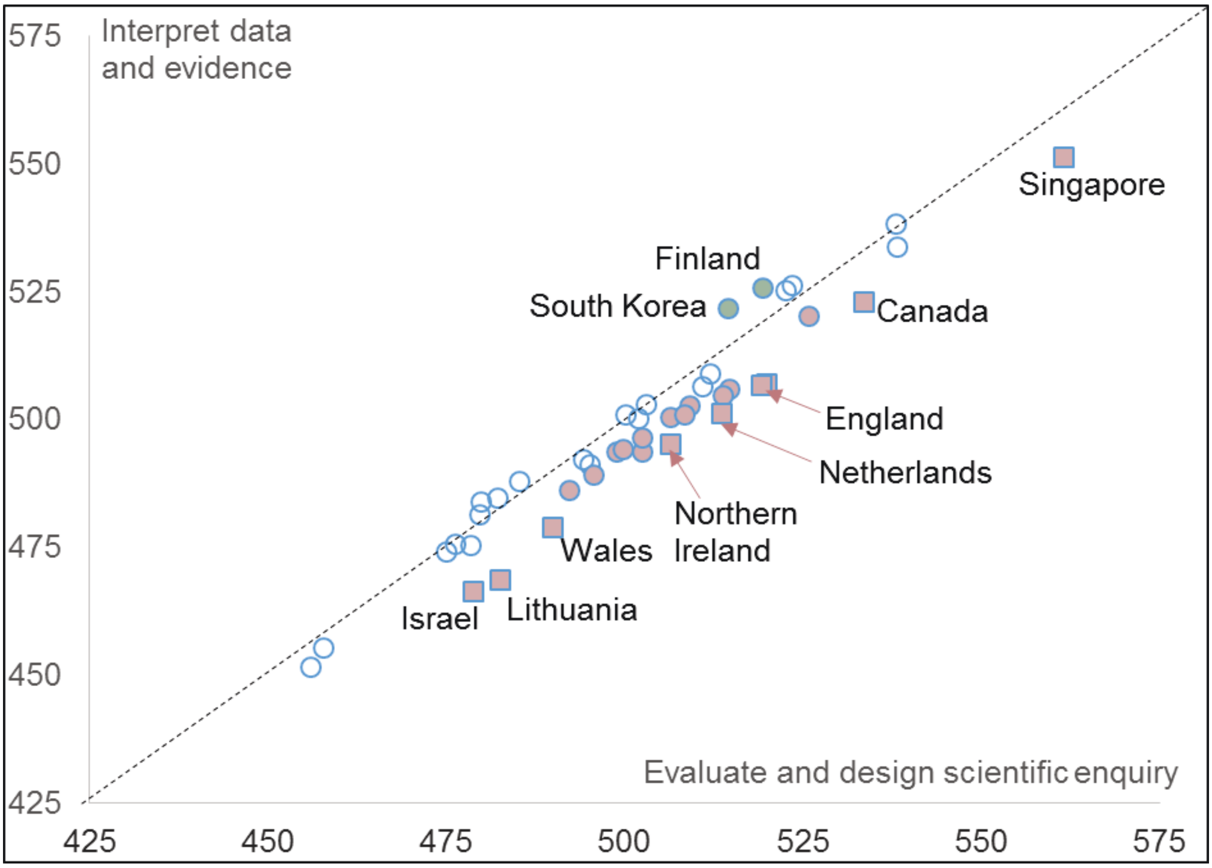
Source: OECD (2016:24-26).

10. Pupils in England tend to be weaker, on average, at interpreting data and evidence scientifically (507) than at either explaining phenomena scientifically (516) or evaluating and designing scientific enquiry (519). This is not unique to England. With the exception of Finland and South Korea, there are few countries where pupils perform more than five points higher on interpreting data and evidence than on evaluating and designing scientific enquiry (there are very few green shaded points in Figure 3.2). On the other hand, there are several countries where the difference is more than five points, but in the other direction (solid red markers in Figure 3.2 panel

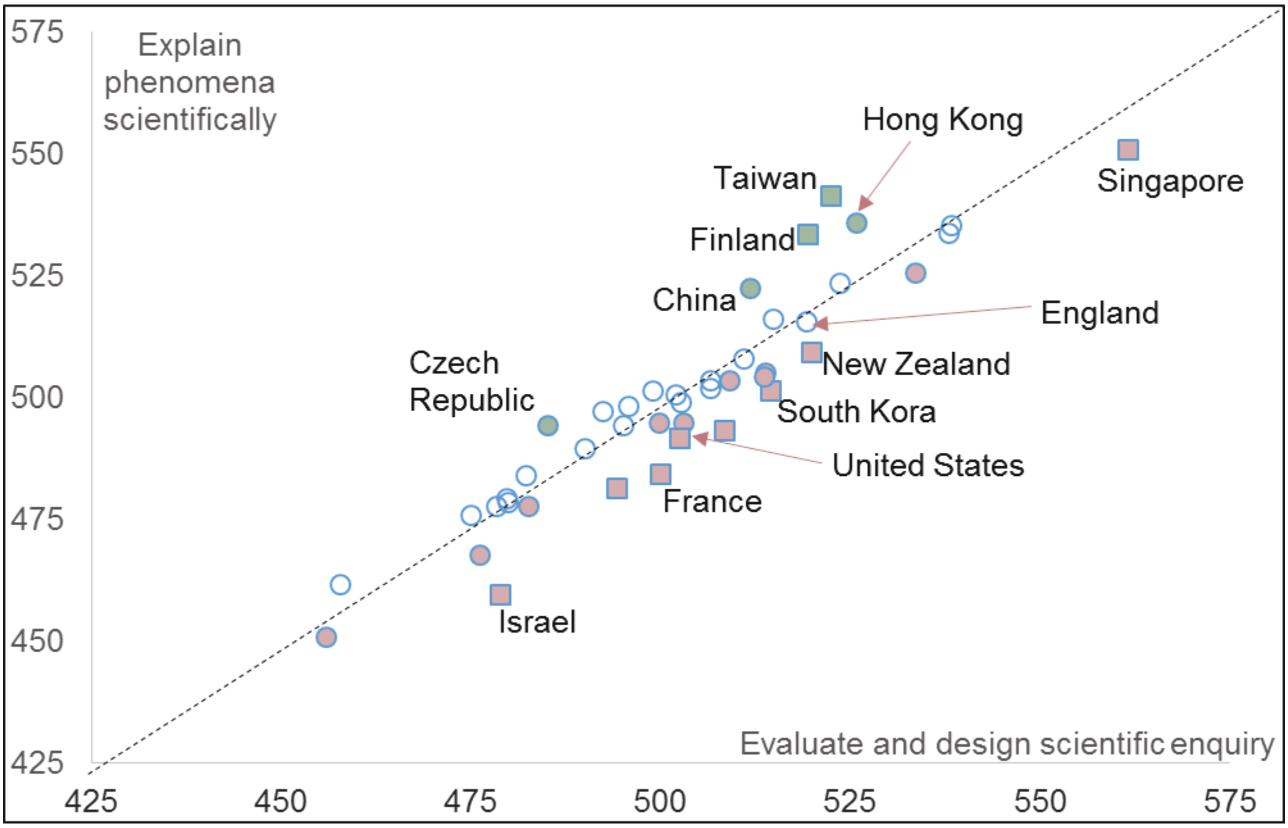
(a). It is therefore a reasonably common occurrence across countries for pupils to be weaker at interpreting data and evidence scientifically than at evaluating and designing scientific enquiry. An important caveat is that in some of the highest-performing countries, such as Japan, Estonia, Taiwan, Finland and Macao, this does not hold true.

Figure 3.2 Average scores for the scientific ‘competencies’ tested in PISA

(a) Evaluate and design scientific enquiry vs interpret data and evidence scientifically



(b) Evaluate and design scientific enquiry vs explain phenomena scientifically



Notes: Figure only includes countries with an average score above 450 points on the overall PISA science scale. Filled circular markers indicate a difference of at least five points across the different PISA sub-domains. Filled square markers indicate a difference of at least 10 points. Further details are provided in Appendix G.

11. England has a strength internationally in the evaluating and designing scientific enquiry domain. This means that pupils in England are particularly adept in designing and evaluating ways of investigating scientific questions, and evaluating how scientists ensure reliability and objectivity of their results. Only in Singapore, Japan, Estonia and Canada is the average score for this competency significantly above the average score for England. These are the results presented in Figure 3.2 and Appendix G.

Key point

Pupils in England are, on average, equally adept at interpreting data and evidence scientifically, evaluating and designing scientific enquiry and explaining phenomena scientifically. This pattern is not unique to England, and occurs in several other countries, including some of the very top-performers.

3.3 How does pupils' knowledge of scientific content and scientific3.3 procedures compare?

12. The PISA test attempts to measure three separate types of scientific knowledge, which together demonstrates pupils' understanding of the natural world. This not only includes knowledge of the science systems listed in Table 3.1, but also of the rigorous processes and procedures that must be applied in order to generate high quality evidence. In PISA 2015, these three complementary forms of knowledge are reported on two separate sub-scales:

- *Content knowledge*. Pupils' knowledge and understanding of the content of the physical, living and earth and space science systems
- *Procedural and epistemic knowledge.* Pupils' understanding of key concepts and procedures underpinning scientific methods, which are used to produce reliable and valid data. Those with such knowledge can explain, with examples, the difference between an observation and an established scientific fact.

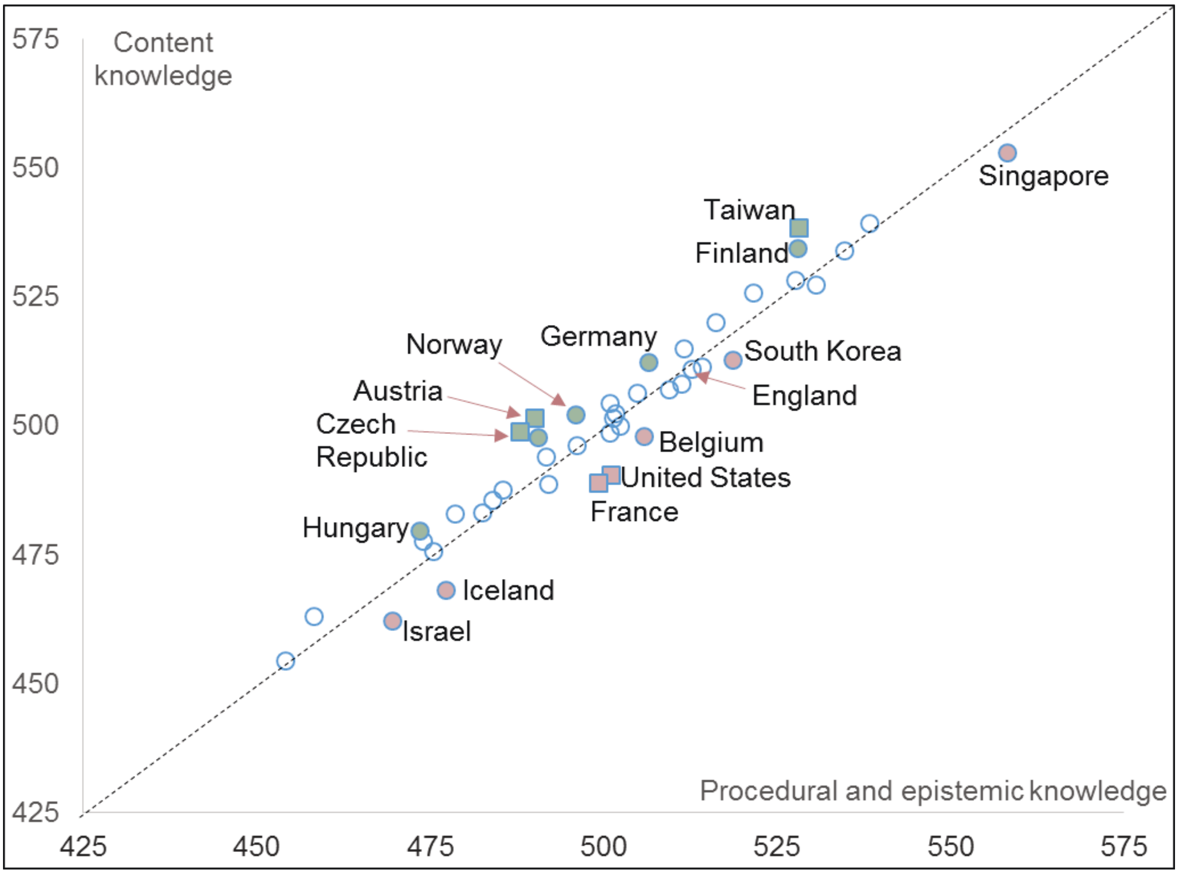
Table 3.3 provides further details on the definition of procedural and epistemic knowledge within the PISA science framework.

Table 3.3 The key components of procedural and epistemic knowledge in the PISA 2015 science framework

Procedural knowledge	Epistemic knowledge
Concept of variables	How claims are supported by data and reasoning
Concepts of measurement	The function of different forms of scientific enquiry
Ways of assessing and minimising uncertainty	How measurement error affects confidence in scientific knowledge
Mechanisms to ensure replicability and accuracy of data	The use and limitations of physical, system and abstract models
Methods of representing and using data	The role of collaboration and critique in establishing scientific claims
The use of control-of-variables and randomised controlled trials to identify possible causal mechanisms	The role of scientific knowledge in identifying societal and technological issues
The nature of an appropriate design for a given scientific question	

Source: OECD (2016:26-27)

Figure 3.3 Average scores across the 'scientific knowledge' sub-domains



Notes: Figure only includes countries with an average score above 450 points on the overall PISA science scale. Filled circular markers indicate a difference of at least five points across the different PISA sub-domains. Filled square markers indicate a difference of at least 10 points. Further details are provided in Appendix G.

13. Pupils in England are equally able in content knowledge (511) and procedural and epistemic knowledge (513). A similar pattern occurs in several of the top-performing countries, and the rest of the UK. Notable exceptions include Taiwan and Finland, where pupils have stronger content knowledge than procedural and epistemic knowledge – see Figure 3.3. In Singapore, South Korea, France and the United States the opposite holds true, with pupils having stronger skills in procedural and epistemic knowledge. A full breakdown of scores is provided in Appendix G.

Key point

In England, pupils' knowledge of science content is slightly stronger than their knowledge of scientific practices and procedures. England is not unusual in this respect, with a similar pattern occurring in many other countries, including some of the top-performers in science.

3.4 Are there gender differences in pupils' performance across the science sub-domains?

14. Although there are some modest differences between the average scores of boys and girls in England across the different science domains, these differences do not quite reach statistical significance[21]. Boys and girls in England have approximately the same skills in the physical, living and earth and space sciences systems[22]. The largest gender differences are observed in the competency and knowledge domains, where boys score eight points higher than girls for 'explaining phenomena scientifically' and 'content' knowledge, but eight points lower in 'evaluating and designing scientific enquiry'. These results are presented in Table 3.4.

Table 3.4 Gender differences in science scores by sub-domain in England

		Girls mean	Boys Mean	Gender gap
System	Physical	510	514	+4
	Living	513	511	-3
	Earth and Space science	513	514	+1
Competency	Explain phenomena scientifically	508	516	+8
	Evaluate and design	514	507	-8
	Interpret data and evidence	514	511	-3
Knowledge	Content knowledge	507	515	+8
	Procedural and Epistemic	515	510	-5
Average score	**Overall science domain**	**512**	**512**	**0**

Source: PISA 2015 database.

Notes: Difference between boys and girls may not equal the gender gap due to rounding.

3.5 Example question 1. Slope face investigation.

15. To further illustrate the content of the PISA science test, we conclude this chapter by providing an analysis of some of the released test questions. The first is the 'slope face investigation task'[23]. To begin, pupils were shown an introductory information screen, as depicted in the top half of Figure 3.4. The screen includes a visual stimulus of two hills in a valley, one with plentiful green vegetation and one

[21] Although, at the 10% level, boys do perform better at explaining phenomena scientifically sub-domain and in demonstrating content knowledge.
[22] The online data tables provide further details by illustrating how England compares to other countries in terms of gender differences across these three science systems.
[23] Although this question is formed of several independently scored parts, our description and analysis focuses upon the first task.

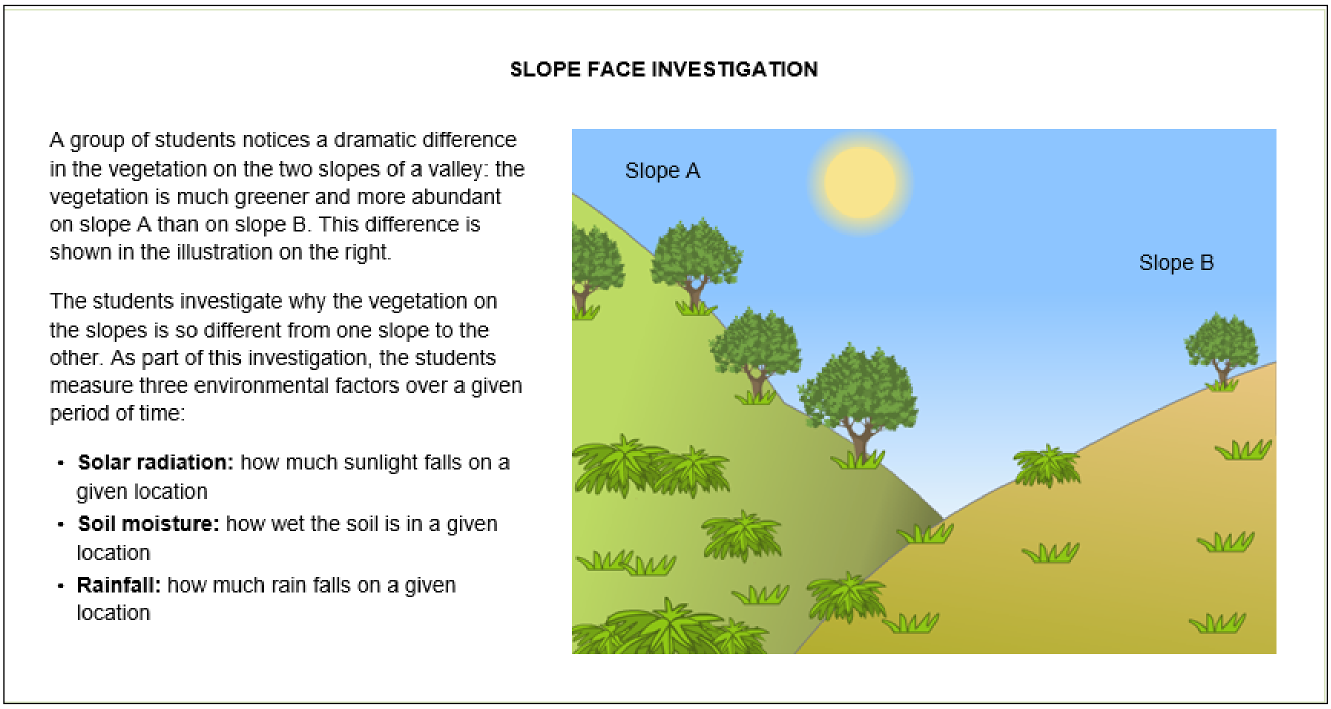
without. It then informs pupils how an investigation is taking place to determine which of three environmental factors (solar radiation, soil moisture and rainfall) is likely to be causing the difference in vegetation.

16. In the following screen, pupils are then told how the individuals who are conducting this investigation have placed two sets of instruments upon each hill slope. This is accompanied by the visual stimulus shown in the lower half of Figure 3.4. They are then asked the following question, with responses to be provided in an open text field:

> *'In investigating the difference in vegetation from one slope to the other, why did the students place two of each instrument on each slope?'*

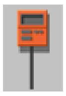
Pupils who succeeded at this question recognised the potential for measurement error to occur in this scientific study. Moreover, they recognised that collecting data from more than one instrument may help to identify and resolve this problem.

Figure 3.4 The 'slope face investigation' question

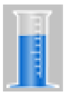


The students place two of each of the following three instruments on each slope, as shown below.

Solar radiation sensor: measures the amount of sunlight, in megajoules per square metre (MJ/m^2)



Soil moisture sensor: measures the amount of water as a percentage of a volume of soil



Rain gauge: measures the amount of rainfall, in millimetres (mm)

Source: PISA 2015 science test.

17. This question tests pupils' epistemic knowledge in the context of the earth and space science system. In terms of scientific competencies, it captures pupils' ability to evaluate and design scientific enquiry (and, in particular, the methods scientists use to ensure the reliability of their results).

18. Table 3.5 describes the key properties of this question. The difficulty of the question is around 517 points on the PISA science scale; pupils achieving at PISA Level three have around a 50/50 chance of answering this question correctly. In England, two-thirds (68 per cent) of pupils who took this question provided the correct response, with girls (71 per cent) performing slightly better than boys (65 per cent). Finally, as the PISA 2015 test was undertaken on computer, we know the median response time of pupils in England who answered this question correctly was around 70 seconds. This compares to approximately 55 seconds for individuals who provided an incorrect response (although with a 20 second difference between boys and girls).

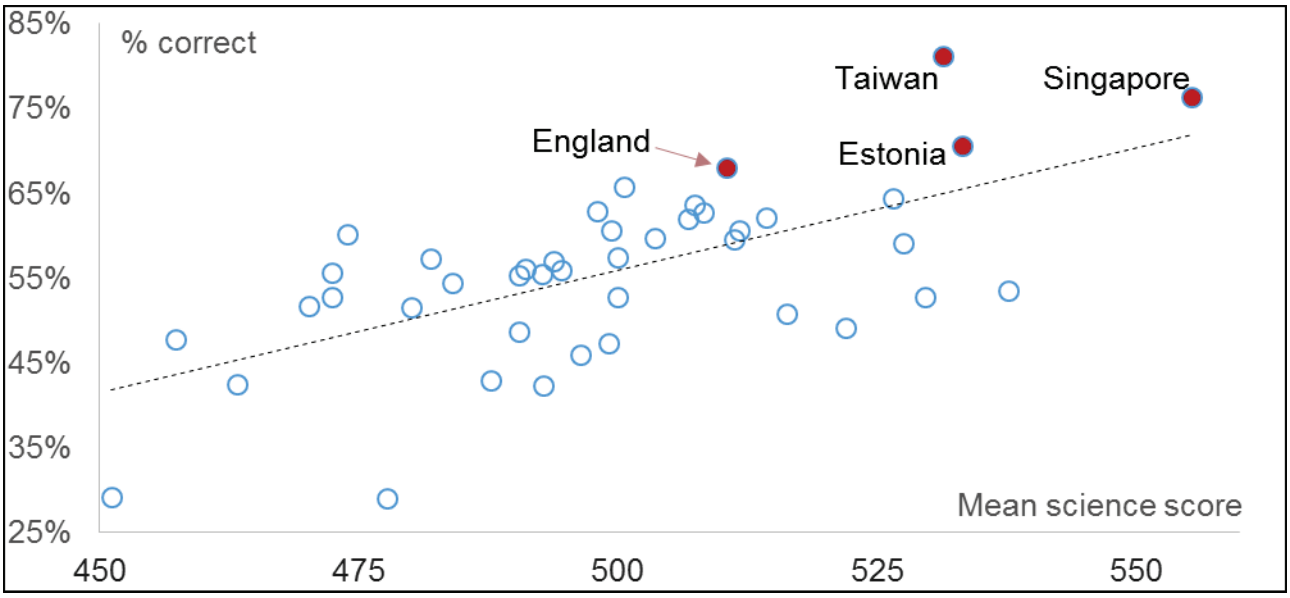
Table 3.5 Properties of the exemplar PISA science questions

	Slope face investigation	Bird migration
Item code	CS637Q01	CS656Q01
Science content system	Earth and space	Living
Scientific competency	Evaluate and design scientific enquiry	Explain phenomena scientifically
Knowledge category	Epistemic	Content
Difficulty	517 science points	501 science points
PISA level	Level 3	Level 3
% correct England	68%	59%
% correct girls in England	71%	60%
% correct boys in England	65%	59%
Median response time (girls correct)	74 seconds	63 seconds
Median response time (boys correct)	66 seconds	62 seconds
Median response time (girls incorrect)	65 seconds	69 seconds
Median response time (boys incorrect)	46 seconds	60 seconds

Source: PISA 2015 database.

19. Pupils in England perform better at the 'slope-face investigation' question than one would anticipate, given England's average science score. Indeed, there are only three countries (Estonia, Singapore and Taiwan) where the proportion of pupils who provided the correct response is higher. Specifically, 68 per cent of pupils in England answered this question correctly, compared to the 60 per cent one would expect based upon the line of best fit plotted in Figure 3.5.

Figure 3.5 The percentage of pupils who answer the slope face investigation question correctly across countries



Source: PISA 2015 database.

3.6 Example question 2. Bird migration.

20. The second example question is from the 'bird migration' module. To begin, pupils were provided the following information on their computer screen, along with a visual stimulus of a tagged bird.

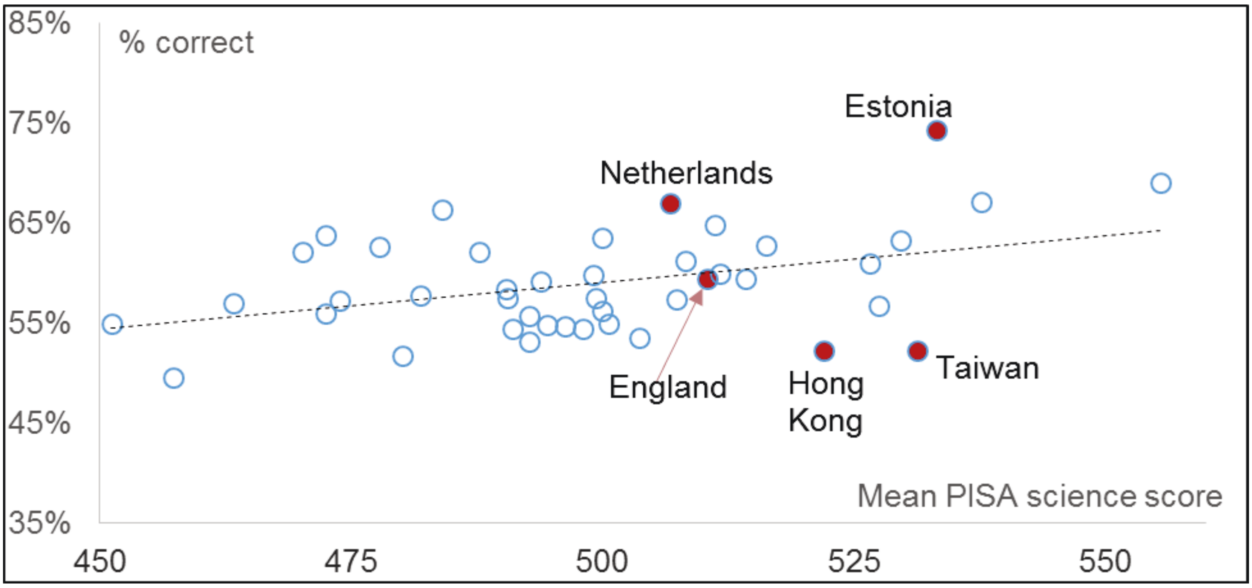
> *'Bird migration is a seasonal large-scale movement of birds to and from their breeding grounds. Every year volunteers count migrating birds at specific locations. Scientists capture some of the birds and tag their legs with a combination of coloured rings and flags. The scientists use sightings of tagged birds together with volunteers' counts to determine the migratory routes of birds.'*

They were then asked the following question, and told to select one of the four multiple choice options:

> *Most migratory birds gather in one area and then migrate in large groups rather than individually. This behaviour is the result of evolution. Which of the following is the best scientific explanation for the evolution of this behaviour in most migratory birds?*
>
> - *Birds that migrated individually or in small groups were less likely to survive and have offspring.*
> - *Birds that migrated individually or in small groups were more likely to find adequate food.*
> - *Flying in large groups allowed other bird species to join the migration.*
> - *Flying in large groups allowed each bird to have a better chance of finding a nesting site*

21. This question examines pupils' content knowledge of a key element within the living scientific system. In terms of scientific competencies, it captures pupils' ability to explain a particular scientific phenomenon. Again, Table 3.5 lists its key features. The difficulty of the question is around 500 points on the PISA science scale; pupils achieving PISA Level 3 have around a 50/50 chance of answering this question correctly. In England, 60 per cent of pupils who took this question provided the correct response, with little difference between girls and boys. The median response time of pupils in England who answered correctly was just over 60 seconds, which is similar to the amount of time that was spent by pupils who answered incorrectly (median time of 60 seconds for boys and 69 seconds for girls).

Figure 3.6 Proportion of pupils answering the 'bird migration' question correctly versus average science scores



Source: PISA 2015 database.

22. In England, 60 per cent of pupils answered this question correctly; this is exactly what one would anticipate for a country with a mean science score of 512. Countries where pupils perform notably better on this question than in England include Estonia (74 per cent correct) and the Netherlands (67 per cent correct). However, the per cent correct in Hong Kong (52 per cent) and Taiwan (52 per cent) is somewhat lower than one might anticipate, given their comparatively high average PISA science scores. These results are presented in Figure 3.6.

23. Pupils went on to be asked a second question about bird migration:

Identify a factor that might make volunteers' counts of migrating birds inaccurate, and explain how that factor will affect the count.

24. This a good example of a question where pupils in England did particularly well; in no other country is the percentage of correct responses higher. This is a harder question; its difficulty is set around 630 points, which is at the top of Level 4 on the PISA scale. In terms of the PISA sub-domains, it tests pupils' procedural knowledge and their ability to evaluate and design scientific enquiries. In England, 50 per cent of pupils who took this question provided the correct response, with little difference between girls and boys. Further details are provided in the online data tables.

3.7 Example question 3. Meteoroids and craters.

25. The final example question is from the ‘meteoroids and craters’ module. Pupils were first provided with the following information:

> *Rocks in space that enter Earth's atmosphere are called meteoroids. Meteoroids heat up, and glow as they fall through Earth's atmosphere. Most meteoroids burn up before they hit Earth's surface. When a meteoroid hits Earth it can make a hole called a crater.*

They were then asked to answer the following question using the on-screen drop-down menus:

> *What is the effect of a planet's atmosphere on the number of craters on a planet's surface? (Select from the drop-down menus to answer the question.)*
>
> *The thicker a planet’s atmosphere is, the <u>more/fewer</u> craters its surface will have because <u>more/fewer</u> meteoroids will burn up in the atmosphere.*

26. This is an example of a question where our pupils do not perform as well as one might anticipate given our average PISA science score. In England, 60 per cent of pupils who took this question provided the correct response, with slightly more boys providing the correct response (63 per cent) than girls (58 per cent). This compares to 69 per cent of pupils, on average, amongst countries with a mean science score above 450 points. This is despite this question being an example of an easier question; its difficulty is set around 450 points, which is around the middle of Level 2 on the PISA science scale. In terms of the PISA sub-domains, it is part of the ‘earth and space’ science system, testing pupils’ content knowledge and their ability to explain phenomena scientifically.

Chapter 4. Achievement in mathematics

- Young people in England score, on average, 493 on the PISA 2015 mathematics test. The average mathematics score in England has remained stable over the last decade since 2006.

- A total of 10 countries score at least 20 points higher in mathematics than England, seven of which are East Asian and include Singapore, Hong Kong and Macao. A further eight countries, all of which are European, score between 10 and 20 points higher than England.

- Whilst England's mathematics score has remained broadly stable since 2006, several countries have experienced increasing scores over the same period. Italy (which experienced the most rapid rise of 28 points since 2006), Portugal and Russia have improved to such an extent over the last decade that they are now in a similar position to England.

- Other countries, including Finland and Australia, have meanwhile experienced a significant decline in their performance in mathematics since 2006.

- England has a similar proportion of *high-achieving* pupils in mathematics (11 per cent) to the average across members of the OECD (11 per cent).

- The gap between the highest and lowest achieving pupils in mathematics in England is 245 test points, which is equivalent to around eight years of schooling. This is bigger than in most other countries (OECD average is 232)

- The gender gap in mathematics is also pronounced, with boys achieving an average 12 points higher than girls. This is in contrast to the results for reading, in which girls do better, and science where girls and boys are equal.

1. An understanding of, and the ability to apply mathematics is central to a young person's readiness for life in modern society. Mathematics is a critical tool for young people as they confront issues and challenges in daily, and in particular professional life. It is therefore important to have an understanding of the degree to which young people emerging from school are adequately prepared to apply mathematics to understanding important issues and solve meaningful problems. This chapter therefore considers performance in the PISA mathematics domain, focusing upon how the scores for pupils in England compare to other countries. The following research questions will be addressed:

- *What is the mean mathematics score in England, and how does this compare to other countries?*
- *How have average mathematics scores in England changed over time? How does this compare to other countries?*
- *What proportion of pupils in England reach each mathematics achievement level?*
- *How do the mathematics scores of the highest achieving pupils in England compare to other countries?*
- *How do the mathematics scores of the lowest achieving pupils in England compare to other countries?*
- *How big is the gap between the pupils with the strongest and weakest mathematics skills? How does England compare to other countries in this respect?*
- *How big is the gender gap in mathematics scores?*

4.1 What is the mean mathematics score in England, and how does this compare to other countries?

2. East Asian countries continue to dominate the top spots in mathematics. In England, the average mathematics score is 493, with seven East Asian countries scoring at least 20 points higher. These are: Singapore, Hong Kong, Macao, Taiwan, Japan, China and South Korea. There are also three non-East Asian countries within this group: Switzerland, Estonia and Canada - they are listed in panel (a) of Table 4.1.

3. Although East Asia dominates the very top, there are a number of European countries with comparatively strong performance in PISA mathematics. In addition to Switzerland and Estonia, there are eight European countries where average scores are between 10 and 20 points (four to eight months of schooling) higher than in England. These are the Netherlands, Denmark, Finland, Slovenia, Belgium, Germany, Poland and Ireland, and can be found in Table 4.1 panel (b).

4. With the exception of Wales, average mathematics scores are similar to England in the rest of the UK. There are also a number of large, industrialised countries where performance is similar to ours, including Australia, France and Italy. Other notable countries with a similar average performance to England include Vietnam, Russia, Sweden and New Zealand. These are the countries included in panel (c), with differences compared to England of less than four months of schooling, and generally not outside the range one would expect given sampling error (with the exception of Norway, Spain and Luxembourg).

Table 4.1 Mean mathematics scores

(a) Countries more than 20 points ahead of England

Country	Mean score	Country	Mean score
Singapore	**564***	**China**	**531***
Hong Kong	**548***	**South Korea**	**524***
Macao	**544***	**Switzerland**	**521***
Taiwan	**542***	**Estonia**	**520***
Japan	**532***	**Canada**	**516***

(b) Countries between 10 and 20 points ahead of England

Country	Mean score	Country	Mean score
Netherlands	**512***	**Belgium**	**507***
Denmark	**511***	**Germany**	**506***
Finland	**511***	**Poland**	**504***
Slovenia	**510***	**Ireland**	**504***

(c) Countries within 10 points of England

Country	Mean score	Country	Mean score
Norway	**502***	Northern Ireland	493
Austria	497	Czech Republic	492
New Zealand	495	Portugal	492
Vietnam	495	Scotland	491
Russia	494	Italy	490
Sweden	494	Iceland	488
Australia	494	**Spain**	**486***
England	493	**Luxembourg**	**486***
France	493		

(d) Countries between 10 and 20 points behind England

Country	Mean score	Country	Mean score
Latvia	**482***	**Wales**	**478***
Malta	**479***	**Hungary**	**477***
Lithuania	**478***	**Slovakia**	**475***

(e) Countries between 20 and 30 points behind England

Country	Mean score	Country	Mean score
Israel	**470***	**Croatia**	**464***
United States	**470***		

Source: PISA 2015 database.

Note: Bold with a * indicates mean score significantly different from England at the five per cent level. Countries shaded in red not significantly different from England. Table does not include countries with average mathematics scores more than 30 points lower than in England.

5. The average mathematics score in Wales is 15 points lower than in England. Wales is grouped with four Eastern European countries (Latvia, Lithuania, Hungary and Slovakia) and Malta, where performance is between 10 and 20 points lower than England. The United States is a prominent example of a country where performance is even weaker - it is joined by Israel and Croatia in having an average mathematics score between 20 and 30 points lower than in England. These are the countries in panels (d) and (e).

6. Results have not been presented for 27 countries, including some members of the OECD, such as Greece (454) where mean mathematics scores are more than 30 points below the score for England. A full set of average scores, including all participating countries, is provided in Appendix E and the online data tables.

Key point

The average mathematics score in England is 493. Seven countries from East Asia are the top-performers internationally. In 18 countries, the average score is at least 10 test points higher than in England, and there are 36 countries where the average is at least 10 test points lower.

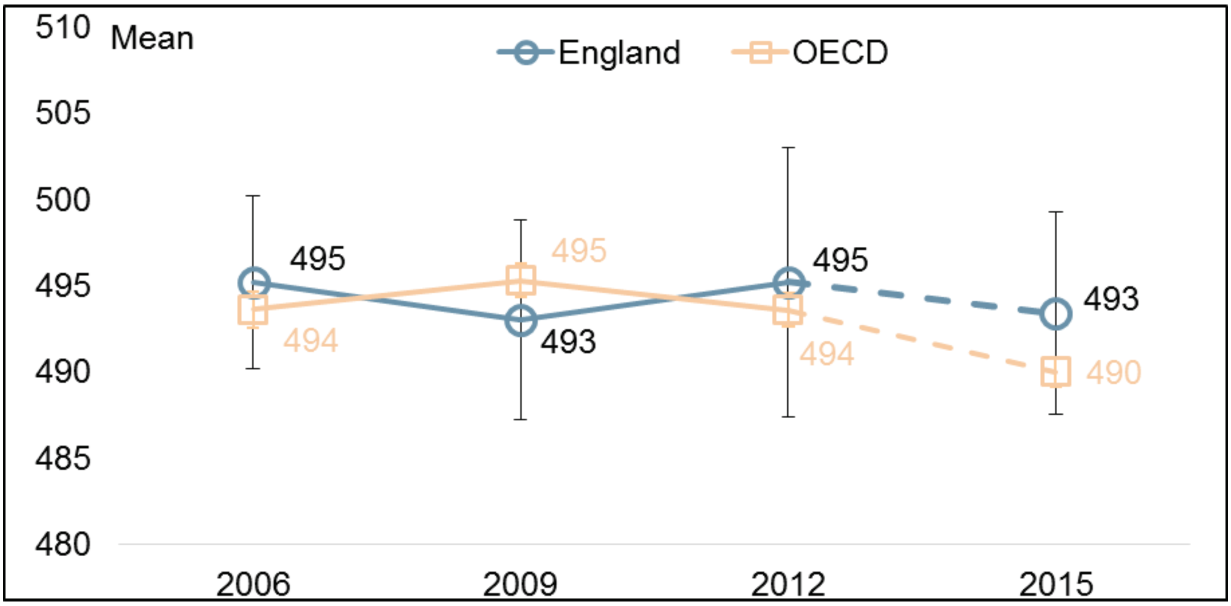
4.2 How have average mathematics scores in England changed over time?

7. The mean mathematics score for England has remained stable over the last decade. It has also remained level with the OECD average throughout this period. Figure 4.1 provides further details.

8. While England's average score has remained stable since 2006, other countries have moved around us. Italy has experienced the greatest improvement in mean mathematics scores between 2006 to 2015, gaining approximately 28 points (moving from 462 to 490 on the mathematics scale). Other countries with a more than 20 test point (eight months of schooling) increase include Israel and Portugal yet in contrast, Finland (-37 points, falling from 548 to 511), New Zealand (-27 points, falling from 522 to 495) and Australia (-26 points, from 520 to 494) have suffered the

most pronounced declines. Table 4.2 panel (a) provides further details on the five fastest improving / decline countries in mathematics since 2006.

Figure 4.1 Mean mathematics scores for England between 2006 and 2015



Sources: Bradshaw et al. (2007), Bradshaw et al. (2010), Wheater et al. (2014), PISA 2015 database.

Note: The dashed line between 2012 and 2015 refers to the introduction of computer based testing. Thin line through each data point refers to the estimated 95 per cent confidence interval. OECD average based upon the 'AV09' results presented in the OECD international results Table I.5.4a. See Appendix F for further information on trends in performance over time.

Table 4.2 The five fastest improving and declining countries in mathematics

(a) PISA mathematics scores, 2006 to 2015

Country	From	To	Change
Italy	462	490	**+28***
Israel	442	470	**+28***
Portugal	466	492	**+25***
Macao	525	544	**+19***
Russia	476	494	**+18***
Netherlands	531	512	**-18***
South Korea	547	524	**-23***
Australia	520	494	**-26***
New Zealand	522	495	**-27***
Finland	548	511	**-37***

(b) PISA mathematics scores, 2012 to 2015

Country	From	To	Change
Sweden	478	494	**+16***
Norway	489	502	**+12***
Russia	482	494	**+12***
Denmark	500	511	**+11***
Wales	468	478	+10
Poland	518	504	**-13***
Hong Kong	561	548	**-13***
Vietnam	511	495	**-17***
Taiwan	560	542	**-18***
South Korea	554	524	**-30***

Source: PISA 2015 database.

Note: Figures refer to change between cycles in the mean mathematics score. Table restricted to only those countries with a mean score above 450 in the PISA 2015 mathematics test. Bold font and a * next to the figure indicates statistically significant change. Figures in the 'change' column may not equal the difference between the 'from' and 'to' columns due to rounding.

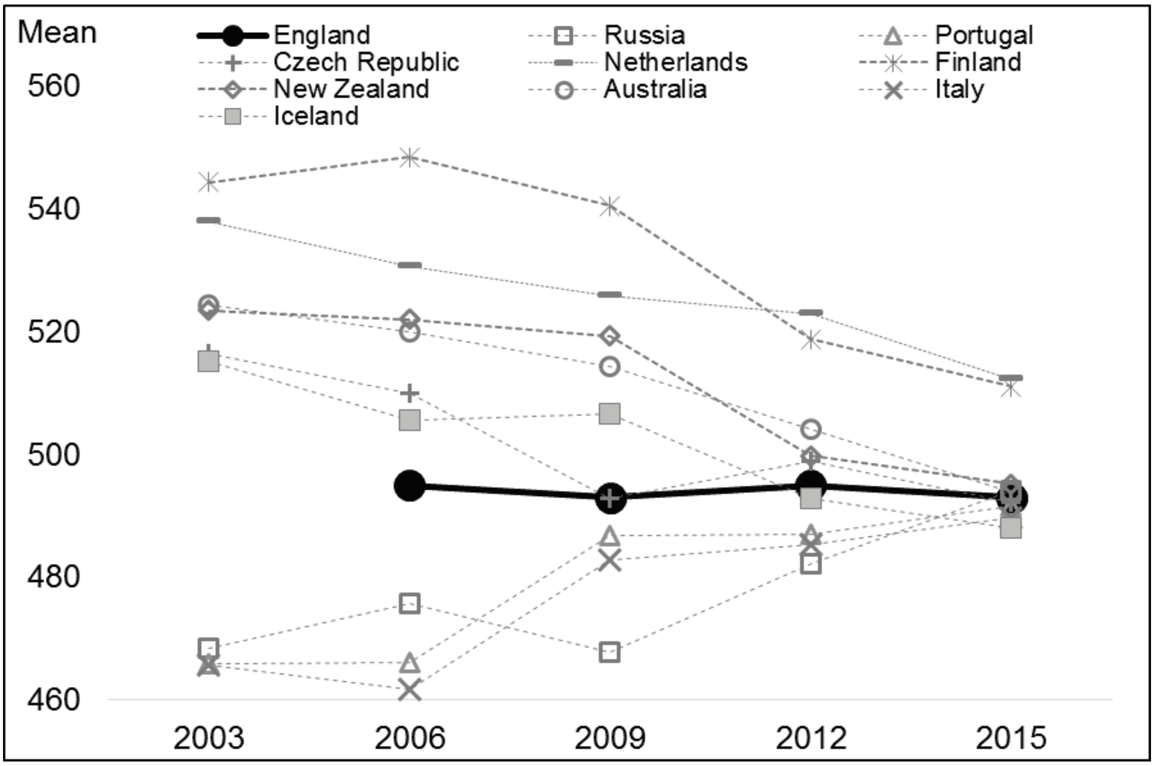
9. Three of the five countries with the biggest falls in mathematics since the last PISA cycle in 2012 are high-performing East Asian countries (Hong Kong, Taiwan and South Korea). Despite the falls, however, strong previous performance means they remain amongst the highest-performing countries internationally. A significant 30-point fall was experienced in South Korea, but it is too early to tell if this decline is a once-off fall or part of a sustained trend[24]. Sweden saw the biggest increase in mathematics scores between 2012 and 2015 (from 478 to 494), returning the mean for Sweden back to its level in 2009. Other countries with a notable improvement or decline in mean mathematics scores since 2012 include Norway (+12 points), Taiwan (-18 points) and Vietnam (-17 points).

10. When considering long-term trends in more detail, it becomes evident that while England has continued to perform consistently, some countries have caught up, while others have fallen behind. For instance, England, Slovakia and Hungary all had similar average mathematics scores in 2006 (495, 492 and 491 respectively), yet whereas England's average score has remained stable, the average score in these two Eastern European countries has fallen significantly. Similarly, whereas the Czech Republic (510), Australia (520), New Zealand (522) and Iceland (506) all had higher average mathematics scores than England in 2006, their mean scores are now all at a similar level. In contrast, in 2006 Russia (476), Portugal (466) and Italy (462) all had an average mathematics score below England's yet this is no longer

[24] In particular, note the mean mathematics score in South Korea was 542 in 2003, 547 in 2006, 546 in 2009 and 554 in 2012, before a sharp drop to 524 in 2015.

the case in 2015, with differences between these countries small and statistically insignificant. Documentation of long-term mathematics trends across countries is provided in Figure 4.2 and Appendix F.

Figure 4.2 Long-term trends in mathematics scores



Source: OECD international data Table I.5.4a and PISA database.

Notes: Figures are reported back to 2003, where available, as this was the first time point when mathematics was the focus of PISA. However, figures for the UK countries are reported from 2006 onwards, due to the low response rate in 2003. Further details provided in Appendix F. Three-year average statistically significant in all countries presented except England.

Key point

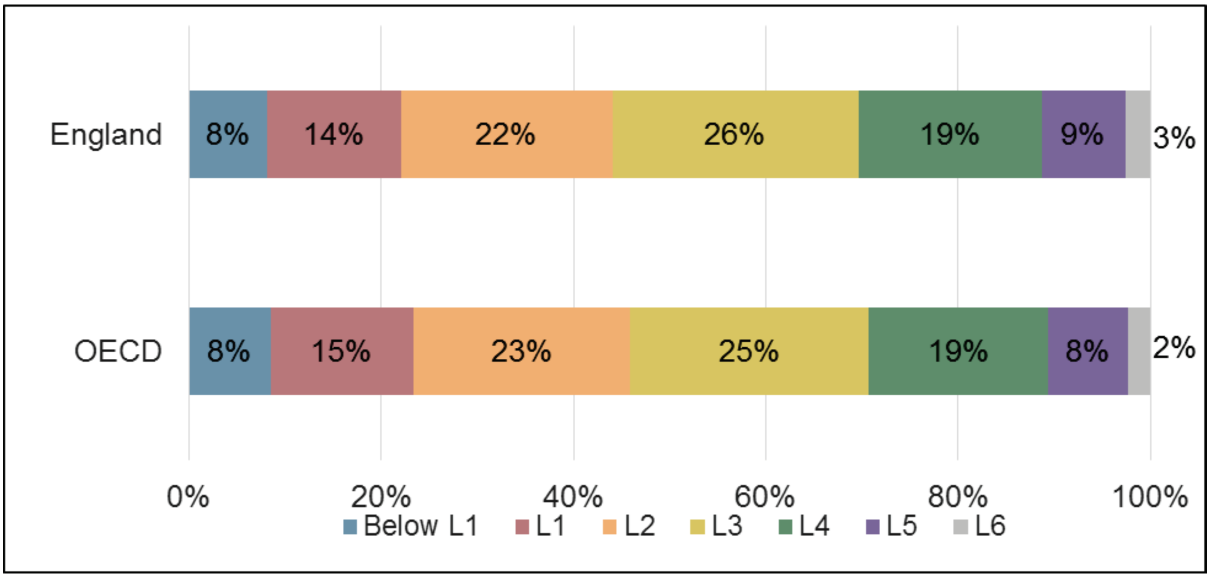
The average mathematics score in England has remained stable since 2006. Average mathematics scores in Italy, Portugal and Russia have improved over the last decade, and are now in a similar position to England. There has been a fall in the mean scores of some high-performing countries over the same period, including Finland, Australia, the Netherlands and South Korea.

4.3 What proportion of pupils in England reach each mathematics proficiency level?

11. The proportion of 'low-achievers' in England (22 per cent) is similar to the OECD average (23 per cent), with 14 per cent of 15-year-olds reaching mathematics Level 1, and eight per cent working below this standard. A similar finding holds true

for high mathematics achievers; the proportion in England is similar to the average across members of the OECD. For instance, around 11 per cent of pupils in England reach PISA Level 5 or Level 6 in mathematics, which is similar to the OECD average. England's share of high-achieving pupils in mathematics is at the level one would anticipate given England's mean score[25]. Information on the PISA level descriptors for mathematics can be found in Table 4.3, with the proportion of pupils reaching each level presented in Figure 4.3, and evidence on how this compares to average scores in Figure 4.4.

Figure 4.3 The per cent of pupils in England reaching each mathematics proficiency level



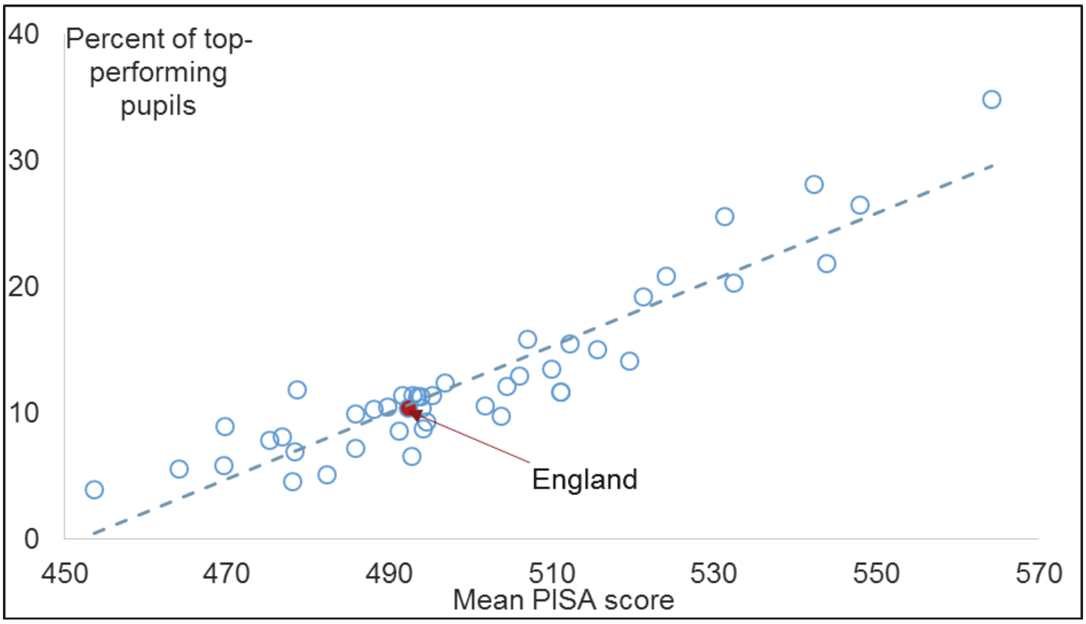
Source: PISA 2015 database

[25] This is illustrated by the fact England sits directly upon the dashed line of best fit in Figure 4.4.

Table 4.3 The PISA mathematics proficiency levels

Level	Description of the mathematics proficiency levels
Level 6	Pupils can conceptualise, generalise and utilise information based on their investigations and modelling of complex problem situations, and can use their knowledge in relatively non-standard contexts. They can link different information sources and representations and flexibly translate among them. Pupils at this level are capable of advanced mathematical thinking and reasoning. These pupils can apply this insight and understanding, along with a mastery of symbolic and formal mathematical operations and relationships, to develop new approaches and strategies for attacking novel situations. pupils at this level can reflect on their actions, and can formulate and precisely communicate their actions and reflections regarding their findings, interpretations, arguments, and the appropriateness of these to the original situation
Level 5	At Level 5 pupils can develop and work with models for complex situations, identifying constraints and specifying assumptions. They can select, compare, and evaluate appropriate problem-solving strategies for dealing with complex problems related to these models. Pupils at this level can work strategically using broad, well-developed thinking and reasoning skills, appropriate linked representations, symbolic and formal characterisations, and insight pertaining to these situations. They begin to reflect on their work and can formulate and communicate their interpretations and reasoning.
Level 4	At Level 4 pupils can work effectively with explicit models for complex concrete situations that may involve constraints or call for making assumptions. They can select and integrate different representations, including symbolic, linking them directly to aspects of real-world situations. Pupils at this level can utilise their limited range of skills and can reason with some insight, in straightforward contexts. They can construct and communicate explanations and arguments based on their interpretations, arguments, and actions.
Level 3	At Level 3 pupils can execute clearly described procedures, including those that require sequential decisions. Their interpretations are sufficiently sound to be a base for building a simple model or for selecting and applying simple problem-solving strategies. Pupils at this level can interpret and use representations based on different information sources and reason directly from them. They typically show some ability to handle percentages, fractions and decimal numbers, and to work with proportional relationships. Their solutions reflect that they have engaged in basic interpretation and reasoning
Level 2	At Level 2 pupils can interpret and recognise situations in contexts that require no more than direct inference. They can extract relevant information from a single source and make use of a single representational mode. Pupils at this level can employ basic algorithms, formulae, procedures, or conventions to solve problems involving whole numbers. They are capable of making literal interpretations of the results.
Level 1	At Level 1 pupils can answer questions involving familiar contexts where all relevant information is present and the questions are clearly defined. They are able to identify information and to carry out routine procedures according to direct instructions in explicit situations. They can perform actions that are almost always obvious and follow immediately from the given stimuli.

Figure 4.4 The per cent of top-performing pupils in mathematics compared to mean mathematics scores: a cross-country analysis



Source: PISA 2015 database.

Notes: The sample of countries included in this figure has been restricted to those with a mean mathematics score above 450.

Key point

The proportion of high-achieving and low-achieving pupils in England in mathematics is similar to the average across members of the OECD. The share of high-performing pupils is at the expected level given England's average score.

4.4 How do the mathematics scores of the *highest* achieving pupils compare across countries?

12. East Asian countries also dominate the top spots when comparing the performance of the top 10 per cent of pupils internationally. There are eight countries where the top 10 per cent of pupils achieve mathematics scores more than 20 points higher than England, with seven of these from East Asia and accompanied by Switzerland. Outside of East Asia, there are only five countries whose high-achievers score at least 10 points higher than the 613 points in England. A number of large industrialised countries, including Germany, Australia, France and Italy are statistically similar to England, as are the four Scandinavian countries: Sweden, Norway, Finland and Denmark. Table 4.4 provides further details.

Table 4.4 The 90th percentile of mathematics scores

(a) Countries more than 20 points ahead of England

Country	90th percentile	Country	90th percentile
Singapore	**682***	**South Korea**	**649***
Taiwan	**670***	**Macao**	**643***
China	**664***	**Japan**	**643***
Hong Kong	**659***	**Switzerland**	**641***

(b) Countries between 10 and 20 points ahead of England

Country	90th percentile	Country	90th percentile
Belgium	**630***	**Netherlands**	**627***
Canada	**627***	**Estonia**	**623***

(c) Countries within 10 points of England

Country	90th percentile	Country	90th percentile
Slovenia	622	New Zealand	613
Germany	620	France	613
Austria	618	Norway	610
Poland	617	Italy	610
Malta	616	Sweden	609
Finland	614	Czech Republic	608
Denmark	614	Iceland	608
Portugal	614	Luxembourg	607
Australia	613	Ireland	606
England	613	Vietnam	604

(d) Countries between 10 and 20 points behind England

Country	90th percentile	Country	90th percentile
Russia	**601***	**Hungary**	**598***
Israel	601	**Slovakia**	**596***
Scotland	**601***	**Spain**	**593***

(e) Countries between 20 and 30 points behind England

Country	90th percentile	Country	90th percentile
Northern Ireland	**592***	**United States**	**585***
Lithuania	**590***		

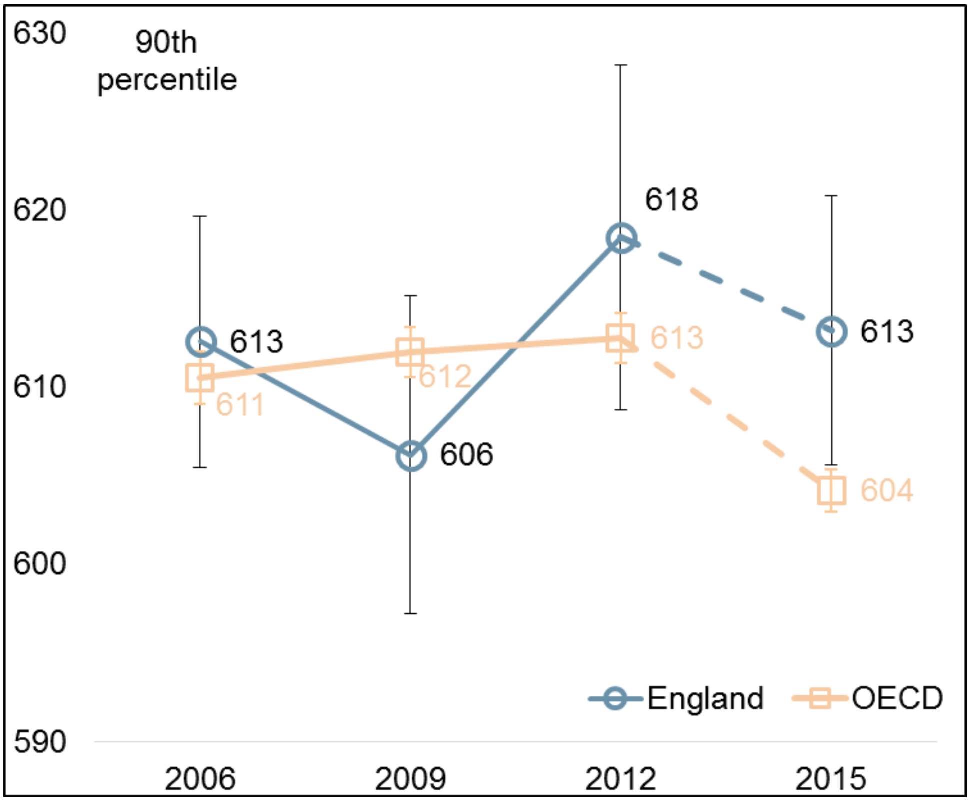
Source: PISA 2015 database.

Note: * and bold font indicates significantly different from England at the five per cent level. Countries shaded in red not significantly different from England. Table does not include countries where the 90th percentile of the mathematics proficiency distribution is more than 30 points below England.

13. The achievement of England's top 10 per cent of pupils has remained stable since 2006. There is no statistically significant difference between the cut-off to make it into the top 10 per cent in 2006 (613), 2009 (606), 2012 (618) and 2015 (613). England has remained in-line with the OECD average in this respect between 2006 and 2012, though has risen slightly above it in 2015 (613 versus 604) and these results are presented in Figure 4.5.

14. The stable trend observed for England in Figure 4.5 is typical of many other countries with similar mathematics scores. There are, however, some important exceptions including the Czech Republic (641 to 608), New Zealand (650 to 613), and Slovakia (619 to 596). These countries have a similar mathematics score to England yet have seen a pronounced and statistically significant decline in the performance of their high-achieving pupils between 2003 and 2015. Italy and Portugal however, saw the scores of the top 10 per cent of pupils rise significantly between 2003 and 2015 (589 to 610 and 580 to 614 respectively).

Figure 4.5 The 90th percentile of mathematics scores between 2006 and 2015



Sources: Bradshaw et al. (2007), Bradshaw et al. (2010), Wheater et al. (2014), PISA 2015 database.

Note: The dashed line between 2012 and 2015 refers to the introduction of computer based testing. Thin line through each data point refers to the estimated 95 per cent confidence interval. Confidence intervals do not include link error for comparing changes over time. OECD average based upon the 'AV09' results presented in the OECD international results Table I.5.4b. See Appendix F for further information on trends in performance over time.

Key point

The PISA scores of England's highest achieving pupils in mathematics have remained stable since 2006 and remain significantly behind the high-performing countries of East Asia.

4.5 How do the mathematics scores of the *lowest* achieving pupils in England compare to other countries?

15. The mathematics skills of England's lowest achievers are significantly below those of the lowest achievers in several other Western, European and industrialised countries. In total, there are 17 countries where low-achieving pupils are more than eight months (two terms) of schooling ahead of their peers in England in mathematics, and a further six countries that are more than four months (one term) ahead.

16. Along with the high-performing East Asian nations, there are several European countries where the lowest-achieving 10 per cent of pupils obtain a mathematics score more than 20 points above their peers in England. Prominent examples include Poland (391), the Netherlands (390) and Germany (389). It is also notable how the lowest achieving 10 per cent of pupils in Northern Ireland and Scotland are significantly above their peers in England, despite these three countries having similar average mathematics scores. Likewise, the lowest achieving 10 per cent of pupils in England have similar mathematics skills to the worst performing 10 per cent of pupils in Wales, despite England having a significantly higher average mathematics score. Table 4.5 provides further information on the mathematics scores of low-achieving pupils across countries.

Table 4.5 The 10th percentile of mathematics scores

(a) Countries more than 20 points ahead of England

Country	10th percentile	Country	10th percentile
Macao	439*	Ireland	400*
Singapore	436*	Switzerland	394*
Hong Kong	426*	Slovenia	394*
Japan	416*	Poland	391*
Estonia	415*	South Korea	391*
Denmark	405*	Norway	391*
Finland	404*	Netherlands	390*
Taiwan	404*	Germany	389*
Canada	400*		

(b) Countries between 10 and 20 points ahead of England

Country	10th percentile	Country	10th percentile
Vietnam	**388***	**Russia**	**387***
China	**388***	**Scotland**	**382***
Northern Ireland	**388***	**Latvia**	**382***

(c) Countries within 10 points of England

Country	10th percentile	Country	10th percentile
Wales	377	England	369
Sweden	376	Italy	368
New Zealand	375	Iceland	367
Belgium	374	Lithuania	365
Spain	374	Portugal	365
Czech Republic	373	France	364
Australia	371	Luxembourg	363
Austria	370		

(d) Countries between 10 and 20 points behind England

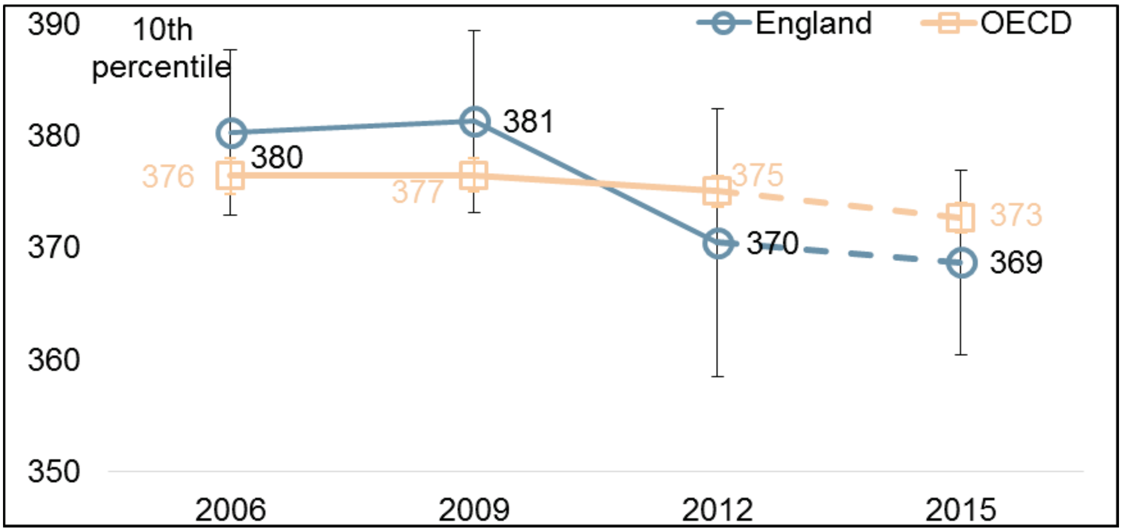
Country	10th percentile	Country	10th percentile
United States	**355***	**Croatia**	**351***
Hungary	**351***	**Slovakia**	**349***

Source: PISA 2015 database.

Note: Bold font and * indicates significantly different from England at the five per cent level. Countries shaded in red not significantly different from England. There is no country where the 90th percentile is between 20 and 30 points below England. Table does not include countries where the 10th percentile of the mathematics distribution is more than 30 points below England.

17. The mathematics performance of England's lowest-achieving pupils has remained stable since 2006. It has also remained level with the OECD average throughout this period. Figure 4.6 illustrates these results.

Figure 4.6 The 10th percentile of mathematics scores between 2006 and 2015



Sources: Bradshaw et al. (2007), Bradshaw et al. (2010), Wheater et al. (2014), PISA 2015 database.

Note: The dashed line between 2012 and 2015 refers to the introduction of computer based testing. Thin line through each data point refers to the estimated 95 per cent confidence interval. Confidence intervals do not include link error for comparing changes over time. OECD average based upon the 'AV09' results presented in the OECD international results Table I.5.4b. See Appendix F for further information on trends in performance over time.

18. Although the mathematics performance of England's low-achieving pupils has remained stable, other countries have moved around us, with some catching up while others have fallen behind. Of the countries with a similar or higher mathematics score to England, the mathematics skills of the lowest achieving pupils in Australia (399 to 371) and Iceland (396 to 367) has fallen between 2003 and 2015. In contrast, Russia (351 to 387) and Italy (342 to 368) are two countries with a similar average PISA 2015 mathematics score to England where the mathematics skills of the lowest achievers has substantially improved.

Key point

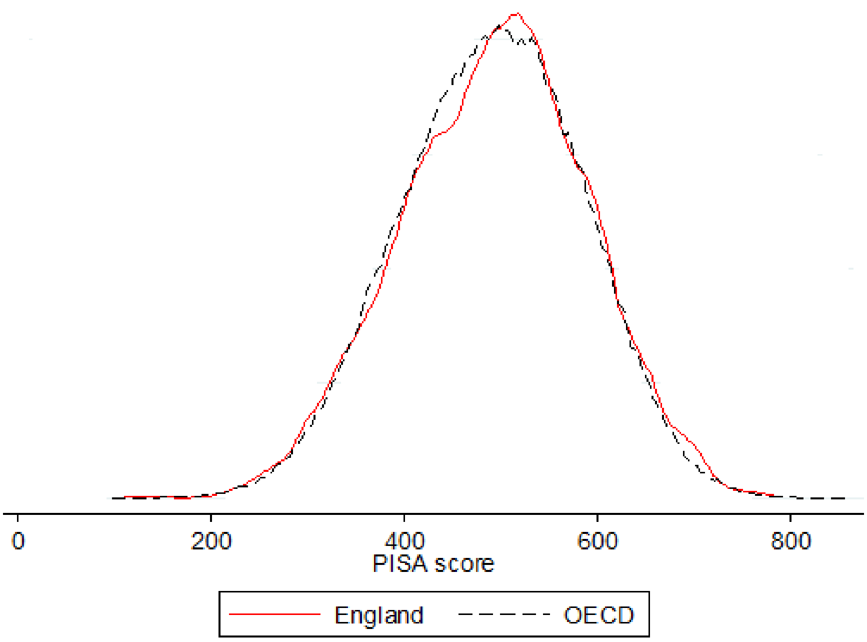
There are 23 countries where the lowest achieving 10 per cent of pupils in mathematics obtain scores at least 10 test points higher than the lowest achieving pupils in England. The mathematics scores of low-achieving pupils in England have remained stable since 2006.

4.6 How big is the gap between the pupils with the strongest and weakest mathematics skills?

19. The distribution of 15-year-olds' mathematics achievement in England is relatively unequal in comparison to other countries. The difference in mathematics performance between the highest and lowest achieving 10 per cent of pupils is 245 points (approximately eight years of schooling) which is above the OECD average of

232. Out of the countries with a mean score above 450, only in Malta, China, Israel and Taiwan is inequality in mathematics scores significantly greater than in England. Conversely, there are 21 countries where inequality in mathematics achievement is significantly lower. Some, such as Canada and Japan, achieve a higher mean score than England while also being more equitable. Others, including China and Taiwan, have greater levels of inequality in pupils’ mathematics skills. Evidence on the distribution and inequality in mathematics scores across countries is presented in Figures 4.7 and 4.8.

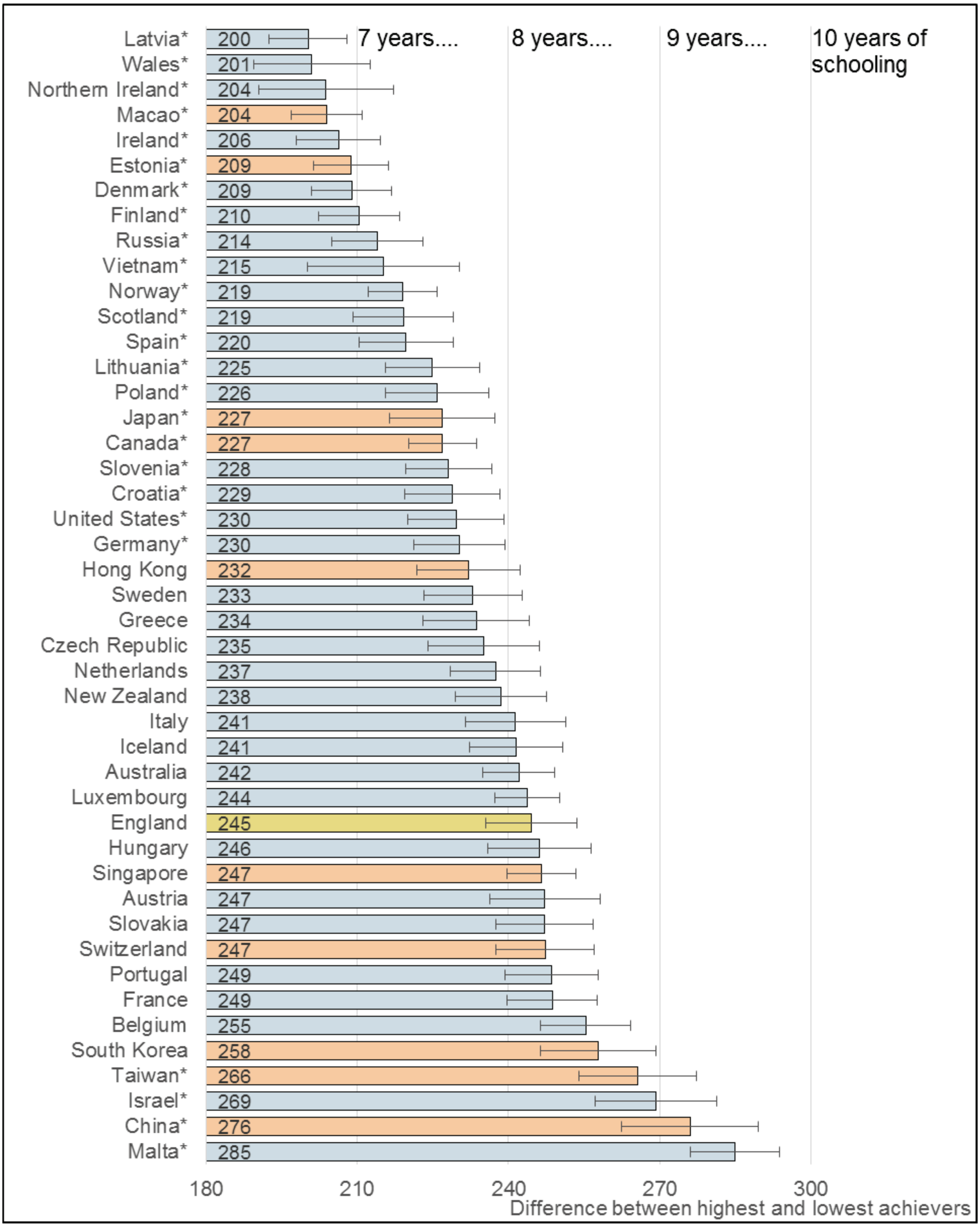
Figure 4.7 The distribution of mathematics scores in England compared to the OECD average



Source: PISA 2015 database.

Notes: Distributions produced using the first plausible value only.

Figure 4.8 Difference between the highest and lowest achievers in mathematics



Source: PISA 2015 database.

Note: * indicates statistically significant difference compared to England at the five per cent level. Figure only includes countries where the mean mathematics score is above 450. High-performing countries in mathematics highlighted in orange. Thin line through the centre of each bar refers to the estimated 95 per cent confidence interval.

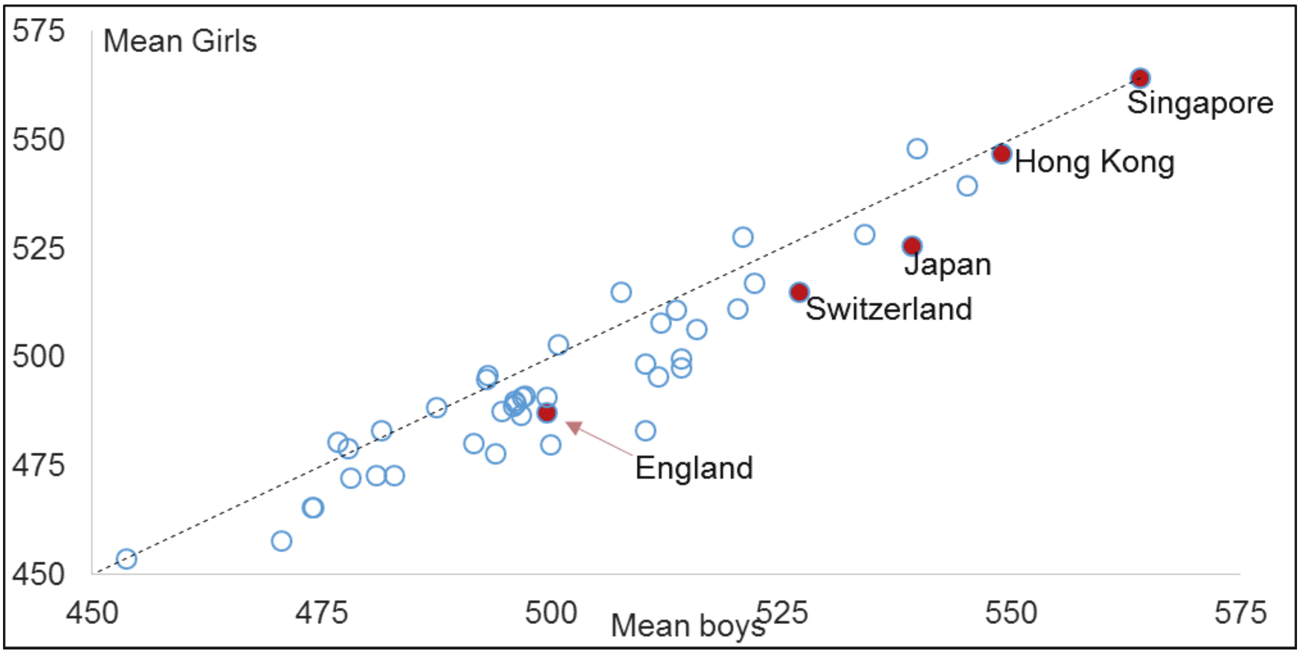
Key point

Of the 45 countries with average mathematics scores above 450 points, there are only four where the gap between the highest and lowest achievers is bigger than in England, but 21 where the gap is smaller. The distribution of performance in England is therefore comparatively unequal.

4.7 How big is the gender gap in mathematics scores?

20. In England, boys achieve a mean score of 500 compared to 487 for girls, which (after taking into account the rounding of figures) means the gender gap in mathematics is equal to a statistically significant 12 points. This is somewhat different to the pattern observed for mathematics GCSEs, where the proportion of A* to C grades for boys (71 per cent) is roughly the same as for girls (73 per cent)[26]. It is however consistent with evidence from other international assessments such as Year 9 TIMSS, where boys also achieve somewhat higher scores on the mathematics test than girls. Each of these assessments differ in terms of the knowledge and skills that are being measured, and also the impact they have on pupils' future learning, which may explain the different patterns observed (see Box 1.1 for further details).

Figure 4.9 Average mathematics scores of boys and girls across countries



Source: PISA 2015 database.

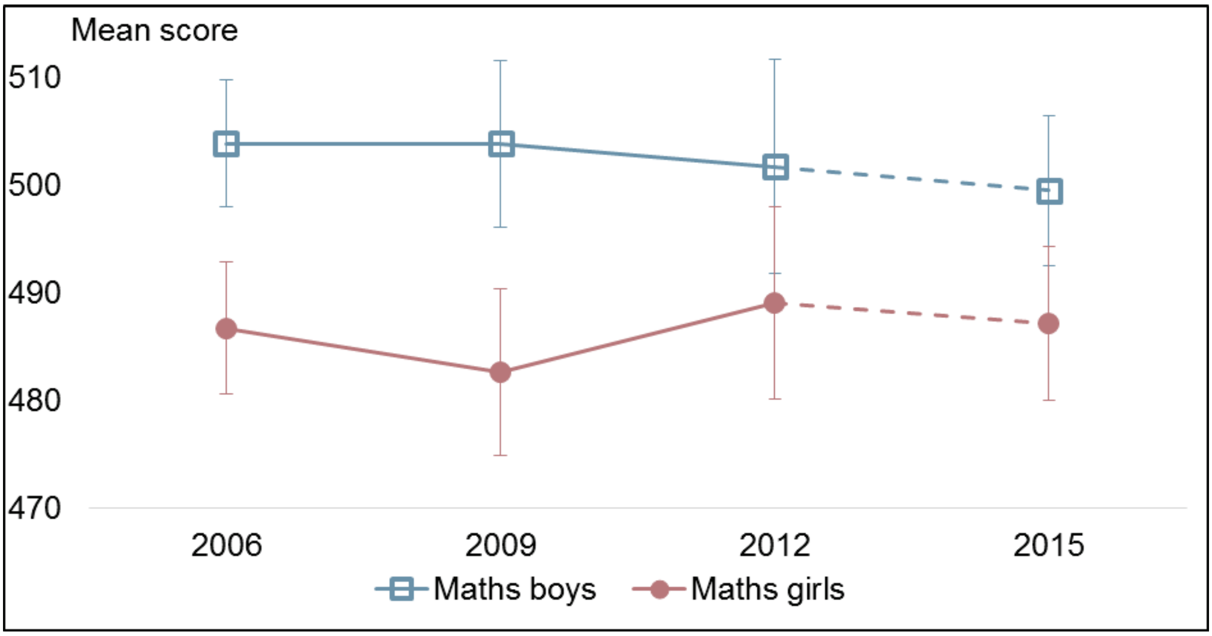
Note: Sample of countries restricted to those with a mean mathematics score above 450 points. Dashed line illustrates where the mean score for boys and girls is equal.

[26] Department for Education (2016b: Table S1). Figures for mathematics.

21.	England is typical in experiencing a gender difference in 15-year-olds mathematics skills. On average, the gender gap in mathematics is six test points across those countries that score above 450 points and eight points across the OECD. There is also little evidence of a consistent pattern emerging across the 10 countries with the highest average mathematics scores. For instance, in Japan and Switzerland boys achieve significantly higher average mathematics scores than girls, while in others, such as Singapore and Hong Kong, there is no statistically significant difference. Further details can be found in Figure 4.9.

22.	Over the last decade, boys in England have consistently achieved higher average mathematics scores than girls, with a difference of at least 10 test points. For both boys and girls, the trend has remained stable over time. The results from PISA 2015 are therefore consistent with results from previous cycles in this respect, which is illustrated in Figure 4.10.

Figure 4.10 Average mathematics scores in England by gender since 2006



Sources: Bradshaw et al. (2007), Bradshaw et al. (2010), Wheater et al. (2014), PISA 2015 database.

Note: Dashed line refers to the introduction of computer based testing in 2015. Thin line through each data point refers to the estimated 95 per cent confidence interval. Confidence intervals do not include the link error for comparisons over time. See Appendix F for further information on trends in performance over time.

Key points

The average mathematics score is 12 points higher for boys (500) than girls (487). This is similar to many of the high-performing countries, and not much higher than the OECD average. Average mathematics scores of boys continue to be higher than girls in England, and this has remained stable since 2006.

Chapter 5. Achievement in reading

- On average, young people in England score 500 on the PISA 2015 reading test, which is consistent with the average performance of 15-year-olds over the last decade. As the OECD average has declined slightly (not significantly) in 2015, pupils in England perform significantly, but only just, above the average - for the first time.

- Notable countries with a similar average reading score to England include Australia, Taiwan, China and the United States.

- Meanwhile there are nine countries with PISA scores more than 10 points ahead of England in 2015. In five countries, including Singapore and Ireland, the average PISA reading score is more than 20 points higher, and in four, including Estonia and Norway, the average is at least 10 points higher.

- In contrast to England's stability, several countries experienced improvements in reading scores since 2006, including Russia (with the greatest improvement since 2006, of 55 test points), Israel, Norway and Portugal. In contrast, South Korea and Finland have suffered statistically significant declines in reading performance.

- At a score of 625 test points or more, performance among the top-performing 10 per cent of 15-year-olds in England was substantially above the national average of 500. There are only seven countries (Singapore, New Zealand, Canada, Finland, South Korea, France and Norway) where the highest-achieving 10 per cent of pupils have significantly stronger reading skills than in England.

- By contrast, however, the lowest 10 per cent of achievers in reading in England score 371 points or below. This is a substantial difference between the lowest and highest 10 per cent, and is equivalent to around eight and a half years of schooling.

- In only seven countries is inequality of reading performance (as measured by the difference between the highest and lowest achievers) greater than in England. Of those, only New Zealand is a top-10 country in terms of average reading scores.

- There is also some divergence of scores in terms of gender, with girls in England performing around nine months of schooling ahead of boys. However, this is similar to the situation in most other countries.

1. Achievement in reading literacy is not only a foundation for achievement in other subject areas, but also a prerequisite for successful participation in most areas of adult life. Indeed, although greater levels of reading literacy are associated with higher economic returns[27], the impact of reading literacy upon personal well-being and social cohesion is likely to be just as important[28]. This chapter analyses the reading proficiency of 15-year-olds in England, and how this compares to the reading skills of young people living in other countries. It addresses the following research questions:

- *What is the mean reading score in England, and how does this compare to other countries?*
- *How have average reading scores in England changed over time? How does this compare to other countries?*
- *What proportion of pupils in England reach each reading achievement level?*
- *How do the reading scores of the highest achieving pupils in England compare to other countries?*
- *How do the reading scores of the lowest achieving pupils in England compare to other countries?*
- *How big is the gap between the pupils with the strongest and weakest reading skills? How does England compare to other countries in this respect?*
- *How big is the gender gap in reading scores?*

5.1 What is the average reading score in England, and how does this compare to other countries?

2. There are just four European countries where the average reading score is more than 10 points above the average score in England (500 points). These are Finland, Ireland, Estonia and Norway. Similarly, only two primarily English-speaking countries (Canada and Ireland) are more than 10 points ahead of England. The remaining countries within this group are all East Asian: Singapore, Hong Kong, South Korea and Japan and these are the countries in panels (a) and (b) of Table 5.1.

3. China, Russia, the United States, Australia, France and Spain are all examples of major world economies where average reading scores of 15-year-olds are similar to in England. Scotland and Northern Ireland also sit within this group, as do Sweden and Denmark. These are the countries within panel (c), with differences of less than four months of schooling from England, and (with the exception of New Zealand, Germany and Macao) not reaching statistical significance.

[27] Machin and McNally (2008).
[28] Friedman (2005) and OECD (2001).

Table 5.1 Mean reading scores

(a) Countries more than 20 points ahead of England

Country	Mean score	Country	Mean score
Singapore	**535***	**Finland**	**526***
Hong Kong	**527***	**Ireland**	**521***
Canada	**527***		

(b) Countries between 10 and 20 points ahead of England

Country	Mean score	Country	Mean score
Estonia	**519***	**Japan**	**516***
South Korea	**517***	**Norway**	**513***

(c) Countries within 10 points of England

Country	Mean score	Country	Mean score
New Zealand	**509***	Belgium	499
Germany	**509***	Portugal	498
Macao	**509***	Taiwan	497
Poland	506	Northern Ireland	497
Slovenia	505	United States	497
Netherlands	503	Spain	496
Australia	503	Russia	495
Sweden	500	China	494
Denmark	500	Scotland	493
England	500	Switzerland	492
France	499		

(d) Countries between 10 and 20 points behind England

Country	Mean score	Country	Mean score
Latvia	**488***	**Austria**	**485***
Czech Republic	**487***	**Italy**	**485***
Croatia	**487***	**Iceland**	**482***
Vietnam	**487***	**Luxembourg**	**481***

(e) Countries between 20 and 30 points behind England

Country	Mean score	Country	Mean score
Israel	**479***	**Lithuania**	**472***
Wales	**477***		

Source: PISA 2015 database.

Note: Bold font with a * indicates mean score significantly different from England at the five per cent level. Countries shaded in red not significantly different from England. Table does not include countries with average reading scores more than 30 points lower than in England.

4. There is a notable difference in the average reading scores of pupils in England and Wales; the gap is more than 20 points (eight months of schooling) and is statistically significant. England is also more than 10 points ahead of a number of Eastern and Central European countries, including Latvia, the Czech Republic, Croatia, Austria, Luxembourg and Lithuania. These countries are listed in panels (d) and (e).

5. Results have not been presented for 30 countries where the average reading score is more than 30 points lower than in England, including some members of the OECD, such as Greece (467). A full set of average scores, including all participating countries, is provided in Appendix E and the online data tables.

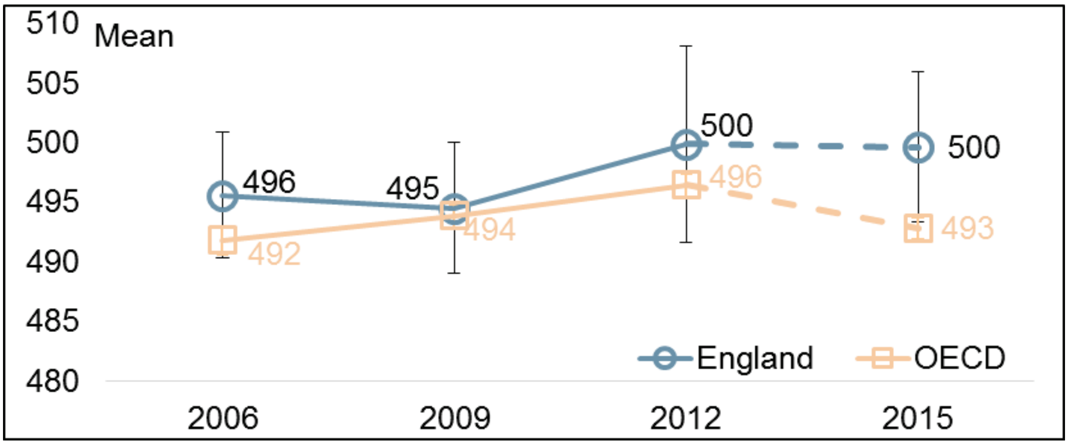
Key point

The average reading score in England is 500. There are nine countries where the average is at least 10 test points higher than in England, and 41 countries where the average is at least 10 test points lower.

5.2 How have average reading scores in England changed over time?

6. The average reading score for England has remained stable since 2006, and has always been within 10 points of the OECD average. For the first time, in 2015 pupils in England perform significantly, but only just, above the OECD average. Figure 5.1 illustrates how the mean reading score for England (500) in 2015 is not significantly different from the mean score in 2012 (500), 2009 (495) or 2006 (496).

Figure 5.1 Mean reading scores between 2006 and 2015



Sources: Bradshaw et al. (2007), Bradshaw et al. (2010), Wheater et al. (2014), PISA 2015 database.

Note: The dashed line between 2012 and 2015 refers to the introduction of computer based testing. Thin line through each data point refers to the estimated 95 per cent confidence interval. OECD average based upon the 'AV09' results presented in the OECD international results Table I.4.4a. See Appendix F for further information on trends in performance over time.

7. While England's reading score has remained stable over the last decade, other countries have moved around us. Russia has experienced the greatest improvement, gaining approximately 55 test points, moving from 440 to 495 on the reading scale. Other countries with a statistically significant and greater than 20 test point (eight months of schooling) increase include Israel (+40, from 439 to 479), Spain (+35, from 461 to 496), Norway (+29, from 484 to 513) and Portugal (+26, from 472 to 498). In contrast, South Korea (-39 points, falling from 556 to 517) and Finland (-20 points, from 547 to 526) have suffered statistically significant declines. Table 5.2 panel (a) provides further details on the five fastest improving / declining countries since 2006.

Table 5.2 The five fastest improving and declining countries in reading

(a) PISA 2006 to 2015

Country	From	To	Change
Russia	440	495	**+55***
Israel	439	479	**+40***
Spain	461	496	**+35***
Norway	484	513	**+29***
Portugal	472	498	**+26***
New Zealand	521	509	-12
Hungary	482	470	-13
Slovakia	466	453	-14
Finland	547	526	**-20***
South Korea	556	517	**-39***

(b) PISA 2012 to 2015

Country	From	To	Change
Slovenia	481	505	**+24***
Russia	475	495	**+19***
Chile	441	459	**+17***
Sweden	483	500	**+17***
Portugal	488	498	+10
South Korea	536	517	**-18***
Hungary	488	470	**-19***
Vietnam	508	487	**-21***
Japan	538	516	**-22***
Taiwan	523	497	**-26***

Source: PISA 2015 database.

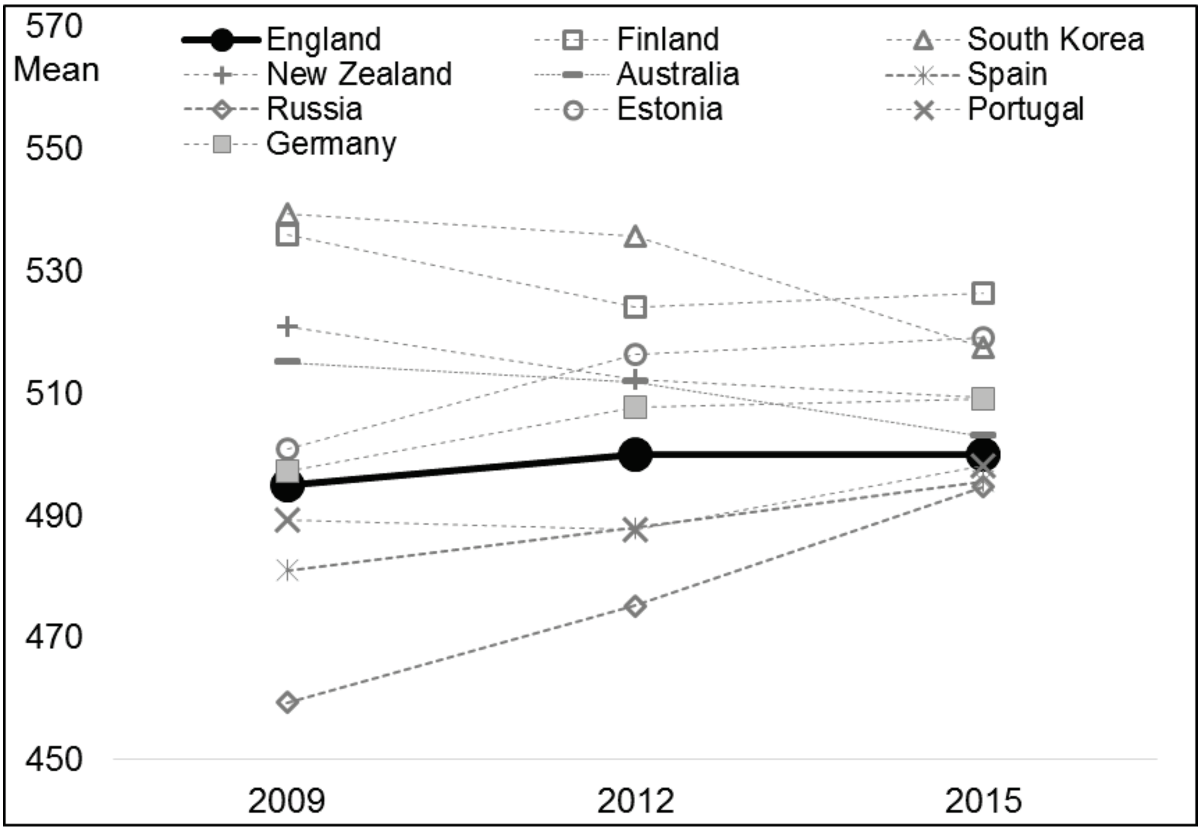
Note: Figures refer to change between cycles in the mean reading score. Table restricted to only those countries with a mean score above 450 in the PISA 2015 reading test. Bold font and * indicate change statistically significant at the five per cent level. Figures in the ‘change’ column may not equal the difference between the ‘from’ and ‘to’ columns due to rounding.

8. Four of the five countries with the biggest declines in average reading scores since the last PISA cycle in 2012 are East Asian. Due to their high starting points, they nevertheless still remain amongst the top-performers. This includes South Korea (-18 points, from 536 to 517), Japan (-22 points, from 538 to 516), Vietnam (-21 points, from 508 to 487) and Taiwan (-26 points, from 523 to 497). However, for many of these countries, it is too early to tell whether this is due to a one-off fall or part of a sustained trend. On the other hand, Slovenia (+24 points), Russia (+19 points), Sweden (+17 points) and Chile (+17 points) have demonstrated the greatest improvement in average reading scores since PISA 2012.

9. While the trend for England has remained stable since 2009[29], a number of countries have improved to catch up, including Portugal (489 to 498), Spain (481 to 496) and Russia (459 to 495). Countries with a similar mean score to England in 2009 who have since improved include Norway (503 to 513) and Germany (497 to 509). Of the countries that achieved a higher average reading score than England in 2009, Australia (515 to 503) and New Zealand (521 to 509) have fallen, Japan, Canada and Hong Kong have stood still, while Singapore has improved (526 to 535). Figure 5.2 and Appendix F provides further evidence on trends in reading scores across countries since 2009

[29] We follow the OECD and report figures for reading trends for other countries back to 2009. Note that, although comparison of PISA reading scores to earlier cycles (e.g. to 2006) is possible, such comparisons are considered less stable due to the limited number of ‘trend’ questions that were included for the reading domain.

Figure 5.2 Trends in reading scores since 2009 across countries



Source: OECD international data Table I.4.4a and PISA database.

Notes: The OECD long-term trend measure in reading uses 2009 as the base year due to the small number of 'trend' questions included in earlier cycles. The three-year average is statistically significant in all countries presented other than England and Portugal. Further details can be found in Appendix F.

Key point

Average reading scores in England have remained stable over time. Since 2009, a number of countries have improved to catch up with England, including Portugal (489 to 498), Spain (481 to 496) and Russia (459 to 495). Norway (503 to 513) and Germany (497 to 509) had similar average reading scores to England in 2009 but have since improved.

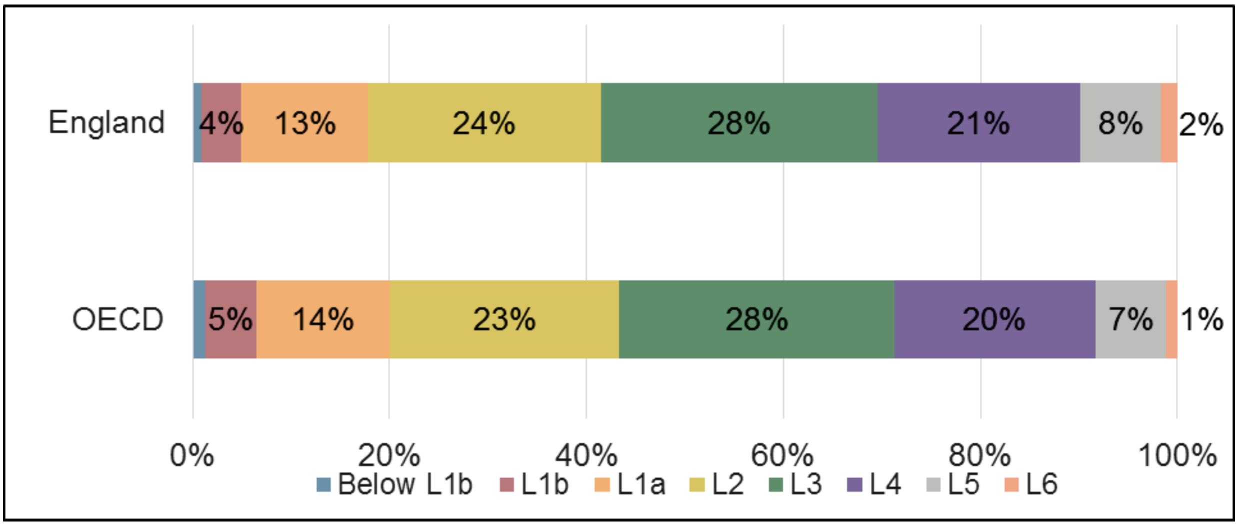
5.3 What proportion of pupils in England reach each reading proficiency level?

10. The proportion of 'low-achievers' in England (18 per cent) is slightly below the average across members of the OECD (20 per cent). Specifically, In England, one per cent of pupils are working below Level 1b, four per cent reach Level 1b, while 13 per cent of 15-year-olds reach PISA reading Level 1a (see Figure 5.3). Analogous figures for the average across OECD members are one per cent below Level 1b, five

per cent at Level 1b and 14 per cent at Level 1a. For further information, the PISA level descriptors can be found in Table 5.3 and the proportion of pupils reaching each proficiency level in Figure 5.3.

11. Around 10 per cent of pupils in England are high-achievers in reading, compared to an average across OECD members of around eight per cent – slightly more than one would expect for a country with an average score of 500. Interesting comparator countries include France and Denmark, whose average reading scores are very similar to England, yet the former has more high-achieving pupils than England (13 per cent) whilst the latter has fewer (six per cent). Ireland is another interesting example; it has the same proportion of high-achieving pupils as England, despite its significantly higher average score. These results can be found in Figures 5.3 and 5.4.

Figure 5.3 The per cent of pupils reaching each reading proficiency level



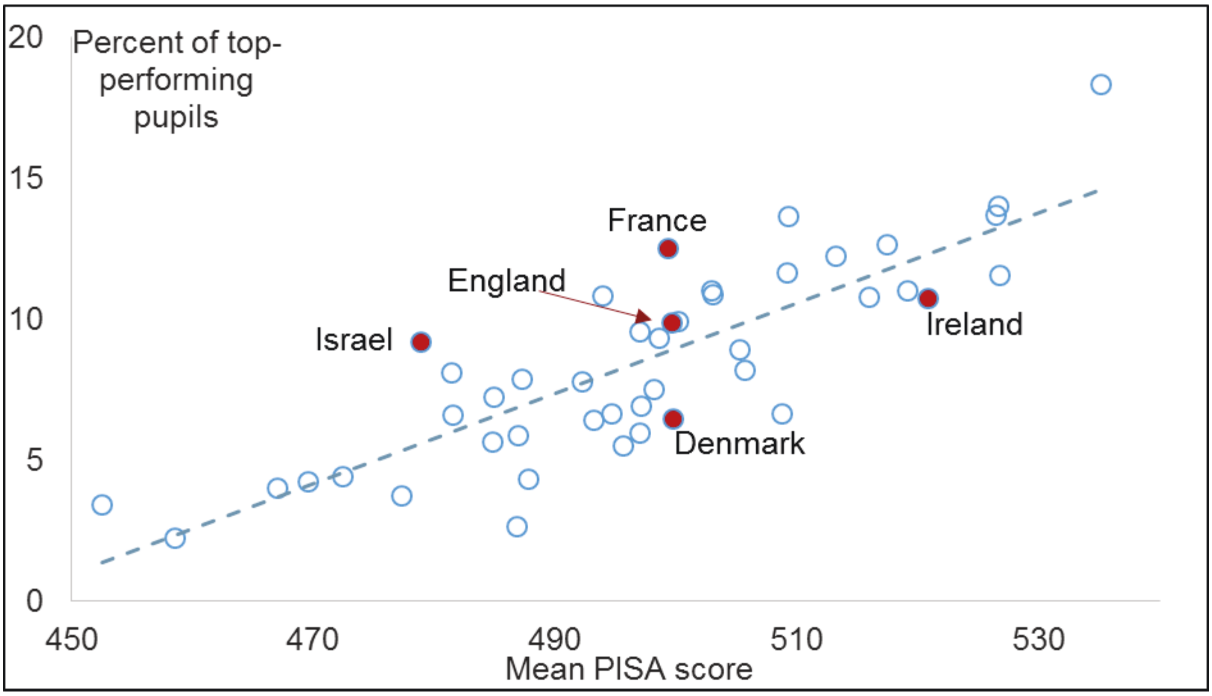
Source: PISA 2015 database.

Table 5.3 The PISA reading proficiency levels

Level	Description of the reading proficiency levels
Level 6	The reader can make multiple inferences, comparisons and contrasts that are both detailed and precise. They demonstrate a full and detailed understanding of one or more texts and may integrate information from more than one text. The reader can deal with unfamiliar ideas, in the presence of competing information, and to generate abstract categories for interpretations. The reader can hypothesise about or critically evaluate a complex text on an unfamiliar topic, taking into account multiple perspectives, and applying sophisticated understandings from beyond the text.
Level 5	Tasks at this level that involve retrieving information require the reader to locate and organise several pieces of deeply embedded information, inferring which information in the text is relevant. Reflective tasks require critical evaluation or hypothesis, drawing on specialised knowledge.

Level	Description of the reading proficiency levels
Level 4	Tasks at this level that involve retrieving information require the reader to locate and organise several pieces of embedded information. Some tasks require interpreting the meaning of nuances of language in a section of text by taking into account the text as a whole. Other tasks require understanding and applying categories in an unfamiliar context. Reflective tasks at this level require readers to use formal or public knowledge to hypothesise about or critically evaluate a text. Readers must demonstrate an accurate understanding of long or complex texts whose content or form may be unfamiliar.
Level 3	Tasks require the reader to locate, and in some cases recognise the relationship between, several pieces of information that meet multiple conditions. Interpretative tasks require the reader to integrate several parts of a text in order to identify a main idea, understand a relationship or construe the meaning of a word or phrase. They need to take into account many features in comparing, contrasting or categorising. Often the required information is not prominent or there is much competing information; or there are other text obstacles, such as ideas that are contrary to expectation or negatively worded. Reflective tasks at this level may require connections, comparisons, and explanations, or they may require the reader to evaluate a feature of the text. Some reflective tasks require readers to demonstrate a fine understanding of the text in relation to familiar, everyday knowledge. Other tasks do not require detailed text comprehension but require the reader to draw on less common knowledge.
Level 2	Some tasks at this level require the reader to locate one or more pieces of information, which may need to be inferred and may need to meet several conditions. Others require recognising the main idea in a text, understanding relationships, or construing meaning within a limited part of the text when the information is not prominent and the reader must make low level inferences. Tasks at this level may involve comparisons or contrasts based on a single feature in the text. Typical reflective tasks at this level require readers to make a comparison or several connections between the text and outside knowledge, by drawing on personal experience and attitudes.
Level 1a	Tasks require the reader to locate one or more independent pieces of explicitly stated information; to recognise the main theme or author's purpose about a familiar topic, or to make a simple connection between information in the text and common, everyday knowledge. The required information in the text is prominent and there is little, if any, competing information. The reader is explicitly directed to consider relevant factors in the task and text.
Level 1b	Tasks at this level require the reader to locate a single piece of explicitly stated information in a prominent position in a short, syntactically simple text with a familiar context and text type, such as a narrative or a simple list. The text typically provides support to the reader, such as repetition of information, pictures or familiar symbols. There is minimal competing information. In tasks requiring interpretation the reader may need to make simple connections between adjacent pieces of information.

Figure 5.4 The per cent of top-performing pupils in reading compared to average reading scores: a cross-country analysis



Source: PISA 2015 database.

Notes: The sample of countries included in this figure has been restricted to those with a mean reading score above 450 points.

> **Key point**
>
> In reading, England has slightly more high-achieving pupils and slightly fewer low-achieving pupils than the average across members of the OECD.

5.4 How do the reading scores of the *highest* achieving pupils in England compare to other countries?

12. There are relatively few countries across the world where the highest-achieving pupils have substantially stronger reading skills than the highest-achieving pupils in England. There are seven in total: three in Europe (Finland, France and Norway), two predominantly English-speaking countries (Canada and New Zealand) and two from East Asia (Singapore and South Korea). Singapore is the only country where the top 10 per cent of pupils scores more than 20 points above the top 10 per cent in England and these results are provided in Table 5.4.

Table 5.4 The 90th percentile of reading scores

(a) Countries more than 20 points ahead of England

Country	90th percentile
Singapore	**657***

(b) Countries between 10 and 20 points ahead of England

Country	90th percentile	Country	90th percentile
New Zealand	**643***	**South Korea**	**637***
Canada	**642***	**France**	**637***
Finland	**640***	**Norway**	**636***

(c) Countries within 10 points of England

Country	90th percentile	Country	90th percentile
Germany	634	Sweden	625
Hong Kong	632	England	625
Australia	631	United States	624
Estonia	630	Belgium	623
China	630	Israel	621
Netherlands	630	Slovenia	621
Japan	629	Poland	617
Ireland	629	Luxembourg	616

(d) Countries between 10 and 20 points behind England

Country	90th percentile	Country	90th percentile
Czech Republic	**614***	**Macao**	**610***
Switzerland	**614***	**Denmark**	**608***
Portugal	**614***	**Scotland**	**608***
Austria	**611***	**Russia**	**608***
Taiwan	**611***	**Iceland**	**607***

(e) Countries between 20 and 30 points behind England

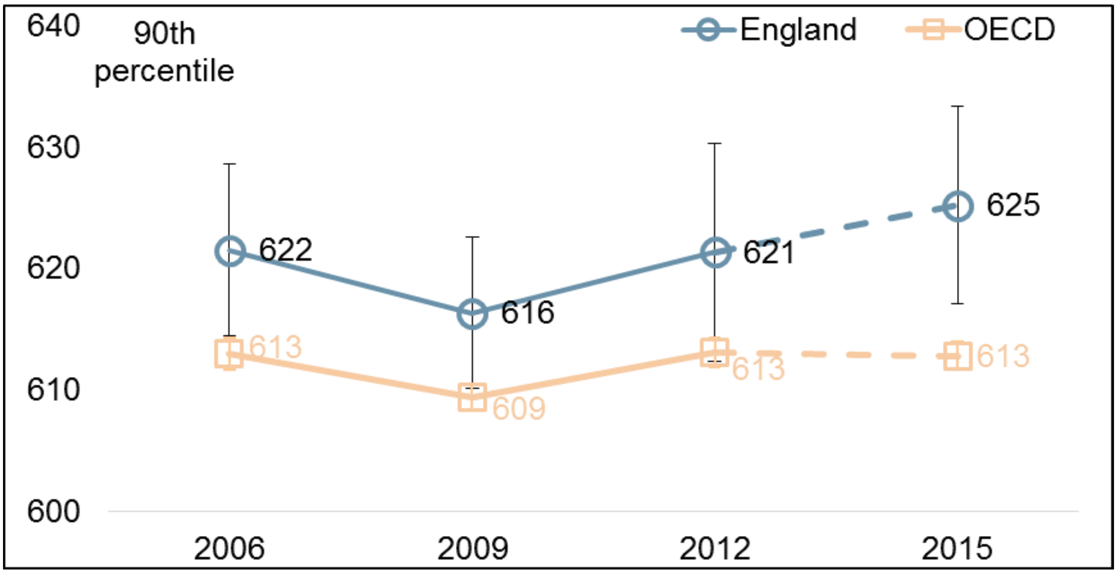
Country	90th percentile	Country	90th percentile
Northern Ireland	**605***	**Spain**	**603***
Croatia	**603***	**Italy**	**602***

Source: PISA 2015 database.

Note: Bold font and a * indicates significantly different from England at the five per cent level. Countries shaded in red not significantly different from England. Table does not include countries where the 90th percentile is more than 30 points below England.

13. The reading performance of England's high-achieving pupils has remained stable since 2006. It has remained around 10 points above the OECD average throughout this period. Further details can be found in Figure 5.5.

Figure 5.5 The 90th percentile of reading scores between 2006 and 2015



Sources: Bradshaw et al. (2007), Bradshaw et al. (2010), Wheater et al. (2014), PISA 2015 database.

Note: The dashed line between 2012 and 2015 refers to the introduction of computer based testing. Thin line through each data point refers to the estimated 95 per cent confidence interval. Confidence intervals do not include link error for comparing changes over time. OECD average based upon the 'AV09' results presented in the OECD international results Table I.4.4b. See Appendix F for further information on trends in performance over time.

14. Whereas the trend for England's high-performers has been stable over time, other previously lower performing countries have caught up to England's level. These include Norway (where the scores of the top 10 per cent have increased from 619 in 2009 to 636 in 2015), the Czech Republic (598 to 614), Portugal (599 to 614), Russia (572 to 608) and Spain (588 to 603). With the exception of Japan, where the reading performance of high-achieving pupils has fallen from 639 to 629, there are few countries where the scores of high-achieving pupils has fallen.

Key point

The PISA reading scores of England's highest achieving pupils has remained stable since 2006.

5.5 How do the reading scores of the *lowest* achieving pupils in England compare to other countries?

15. East Asian countries tend to be particularly strong in maximising the reading skills of their lowest-performing pupils. Compared to England, where the bottom 10 per cent of pupils achieve a reading score below 371, the scores of low-achieving pupils in Hong Kong, Singapore, Macao, Vietnam, Japan and South Korea are at least 10 points higher. There are, however, some important exceptions; low-achieving pupils in Taiwan achieve a similar reading score to low-achieving pupils in England, while the situation in China is significantly worse. There are also some European countries where the performance of low-achieving pupils is substantially higher than in England, including Estonia, Finland, Ireland and Poland. It is also notable that, although Northern Ireland is more than 10 points ahead of England, there are no statistically significant differences compared to other parts of the UK. These results are presented within Table 5.5.

Table 5.5 The 10th percentile of reading scores

(a) Countries more than 20 points ahead of England

Country	10th percentile	Country	10th percentile
Hong Kong	**412***	**Singapore**	**400***
Ireland	**406***	**Macao**	**399***
Estonia	**404***	**Vietnam**	**393***
Canada	**404***	**Japan**	**391***
Finland	**401***		

(b) Countries between 10 and 20 points ahead of England

Country	10th percentile	Country	10th percentile
South Korea	**386***	Denmark	383
Poland	**386***	Slovenia	382
Northern Ireland	385		

(c) Countries within 10 points of England

Country	10th percentile	Country	10th percentile
Norway	381	Taiwan	371
Russia	381	New Zealand	368
Spain	379	Wales	368
Germany	375	Netherlands	368
Portugal	374	Croatia	367
Latvia	374	Australia	365
Scotland	373	United States	364
England	371	Sweden	364

(d) Countries between 10 and 20 points behind England

Country	10th percentile	Country	10th percentile
Belgium	360	**Italy**	**359***
Switzerland	360	**Czech Republic**	**352***

(e) Countries between 20 and 30 points behind England

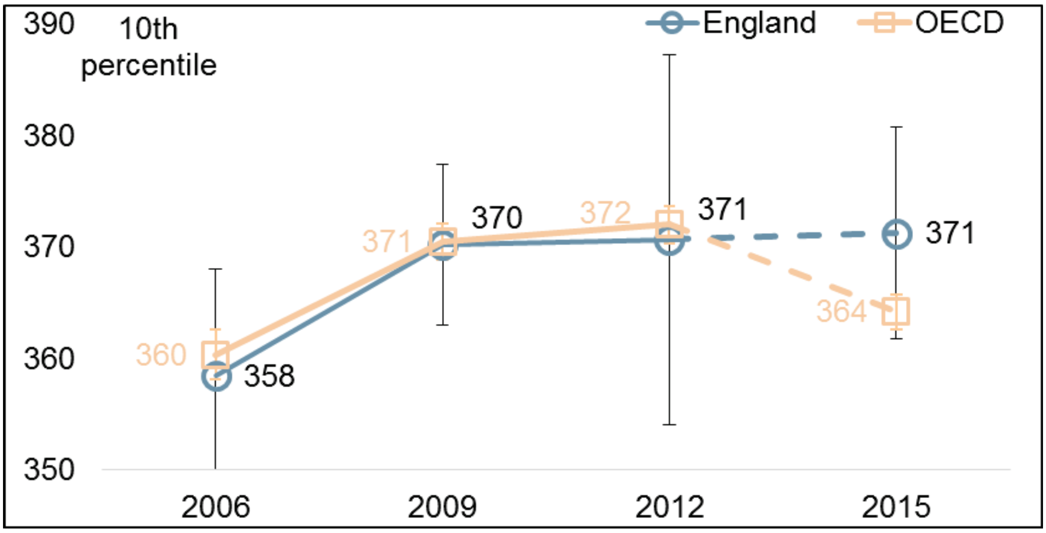
Country	10th percentile	Country	10th percentile
Iceland	**350***	**China**	**346***
Lithuania	**347***	**France**	**344***
Austria	**347***	**Chile**	**342***

Source: PISA 2015 database.

Note: Bold font and * indicates significantly different from England at the five per cent level. Countries shaded in red not significantly different from England. Table does not include countries where the 10th percentile of the reading distribution is more than 30 points below England.

16. There has been no statistically significant change in the performance of England's lowest-achieving pupils in reading since 2006 which has remained in line with the OECD average throughout this period. These results can be found in Figure 5.6, with the score for the bottom 10 per cent of pupils in 2015 (371) being almost identical to the value in 2012 (371) and 2009 (370). Although the figure in 2006 was slightly lower (358), the difference between 2006 and 2015 is not statistically significant.

Figure 5.6 The 10th percentile of reading scores between 2006 and 2015



Sources: Bradshaw et al. (2007), Bradshaw et al. (2010), Wheater et al. (2014), PISA 2015 database.

Note: The dashed line between 2012 and 2015 refers to the introduction of computer based testing. Thin line through each data point refers to the estimated 95 per cent confidence interval. Confidence intervals do not include link error for comparing changes over time. OECD average based upon the 'AV09' results presented in the OECD international results Table I.4.4b. See Appendix F for further information on trends in performance over time.

17. Whereas the trend for England at the 10th percentile has been stable since 2009, there has been a significant change in the performance of low-achievers in some other countries. Of those with a similar or higher reading score than England, the 10th percentile has declined between 2009 and 2015; Australia (384 to 365), South Korea (435 to 386), New Zealand (383 to 368), Switzerland (374 to 360) and the Netherlands (390 to 368). Yet there are also countries where the skills of the lowest achievers in reading have improved over this period, including Russia (344 to 381), Ireland (373 to 406), Spain (364 to 379) and Slovenia (359 to 382). Therefore, while the reading performance of low-achieving pupils in England has remained stable, other countries have moved around us.

Key point

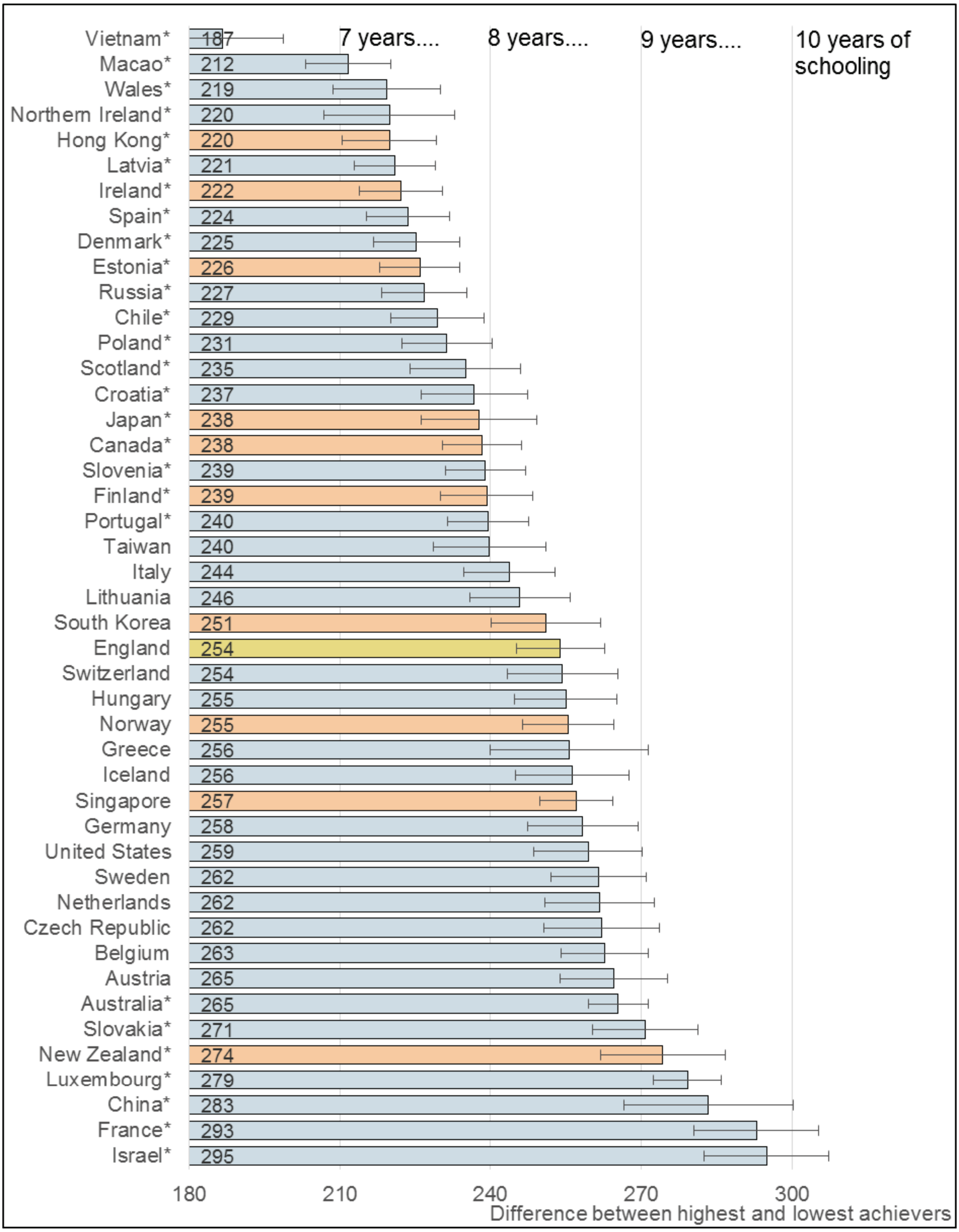
The reading skills of the lowest performing pupils in England has remained stable since 2006. There are 14 countries where the reading skills of the lowest achievers is at least 10 points higher than England (statistically significant on 11 occasions). There are 41 countries where the reading skills of lowest achieving pupils is at least 10 points lower than England (statistically significant on 39 occasions).

5.6 How big is the gap between the pupils with the strongest and weakest reading skills?

18. Inequality in 15-year-olds' reading performance is relatively similar in England to other industrialised countries. The difference in performance between the highest and lowest achieving 10 per cent of pupils is 254 points (around eight and a half years of schooling) which is similar to the OECD average of 249. There are, however, seven countries where inequality in reading performance is significantly greater than in England, including some major world economies: China, France, Australia and New Zealand.

19. Conversely, there are 20 countries with an average reading score above 450 points where inequality in reading achievement is significantly lower than in England. Out of the top-10 countries (in terms of average reading scores) only in New Zealand is there significantly more inequality in reading performance than in England, while in six of the top-10 countries inequality in performance is significantly lower (including in Canada, Finland and Ireland). Further evidence is presented in Figures 5.7 and 5.8.

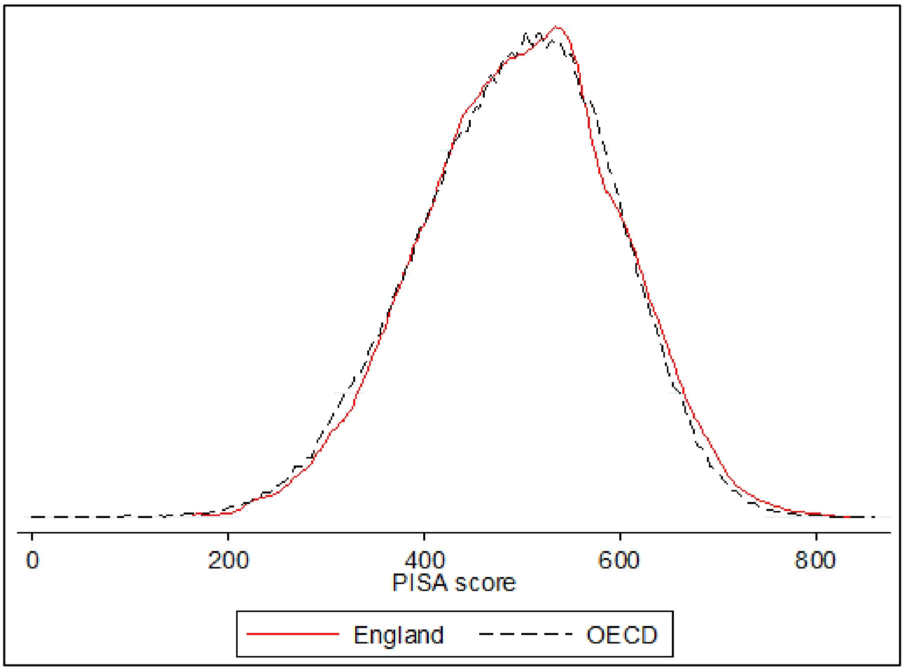
Figure 5.7 Difference between the highest and lowest achievers in reading



Source: PISA 2015 database.

Note: * indicates statistically significant differences compared to England at the five per cent level. Figure only includes countries where the mean reading score is above 450. High-performing countries in science highlighted in orange. Thin line through centre of each bar refers to the estimated 95 per cent confidence interval.

Figure 5.8 The distribution of reading scores in England



Source: PISA 2015 database.

Notes: Distributions produced using the first plausible value only. Bin widths of 10 points are used for England and two points for the OECD average.

Key point

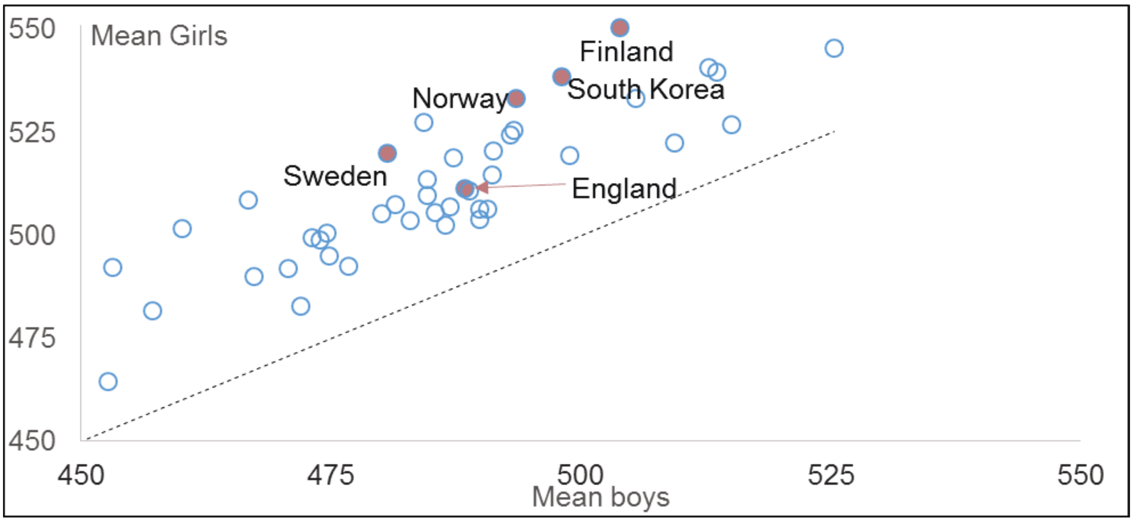
The gap between the highest and lowest achieving pupils in reading is similar to the OECD average.

5.7 How big is the gender gap in reading scores?

20. Although girls outperform boys in reading with a difference roughly equivalent to nine additional months of schooling, England is actually similar to most other countries in this respect. In every country, the average reading score for girls is higher than the average score for boys. In England, the gender gap is equal to 23 points with boys achieving a mean reading score of 488 compared to 511 for girls. This is consistent with GCSE results, where 83 per cent of girls obtain an A*-C grade in English language compared to only 69 per cent of boys [30]. In fact, the gender gap in England is actually slightly below the OECD average of 27 test points and much more extreme gender differences can be observed in countries like Finland, Sweden, Norway and South Korea, where there is a difference of more than 40 points. Figure 5.9 provides further details.

[30] Department for Education (2016b: Table S1). Figures for English Language.

Figure 5.9 Average reading scores of boys and girls across countries

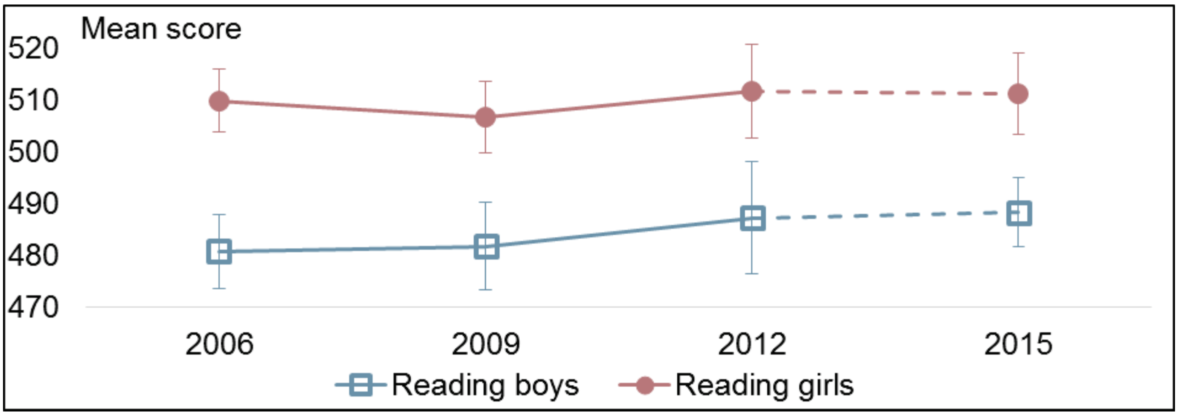


Source: PISA 2015 database.

Note: Sample of countries restricted to those with a mean reading score above 450 points. Dashed line illustrates where the mean score for boys is equal to the mean score for girls.

21. Over the last decade, boys in England have consistently achieved lower reading scores than girls, with a difference of at least 20 test points. For both boys and girls, the trend has remained stable over time. The results from PISA 2015 are therefore consistent with results from previous cycles. This evidence is presented in Figure 5.10.

Figure 5.10 Average reading scores for boys and girls in England since 2006



Sources: Bradshaw et al. (2007), Bradshaw et al. (2010), Wheater et al. (2014), PISA 2015 database.

Note: Dashed line refers to the introduction of computer based testing in 2015. Thin line through each data point refers to the estimated 95 per cent confidence interval. See Appendix F for further information on trends in performance over time.

Key point

The gender gap in reading scores has remained stable since 2006, with girls consistently out-performing boys.

Chapter 6. Variation in PISA scores by pupil characteristics

- Family background continues to have a significant impact on pupils' achievement at school in England. The least advantaged 25 per cent of pupils in England score an average of 475 in the PISA science assessment; almost 80 points (just under three years of schooling) less than the most advantaged 25 per cent of pupils.

- Socio-economic inequality is not an issue specific to England; family background has a similar impact upon pupils' achievement in many other countries, including some top-performers, such as Finland. Yet some countries achieve both higher average performance and more equitable outcomes compared to England, such as Macao and Hong Kong.

- Around one-in-three pupils in England overcomes a disadvantaged socio-economic background to achieve a top score on the PISA science test, compared to an OECD average of around 29 per cent.

- Pupils from immigrant backgrounds achieve lower scores than young people who were born and raised in the UK. Whilst the gap all but vanishes between native-born pupils and second-generation immigrants once pupil background is considered, it remains between native pupils and first-generation immigrants, particularly in science. The gap between first-generation immigrants and native-born pupils is larger than in England in some countries (e.g. Sweden, Denmark) while in others there is no difference at all (e.g. Canada, New Zealand).

- Results in England also vary by ethnicity; White pupils score, on average, between 25-40 points higher in the science, mathematics and reading tests than their Black and Asian peers. This is somewhat different to GCSEs, where Asian pupils obtain similar (if not higher) grades than their White peers.

- A prominent issue in English education policy concerns the performance of the White working class. Results from PISA reveal that working class White pupils perform at similar levels to working class pupils who are not of White ethnicity, but notably worse than more advantaged pupils of White ethnicity.

22. This chapter explores differences in pupils' PISA scores according to selected demographic characteristics – socioeconomic status, immigrant status and ethnic group. Although we already know much about the differences in performance by these characteristics from national GCSE examination data, PISA provides an

opportunity to consider the size and direction of these gaps in a comparative context and according to a different type of test. Specifically, PISA also allows us to re-examine differences between demographic groups using a measure that, unlike GCSEs, has a greater emphasis upon young people's 'functional skills' (see Box 1.1 for further details) and is now delivered on computer. As this chapter will reveal, different patterns of achievement can emerge when using this alternative measure.

23. In summary, this chapter will address the following questions:

- *What is the 'strength' and 'impact' of socio-economic status upon pupils' test scores? How does England compare to other countries in this respect?*
- *What proportion of young people in England are classified as 'resilient' – overcoming the odds to achieve highly in science, despite a disadvantaged socio-economic background?*
- *Do immigrants in England achieve lower average scores than young people who were born in the UK?*
- *Do PISA scores differ between ethnic groups within England? Are there particularly low levels of achievement amongst the White working class?*

6.1 How pronounced is the relationship between socio-economic status and pupils' test scores?

24. The relationship between pupils' family background and their academic achievement has long been recognised as a challenge facing education systems. Previous research[31] has documented the achievement gap between pupils from socio-economically advantaged and disadvantaged backgrounds, with a widespread belief that this is hindering the prospects of greater social mobility[32]. In England, the gap in performance between pupils from more and less advantaged backgrounds has been a focus of many education strategies and reforms, including the introduction of Pupil Premium funding and establishment of the Education Endowment Foundation. Indeed, a key part of the Department for Education 2015-2020 strategy is to '*deliver real social justice by ensuring that irrespective of location, prior attainment or economic or social background, children and young people have access to high-quality provision*'[33]. This sub-section provides evidence on the relationship between socio-economic status and the PISA scores of 15-year-olds in England, and how this compares to other countries. It will therefore illustrate the challenge England faces in narrowing educational inequalities by family background compared to other countries.

[31] See, for example, Blanden and Macmillan (2016) and Jerrim (2012).
[32] Jerrim and Macmillan (2015).
[33] Department for Education (2016c:9).

25. The main measure of socio-economic status in PISA is the Economic, Social and Cultural Status (ESCS) index. This is a continuous index that has been derived by the OECD based upon pupils' responses to the background questionnaire. A score of zero indicates a pupil's socio-economic background is around the average across OECD countries; a negative score indicates the pupil is more disadvantaged and a positive score indicates they are more advantaged. The index encompasses:

- Maternal and paternal education;
- Maternal and paternal occupation;
- Household possessions.

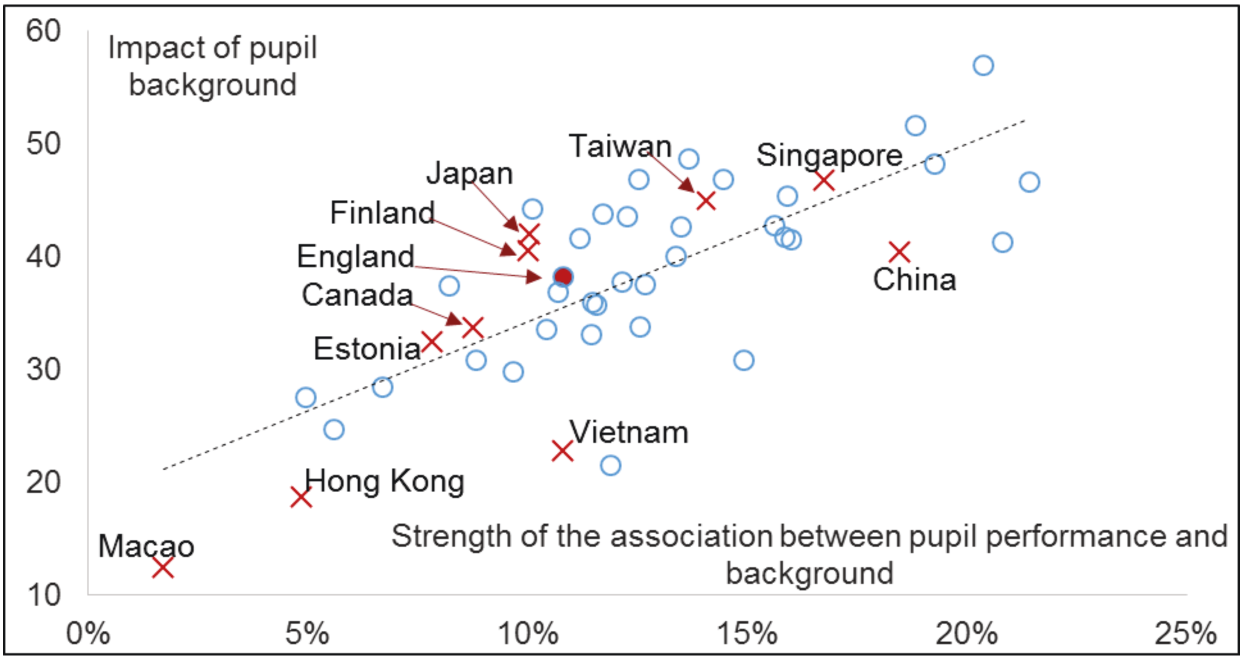
In England, the average pupil has a score of +0.21 on the ESCS index, which indicates our pupils come from more advantaged backgrounds than the average pupil across OECD countries. Across PISA participants, the average pupil is most advantaged in Iceland (ESCS score of +0.73) and least advantaged in Indonesia (ESCS score of -1.87). The OECD use the ESCS measure to estimate the *impact* socio-economic status has upon achievement and the *strength* of this relationship.

26. The *impact* of the relationship between pupils' socio-economic backgrounds (ESCS score) and their performance is measured using the difference in the average scores of pupils with more advantaged backgrounds and their peers with more disadvantaged backgrounds[34]. Low values indicate that socio-economic background has less impact upon pupil performance; high values indicate socio-economic background has more impact upon pupil performance. In England, the impact of socio-economic status upon pupils' science scores is estimated to be around 38 test points, which is a significant amount but no stronger than the OECD average (38 points).

27. The *strength* of the relationship between pupil's socio-economic backgrounds and their performance is measured in terms of the percentage of variance in PISA scores explained by the pupils' backgrounds. The key difference is that whereas the 'impact' measure is influenced by the dispersion of the ESCS index relative to test scores, the 'strength' measure is not. Low values indicate that pupil attainment varies widely, even for pupils with similar backgrounds, while high values indicate that pupil attainment is strongly determined by background. In England, approximately 11 per cent of the variation in pupils' science achievement can be explained by the ESCS index. Again this is around the same size as the association across all OECD countries (13 per cent).

[34] In other words, it is the steepness of the socio-economic gradient for each participating country. These figures refer to the change in science scores per each international standard deviation increase in the ESCS index. It is the parameter estimate generated by a simple Ordinary Least Squares regression of the ESCS index upon PISA scores.

Figure 6.1 The ‘impact’ and ‘strength’ of the relationship between socio-economic status and science scores

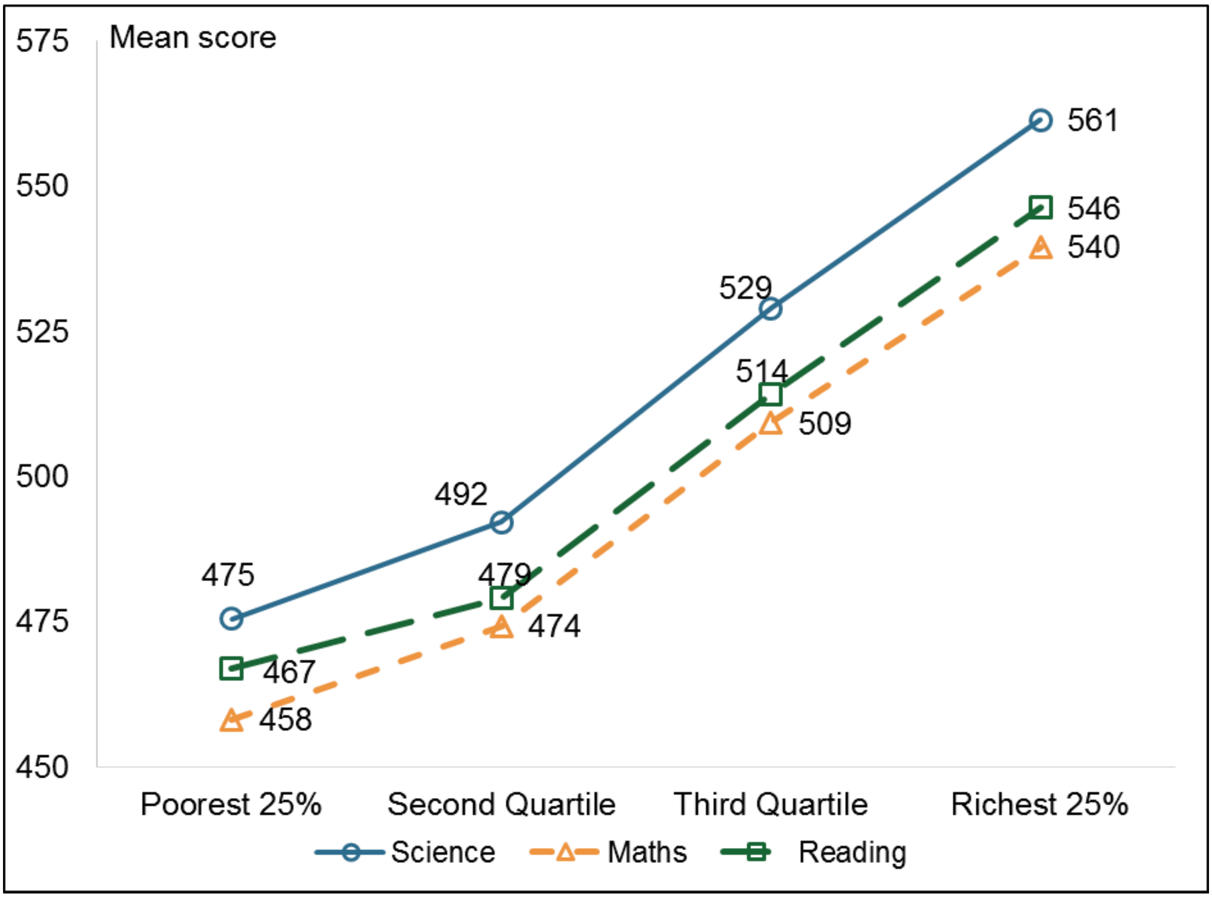


Source: PISA 2015 database.

Notes: ‘Impact’ refers to the bivariate relationship between the ESCS index and science scores, estimated using OLS regression. ‘Strength’ refers to the per cent of variance in science scores that is explained by the ESCS index. Sample of countries restricted to those with a mean science score above 450. The 10 countries with the highest average science scores are highlighted using a red cross. Spain and Latvia have been excluded due to recoding of the ESCS index required at the time of writing.

28. Countries in which the impact of pupil background on performance is high also tend to see a high association, or strength, between pupil performance and background (note the upward sloping regression line in in Figure 6.1). England is a country where socio-economic inequalities do not stand out as particularly large or small compared to elsewhere (note its position in the centre of Figure 6.1). Interestingly, there is no coherent pattern amongst the high-performing countries (the red crosses are spread across Figure 6.1); some of them, including Hong Kong and Macao, have managed to combine high performance with relatively equal outcomes for pupils irrespective of background, whereas pupil background continues to matter considerably in China and Singapore. Other countries with a particularly pronounced impact of family background upon pupils’ performance include France and the Czech Republic, while the impact is lower in Vietnam and Wales. Similar findings emerge regarding the link between family background and pupils’ achievement in reading and mathematics (results provided in the online data tables).

Figure 6.2 Average scores in England by national quartiles of the ESCS index



Source: PISA 2015 database.

29. Pupils from the most disadvantaged 25 per cent of families in England are almost three years of schooling behind pupils from the most advantaged families. Those from low socio-economic backgrounds score, on average, 475 on the science test, 458 in mathematics and 467 in reading, compared to scores of 561, 540 and 546 for pupils from high socio-economic backgrounds. It is also notable how the difference in achievement between the bottom two socio-economic quartiles (17 points in science) is smaller than the gap between all other socio-economic quartiles (e.g. there is a 32 point gap in science between the top two socio-economic quartiles) indicating the biggest impacts of family background in England are actually between the most advantaged pupils and the rest, rather than at the lower end of the distribution. These are the results presented in Figure 6.2. Additional sensitivity analyses are provided in the online data tables.

Table 6.1 The relationship between FSM eligibility and pupils' test scores
Panel (a) FSM results

	Non-FSM pupils	Pupils claiming FSM	FSM gap
Science	514	467	**46***
Mathematics	494	454	**40***
Reading	500	460	**40***
Observations	**4,172**	**519**	

Panel (b) ESCS results

	Other 89 per cent by ESCS	Most disadvantaged 11 per cent by ESCS	ESCS gap
Science	516	465	**51***
Mathematics	497	448	**49***
Reading	503	458	**45***
Observations	**4,011**	**465**	

Source: PISA 2015 matched database.

Notes: * indicates statistically significant difference at the five per cent level. Figures refer to state-funded school pupils only. Estimates presented for pupils where PISA has been successfully linked to the National Pupil Database. ESCS results based upon the sub-sample of pupils where information on both ESCS and FSM available. The 'gap' may not equal the difference between the other two columns due to rounding.

30. Nationally we tend to measure the gap between advantaged and disadvantaged pupils using the difference in performance between those who are eligible for Free School Meals (FSM) and their peers who are not[35]. Evidence from PISA indicates that FSM pupils are more than a year of schooling behind their non-FSM peers, with differences statistically significant in each domain. FSM pupils (467 points) score, on average, 46 points below their non-FSM peers (514 points) in science, with a similar gap in reading (40 points) and mathematics (40 points). These results are in Table 6.1 panel (a).

31. If we use the OECD measure of disadvantage to consider the difference in performance in England between the most disadvantaged 11 per cent of pupils and their peers, the disadvantage gap widens slightly. The difference is 51 points in science, 49 points in mathematics and 45 points in reading, which is around five points bigger than when the FSM measure was used instead. See Table 6.1 panel (b).

[35] Within the cohort that sat the 2015 PISA assessment 11 per cent of pupils were FSM eligible, 81 per cent were not FSM eligible, while data were not available for the remaining eight per cent.

Key point

Family background has a significant impact upon pupils' achievement in England and there is a substantial gap between the performance of the most disadvantaged and the most advantaged groups. The impact and strength of the relationship, however, is actually similar to many other countries, including some of the highest performers, such as Finland.

6.2 To what extent do socio-economically disadvantaged pupils succeed against the odds?

32. A number of studies have highlighted the challenges socio-economically disadvantaged young people face when trying to access professional jobs[36]. For instance, less than 10 per cent of medical undergraduate students in England come from a socio-economically disadvantaged background, compared to 60 per cent from the most advantaged socio-economic group[37]. Many believe that improving the educational achievement of young people from low income backgrounds is key to improving social mobility[38] – and, in particular, increasing the proportion of disadvantaged pupils who achieve the highest grades. At the same time, there remains some debate as to whether comprehensive or selective (grammar-style) schooling systems are more effective at reaching this goal. This sub-section provides some descriptive evidence on these issues. Specifically, it documents the proportion of socio-economically disadvantaged 15-year-olds in England who succeed in PISA against the odds, and compares this to the situation in other countries - particularly those with a more selective education system.

Box 6.1 The OECD definition of 'resilience'

A pupil is classified as resilient if he or she is in the bottom quarter of the PISA index of economic, social and cultural status (ESCS) in the country of assessment and performs in the top quarter of pupils in the focus subject (science in PISA 2015) among all countries, of the same socio-economic status. It therefore captures the proportion of pupils who are amongst the most socio-economically disadvantaged within their country, but who are amongst the highest-performing 15-year-olds in science internationally.

[36] See MacMillan et al. (2015).
[37] Social Mobility and Child Poverty Commission (2012:4).
[38] Economic and Social Research Council (2012).

Table 6.2 The proportion of 'resilient' pupils across countries

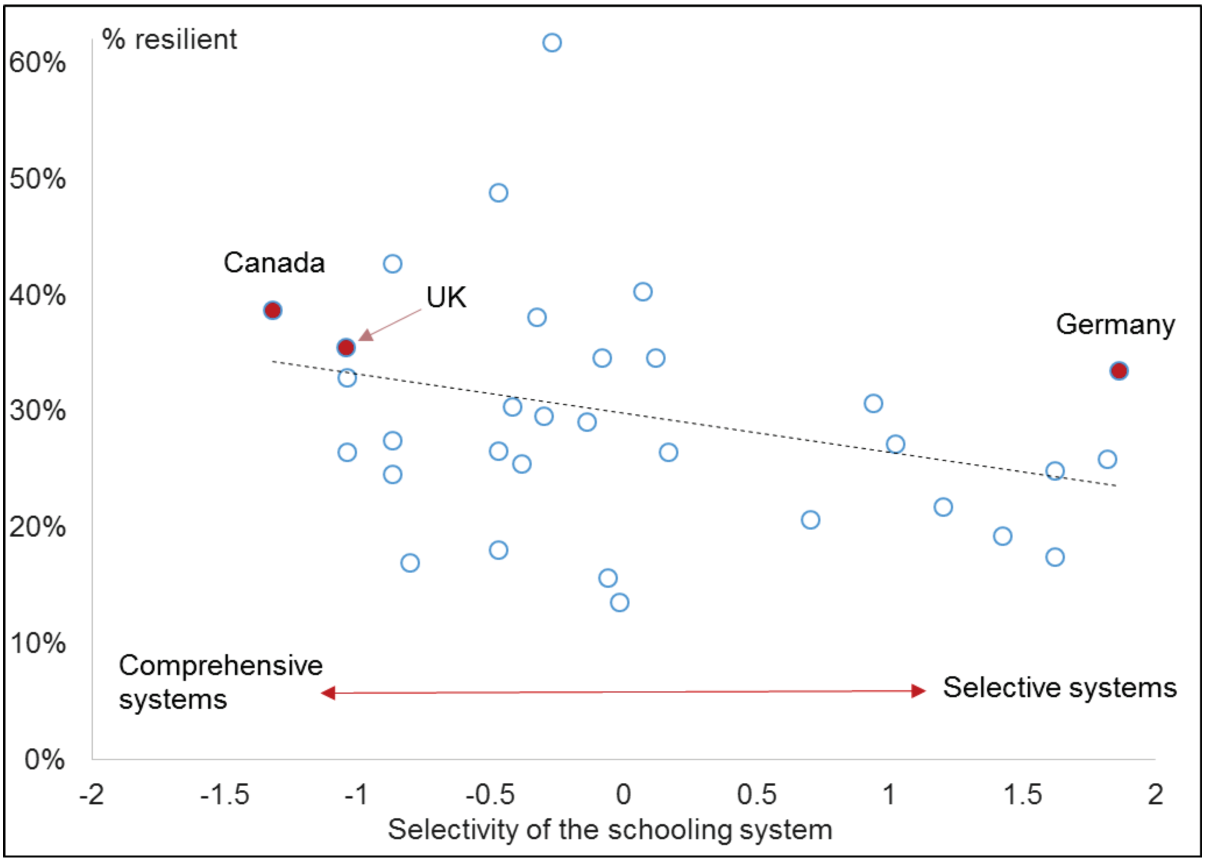
Country	Per cent of resilient pupils	Country	Per cent of resilient pupils
Vietnam	76%	Switzerland	29%
Macao	65%	Wales	29%
Hong Kong	62%	Denmark	28%
Singapore	49%	Scotland	27%
Japan	49%	Belgium	27%
Estonia	48%	France	27%
Taiwan	46%	Italy	27%
China	45%	Norway	26%
Finland	43%	Austria	26%
South Korea	40%	Russia	26%
Canada	39%	Czech Republic	25%
Portugal	38%	Sweden	25%
England	36%	Croatia	24%
Slovenia	35%	Lithuania	23%
Poland	35%	Malta	22%
Germany	34%	Luxembourg	21%
Australia	33%	Hungary	19%
United States	32%	Greece	18%
Netherlands	31%	Slovakia	18%
New Zealand	30%	Iceland	17%
Northern Ireland	30%	Israel	16%
Ireland	30%		

Source: PISA 2015 database.

Notes: The sample of countries has been restricted to those with an average PISA science score greater than 450 points. Spain and Latvia have been excluded due to recoding of the ESCS index required at the time of writing.

33. Eight of the 10 countries with the greatest proportion of resilient pupils (see Box 6.1) are East Asian; the remaining two are Finland and Estonia. It is particularly striking that in some East Asian nations the majority of disadvantaged pupils are classified as resilient: Vietnam (76 per cent), Macao (65 per cent) and Hong Kong (62 per cent). In England, over a third (36 per cent) of pupils from low socio-economic backgrounds are 'resilient', which is similar to countries like Canada (39 per cent), Poland (35 per cent) and Germany (34 per cent). It is also notable how all of the 10 countries with the highest average PISA science scores have a comparatively large proportion of 'resilient' pupils (these are the countries highlighted in orange). Further details are provided in Table 6.2.

Figure 6.3 The proportion of 'resilient' pupils in a country compared to the academic selectivity of its secondary-schooling system



Source: PISA 2015 database and Bol et al. (2014).

Notes: Sample restricted to the countries included in Bol et al. (2014). The horizontal axis provides an index of the selectivity of schooling-systems across the world, based upon Bol et al. (2014). The United Kingdom has been treated here as a single entity, as Bol et al. (2014) does not provide separate information on the selectivity index for England, Scotland, Northern Ireland and Wales. Spain and Latvia have been excluded due to recoding of the ESCS index required at the time of writing.

34. An argument often made in favour of selective school systems is that they may help disadvantaged young people to excel academically and overcome their low socio-economic background. Evidence from PISA, however, provides little support for the notion that pupils from disadvantaged backgrounds are more likely to succeed if they live in a country with an academically selective secondary education system, at least when based upon the OECD definition of resilience. Rather, if anything, the opposite may hold true – countries with more academic selection into secondary schools have the same amount of, or fewer resilient pupils. For instance, the proportion of resilient pupils in countries like the UK and Canada (where most pupils are within a non-selective comprehensive system) is similar to countries like Germany (where the secondary education system is highly selective). These results are presented in Figure 6.3.

35. We have also investigated how the socio-economic gap in 15-year-olds' PISA scores compares across selective versus non-selective school systems. There is little evidence that pupils from low socio-economic backgrounds are more likely to succeed against the odds when academic selection is used to sort pupils into different secondary schools. In fact, again, the opposite may be the case; in countries where academic selection is prominent, the socio-economic gap in science scores tends to be greater (correlation of approximately 0.4). Further details can be found in the online data tables (Figure 6.3b).

Key point

Around one-in-three pupils in England overcomes a disadvantaged socio-economic background to achieve a top score on the PISA science test, according to the PISA measure of resilience.

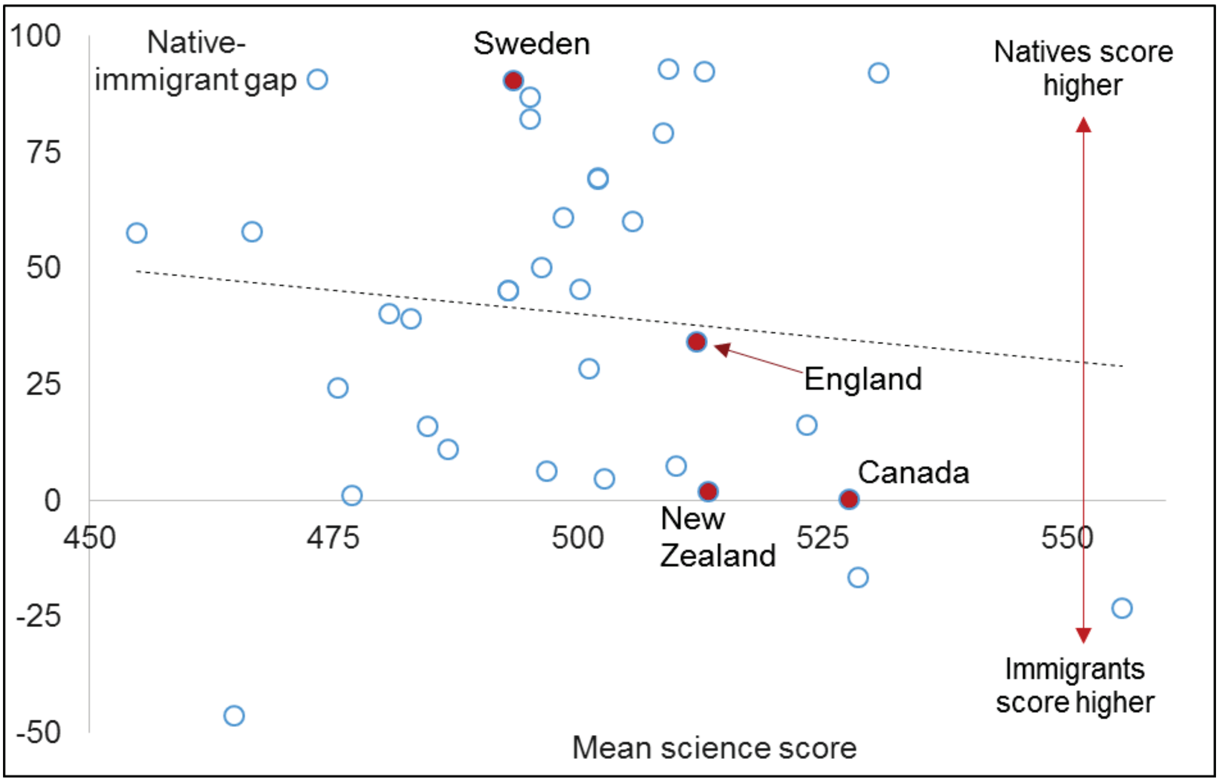
6.3 Do immigrants in England achieve similar test scores to 15-year-olds who were born in the UK?

36. Since 2000, net migration into the United Kingdom has totalled approximately 250,000 individuals per year[39]. The increase in the number of Eastern Europeans now living in the UK has been well documented[40], following earlier waves of migration from India and Pakistan in the 1950s and 1960s. Consequently, almost one-in-five (18 per cent) 15-year-olds in England is now classified as either a first or second generation immigrant (meaning either they or their parent were born outside of the UK)[41]. This compares to around 10 per cent of pupils in England in PISA 2006.

37. There has been much debate internationally about the impact such migration has upon public services, including the education system. While popular opinion has focused upon the strain that this could place upon resources[42], and the challenges that this then poses for teachers[43], others have suggested that there is no link between the number of migrant pupils in a school-system and its level of performance[44]. This then raises the question, how did first and second generation immigrant pupils in England perform on the PISA test?

[39] ONS (2015).
[40] ONS (2015).
[41] PISA 2015 database.
[42] See Reynolds (2008) for a discussion.
[43] See Eleftheriou-Smith (2014).
[44] OECD (2015) and Coughlan (2015).

Figure 6.4 The native-immigrant gap in science scores across countries

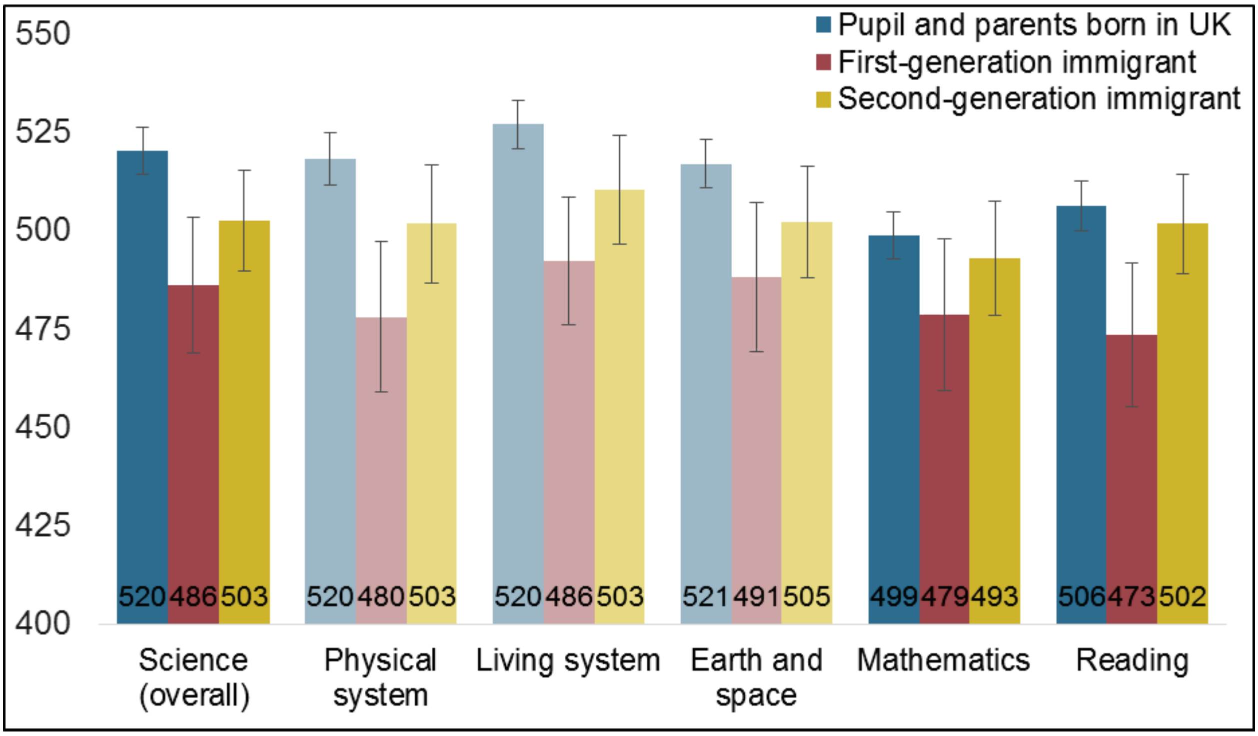


Source: PISA 2015 database.

Notes: 'Immigrants' includes first generation immigrants only. Positive figures indicate that pupils born in the country of the test achieve a higher science score than first-generation immigrants (pupils born outside the country where they took the PISA test).

38. Pupils living in England who were born outside the UK are around a year of schooling behind 15-year-olds who are born in this country. This is consistent with the pattern observed in most other countries, although much more pronounced differences in science scores between natives and immigrants exist elsewhere in the world. In some Scandinavian countries (such as Sweden) there is a difference of more than 60 test points (or two years of schooling). In other countries, such as New Zealand and Canada, there is almost no difference between immigrants and natives. There is also no evidence of an association between the size of the immigrant-native test score gap and average science scores at the country level (correlation = -0.11). Although Figure 6.4 refers specifically to science, similar findings emerge for reading and mathematics as well (see the online data tables for further details).

Figure 6.5 Average scores by immigrant status in England



Source: PISA 2015 database.

Note: Thin line through the centre of each bar refers to the estimated 95 per cent confidence interval.

39. Extending the comparison of pupils who were born in the UK to first and second-generation immigrants, pupils born in the UK are the highest-achieving group, especially when it comes to science (see Figure 6.5). These pupils obtain significantly higher scores than first-generation immigrants, with a difference of around 20 points in mathematics and around 35 test points in reading and science. The gap between UK natives and second-generation immigrants is much less pronounced, particularly in reading and mathematics, where the difference is around five test points, and statistically insignificant. However, second-generation immigrants do achieve significantly lower scores than UK natives in science (mean score of 520 versus 503). Figure 6.5 therefore indicates that 15-year-olds who are immigrants into England achieve lower average scores than young people who were born in the UK (and whose parents were also born in the UK).

40. Once we take underlying characteristics of native and immigrant pupils into account, in particular their socio-economic backgrounds[45], differences in their average performance get smaller (for pupils who immigrated themselves to the UK) or disappear (for pupils born in the UK to immigrant parents). For example, the gap in achievement between UK natives and second generation immigrants in England

[45] An *Ordinary Least Squares* regression model was estimated, with PISA scores as the dependent variable and immigrant group, gender, parental education and parental occupation as the covariates.

becomes small and statistically insignificant once parental education and occupation are considered. In contrast, differences in performance between first-generation immigrants and UK natives generally remain statistically significant (though smaller, declining from 34 to 31 points in science) once differences in parental education and occupation have been taken into account. Consequently, first generation immigrant pupils achieve lower PISA scores than their peers who were born in the UK, even after accounting for differences in the socio-economic backgrounds of these groups.

Table 6.3 Mean scores by English as an Additional Language (EAL) status

	First-Language English (FLE)	English as Additional Language (EAL)	Difference
Science	513	479	**34***
Mathematics	493	469	**24***
Reading	499	474	**26***
Observations	**3,928**	**758**	

Source: PISA 2015 matched database.

Notes: Bold font with a * indicates statistically significant difference at the five per cent level. Figures refer to state school pupils only. Estimates presented for pupils where PISA has been successfully linked to the NPD. The ‘difference’ column may not equal the difference between the ‘FLE’ and ‘EAL’ columns due to rounding.

41. In addition to pupil socio-economic background and country of origin, the language spoken by a pupil at home may also influence their performance in assessments[46]. Previous analysis of the performance of pupils who speak English as an Additional Language (EAL pupils) in GCSE examinations shows that EAL pupils do not trail far behind their ‘First Language English’ (FLE) peers[47] however. Table 6.3 therefore investigates whether the same pattern is replicated in PISA; how do mean scores compare across the EAL and FLE groups?

42. Within all three PISA domains, the gap between EAL and non-EAL pupils is statistically significant, suggesting that EAL pupils do in fact trail behind their peers. The biggest difference is observed within science, where EAL pupils obtain a PISA score approximately 34 test points (more than one year of schooling) below their non-EAL peers (513 versus 479). Differences between EAL and non-EAL pupils are smaller in the PISA reading (26 points) and mathematics (24 points) domains. The results for mathematics are quite different to previous analysis of the EAL achievement gap based upon Key Stage 4 examination results, which have found

[46] Arnot et al. (2014).
[47] Strand et al. (2015).

essentially no difference in GCSE mathematics grades between EAL and FLE pupils[48].

Key point

Pupils from immigrant backgrounds achieve lower scores than young people who were born and raised in the UK. The situation in England is comparable to most other countries, although there are some notable exceptions where there is either a much larger immigrant-native gap or no difference at all.

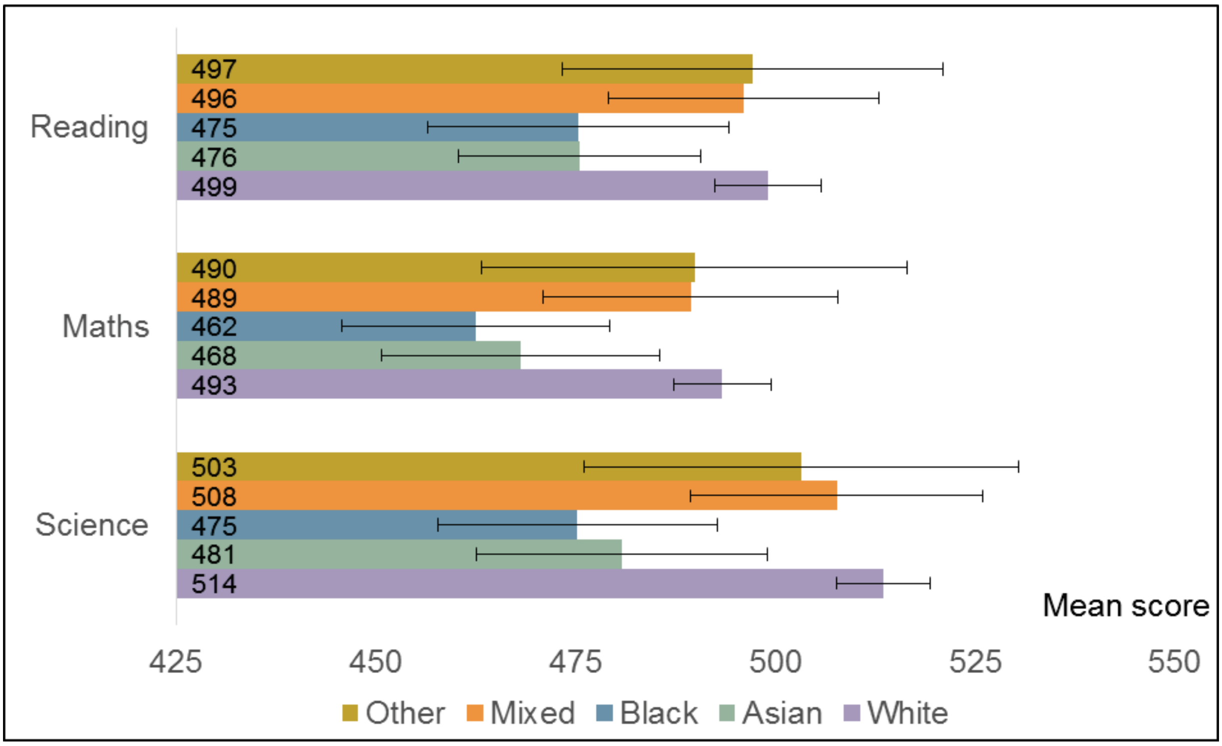
6.4 How do PISA scores vary between ethnic groups within England?

43. In recent years, academics, policymakers and think-tanks in England have shown a particular interest in achievement differences between ethnic groups. Despite ethnic minority groups being more likely to live in income poverty and to be working in lower-status occupations[49], young people of Asian and Mixed ethnic origin actually obtain higher GCSE grades than their White peers[50]. Indeed, previous research has suggested that while White pupils may be ahead of most other ethnic groups in the early years, this situation is reversed by the end of secondary school[51]. It has also been suggested that the high attainment of ethnic minorities can partly explain the 'London effect'; the fact that disadvantaged young people in London achieve better GCSE grades than disadvantaged young people elsewhere in England[52]. We therefore conclude this chapter by investigating whether a similar pattern of ethnic differences in achievement occurs in PISA as with respect to GCSE examinations.

44. In contrast to performance in GCSE examinations, White pupils in England obtain science scores around 40 points (more than a year of schooling) above their Black and Asian peers. Similar results hold in reading (25 points) and mathematics (30 points) with these differences between White and Black and Asian pupils statistically significant in each domain. Conversely, average scores are similar for pupils of White, Other and Mixed ethnicity, and do not ever reach statistical significance - further details are provided in Figure 6.6.

[48] See Strand (2015:36).
[49] Kenway and Palmer (2007); Strand (2011).
[50] DfE (2015).
[51] Centre Forum (2016).
[52] Burgess (2014).

Figure 6.6 Mean science scores by ethnic group within England



Source: PISA 2015 matched database.

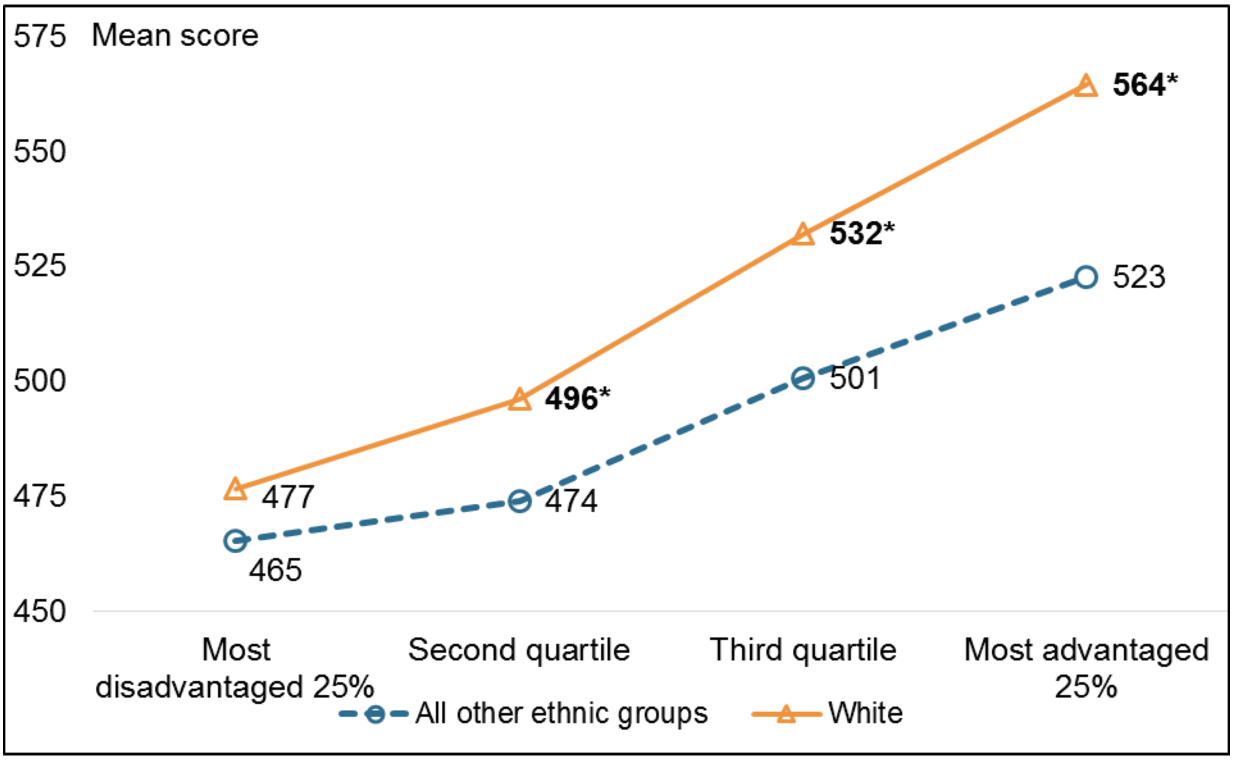
Notes: Thin line through the centre of each bar refers to the estimated 95 per cent confidence interval. 'Other' includes pupils of Chinese ethnicity.

45. Another dimension of ethnicity that has caught policy attention[53] in England is the educational challenges faced by pupils from White working class backgrounds[54]. Evidence from PISA suggests, however, that the key issue surrounding the performance of White working class pupils is their underperformance relative to White pupils from more advantaged socio-economic backgrounds, and not their low performance relative to other ethnic groups. Specifically, there is no evidence that White working class pupils achieve lower PISA scores than working class pupils who are not of White ethnicity. In fact, the average science score across these two groups is quite similar (465 versus 477) and are statistically indistinguishable. Yet there is a more notable difference when it comes to pupils from advantaged socio-economic backgrounds. In particular, White pupils from the top ESCS quartile achieve a science score around 40 points higher than high socio-economic status pupils who are not of White ethnicity. Finally, socio-economic inequality in PISA scores seems to be particularly pronounced for young people who are White. For instance, the gap between the top and bottom ESCS quartiles for White pupils is approximately 90 points (three years of schooling), which compares to a gap of 50 points for pupils not of White ethnic origin. These are the results presented in Figure

[53] House of Commons Education Committee (2014).
[54] Ofsted (2013).

46. Although this graph refers specifically to science, similar conclusions hold for reading and mathematics (see the online data tables for further details).

Figure 6.7 Average science scores of the 'White working class' in England



Source: PISA 2015 matched database.

Notes: Figures refer to state school pupils only. Estimates presented for pupils where PISA has been successfully linked to the NPD. Bold data label with a * indicates score for White pupils significantly above the score for all other ethnic groups.

Key point

On average, young people of White ethnicity achieve significantly higher scores than young people of Black and Asian ethnicity. There is no evidence that White working class pupils achieve lower PISA scores than working class pupils who are not of White ethnicity. Rather, their underachievement is more notable when compared to White pupils from more advantaged socio-economic backgrounds.

Chapter 7. Differences in achievement between schools

- Although there are significant differences between pupil performance across different types of schools in England, the majority of the variation in science performance (77 per cent) occurs between pupils who attend the same school.
- In many other countries with a comprehensive schooling system - including Wales, Canada, Finland and the United States - the proportion of the variation explained within schools is even greater than in England. Conversely, the variation in the performance of pupils in the same school is lower than in England in countries where academic selection is the norm, such as Germany and the Netherlands.
- When comparing performance in schools in England based on admission policy, the average score of pupils who attend grammar schools (595) is significantly higher in science than the average score of pupils who attend independent (566) or comprehensive (502) schools. Almost no pupil who attends a grammar school is a low-achiever in science (one per cent), compared to five per cent of independent school pupils and 19 per cent of those who attend a comprehensive school.
- Focussing on school management types, rather than admissions policy, pupils in independent schools in England score significantly higher in science (566) than the average score of their peers in converter academies (534), sponsored academies (477), community schools (493) and voluntary aided/controlled (503) schools. With an average science score of 566, England's independent school pupils have similar levels of achievement to 15-year-olds in Singapore, PISA's top-performer in science in 2015.

  Comparing performance by Ofsted rating, the average science score of pupils in schools rated as 'inadequate' and 'requiring improvement' is around two years' schooling lower than the average score in schools rated 'outstanding'.

1. This chapter examines differences in young people's science, mathematics and reading competencies by school characteristics. It begins by splitting the variation in test scores into two components: the proportion that occurs *within* schools versus the proportion that occurs *between* schools. The distribution of test scores is then reported by school management type (e.g. academy, community), school admissions policy (e.g. grammar, comprehensive, independent) and by Office

for Standards in Education, Children's Services and Skills (Ofsted) rating. The following research questions will be addressed:

- *To what extent does variation in science achievement occur within schools versus between schools in England?*
- *How do scores vary in England by school management type?*
- *How do scores vary in England by school admissions policy?*
- *How do scores vary in England by school-inspection (Ofsted) rating?*

2. In section 7.2, the report focuses on how PISA scores vary according to school management types. Schools in this section are defined by the following categories of administration:

- Community schools: schools run by the local authority, who also employ the staff, own the school's assets and set the entry criteria.
- Voluntary schools: state schools that usually have a religious affiliation. The school's assets usually owned by a charity or a church.
- Sponsored academies: state-funded schools which are funded directly by the Department of Education and who are independent of local authority control. Sponsored academies have moved to academy status as part of a government intervention strategy, and are managed and operated by a government approved sponsor.
- Converter academies: schools that have voluntarily converted to academy status and are not required to have a sponsor.
- Independent schools: fee-paying private schools that are free of many of the regulations governing state schools.
- Other: this includes foundation schools and all other school types.

3. In contrast, in section 7.3, average science scores are analysed based upon the admissions policy of the school. Schools in this section are divided into:

- Grammar schools: state-funded schools with an academically selective admissions policy.
- Comprehensive (non-grammar) schools: state funded schools without a selective admissions policy.
- Independent schools: Fee-paying private schools; both those with and without a selective admissions policy.

4. Admissions policy is analysed separately in section 7.3 because grammar schools are present in all the different school management groups, with the

exception of sponsored academies and independents. Table 7.1 illustrates the relationship between school admissions policy and school management type.

Table 7.1 Cross-tabulation between school management type and school admissions policy

	Non-grammar	Grammar	Independent	Not applicable / known	Total
Academy Converter	1,505 (61)	324 (12)	0 (0)	0 (0)	**1,829 (73)**
Academy Sponsor Led	862 (36)	0 (0)	0 (0)	80 (3)	**942 (39)**
Community School	825 (31)	138 (5)	0 (0)	0 (0)	**963 (37)**
Other	334 (13)	168 (6)	0 (0)	0 (0)	**502 (19)**
Voluntary	364 (15)	142 (5)	0 (0)	0 (0)	**506 (20)**
Independent	N/a	N/a	452 (18)	N/a	**452 (18)**
Total	**3,890 (157)**	**772 (28)**	**452 (18)**	**80 (3)**	**5,194 (206)**

Source: PISA 2015 matched database.

Notes: Not known / applicable group do not have information reported on their admissions policy on Edubase. Figures refer to number of pupils, with those in brackets referring to the number of schools.

5. All estimates presented within this chapter need to be carefully interpreted as once categorised by type, the number of schools in England participating in PISA within each group is limited. School-level sample sizes are therefore relatively small for certain groups, including independent schools (18 schools with 452 pupils), grammar schools (28 schools with 772 pupils) and those rated as inadequate by Ofsted (nine schools with 224 pupils). Estimates for these groups are accompanied by relatively wide margins of error and need to be treated with a degree of caution.

7.1 To what extent does variation in science achievement occur *within* versus *between* schools?

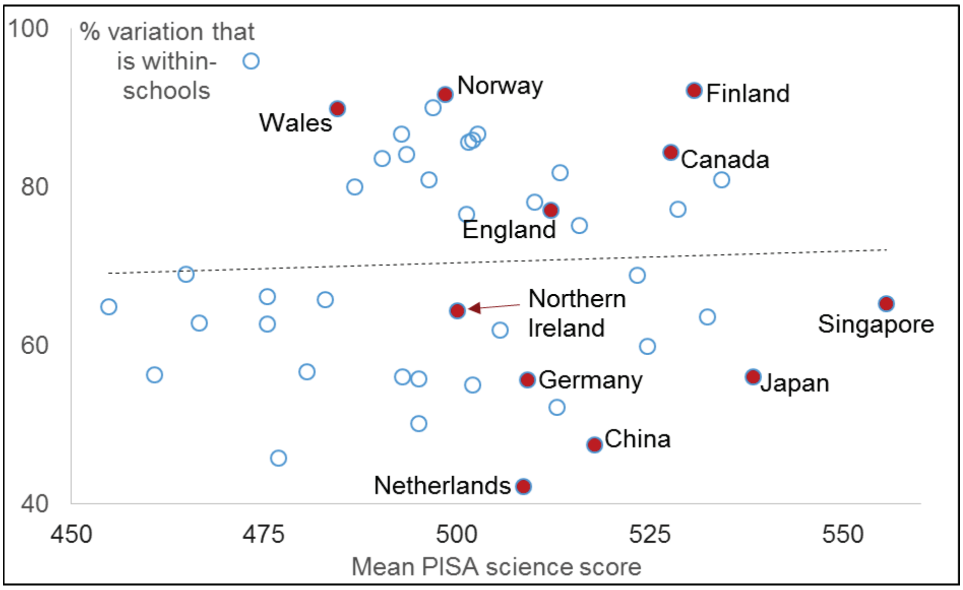
6. Between-school variation refers to the extent to which differences in pupil performance is linked to the sorting of pupils into different schools. In contrast, 'within-school variation' concerns to the degree that test scores differ between pupils who attend the same school. It is important to note that these figures do not reveal the 'importance' or 'impact' of schools per se (i.e. it is not necessarily the case that in countries where the between school variation is higher, schools are more important). Rather, the proportion of the variance explained between schools is partially determined by 'selection effects', reflecting the fact that pupils with certain characteristics disproportionately attend particular types of schools. Nevertheless, previous research has suggested that a reduction '*in within-school variation is linked with an improvement in value-added, so schools embarking on the journey of*

reducing within-school variation can be certain that it will be productive on results[55]'. It is therefore important to understand the extent of within-school achievement variation that occurs in England, and how this compares to the top-performing countries.

7. Despite significant differences in the structure of secondary schooling systems across countries, what happens inside schools (such as the allocation of resources and the quality of teaching) is just as important - if not more important - as the differences that occur between schools. In England, there are substantial differences in the performance of 15-year-olds in science, even when they attend the same school. In fact, most of the variability in science scores occurs within schools (77 per cent), rather than between schools (23 per cent). This is consistent with the results in most other countries; England sits around the middle of Figure 7.1, with the extent of within-school variation comparable to elsewhere is the world. It is also notable how within-school variation is also usually the larger of the two components.

8. Compared to other countries with a comprehensive schooling system, the extent that science scores differ between pupils who attend the same school is comparatively low. For instance, in Finland as much as 92 per cent of the variation in science scores occurs within schools with Wales and Canada at 90 per cent and 84 per cent respectively.

Figure 7.1 The proportion of the variation in pupils' science scores that occurs within schools versus average science scores



Source: PISA 2015 database.

Notes: The sample of countries included has been restricted to those with a mean score above 450 test points.

[55] Reynolds (2007).

9. It is notable that countries with a strong tradition of academic selection into secondary schools sit towards the bottom of Figure 7.1, with a comparatively low proportion of the variance in pupils' science scores occurring within schools. For example, in Germany and the Netherlands around half the variation in pupils' performance occurs within schools. In contrast, countries with a mainly comprehensive schooling system, where the use of academic selection into secondary schools is rare, are generally towards the top of the chart (e.g. Finland, Norway, Wales).

10. There is little evidence to suggest that either a low or high proportion of variation within schools is a common trait amongst the leading PISA countries. In Singapore and Japan, for example, there is a comparatively little variation between the average scores of pupils who attend the same school. In contrast, Canada and Finland experience a high degree of variation within schools. Essentially, as Figure 7.1 shows, there is no correlation between science score and proportion of variation within schools.

Key point

PISA scores vary more *within* schools in England than they do *between* schools; a finding that is reflected in most other countries and amongst the top-performing countries. The proportion of variation within schools, however, differs significantly between countries; and while it is comparatively low in Germany, China and the Netherlands, it is high in countries like Finland, Norway and Wales.

7.2 How do scores vary in England by school management type?

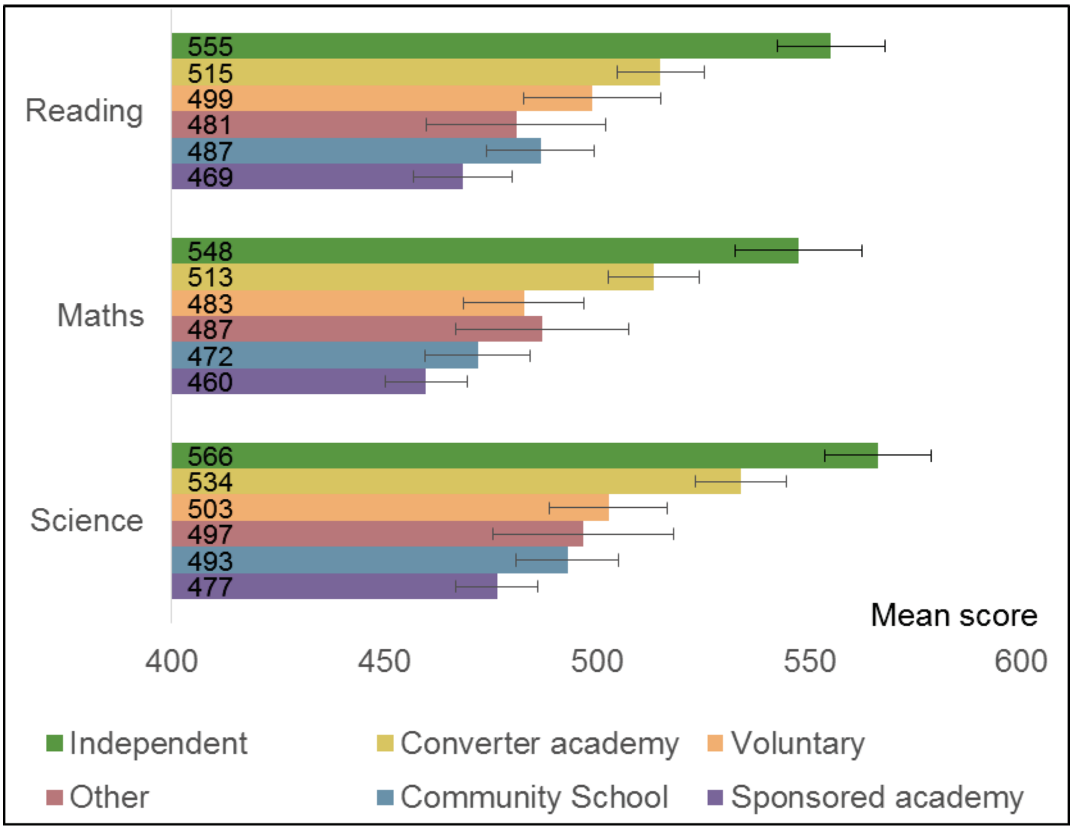
11. PISA 2015 was conducted during a period of significant change to school administration and management in England and as part of a drive towards providing schools with greater autonomy, many secondary schools were converted into academies. Numerous schools, however, remain under local authority control, while others are independent fee-paying institutions. Despite the variety of school administration structures in England, there remains relatively little evidence as to how PISA scores vary by school management type. This section documents the variation in average scores in science, mathematics and reading between six school management groups: (a) independent; (b) voluntary aided/controlled; (c) sponsored academies; (d) converter academies; (e) community and (f) other (including foundation) schools.

12. Pupils in independent schools score on average at least 50 test points (around one and a half years of schooling) more than the average score of their peers in all other school management types - with the exception of academy

converters – and perform as strongly in PISA as the average pupil within the top-performing East Asian countries. Further information can be found in Figure 7.2.

13. There is also a notable difference between the average scores of pupils who attend sponsored academies and those studying at converter academies. Pupils in sponsored academies achieve the lowest average scores across the six school groups with a mean of 477 in science, 460 in mathematics and 469 in reading. This is up to two years of schooling behind pupils who attend converter academies, who achieve the second highest average scores out of the six school groups, behind only independent schools.

Figure 7.2 Mean scores by school management type in England



Source: PISA 2015 matched database.

Note: Thin line through centre of each bar refers to the estimated 95 per cent confidence interval.

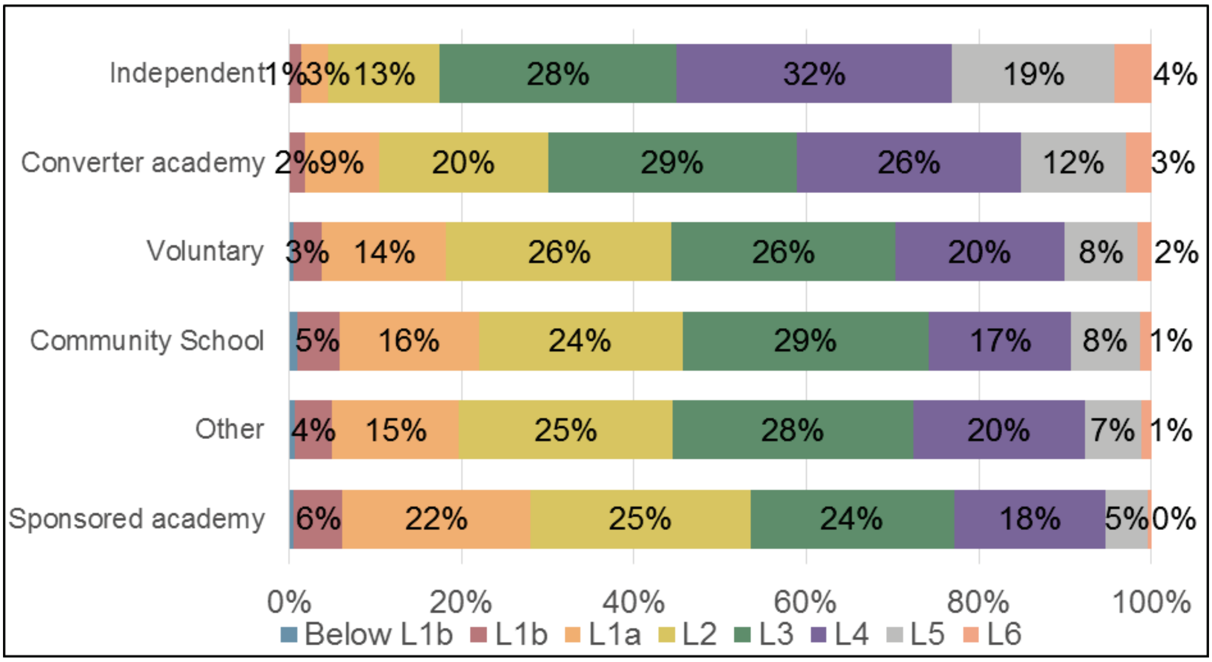
14. Average PISA scores vary by school type in England partly due to the different socio-economic and demographic composition of the pupils that attend. However, analysis of the PISA data suggests that differences in demographic and socio-economic characteristics can explain some - but not all - of the variation in pupil performance at different types of school. For instance, even after controlling for a selection of demographic and socio-economic characteristics, the difference in average scores between pupils in sponsored and converter academies remains

statistically significant, despite falling from 57 to 30 points in science, from 54 to 29 points in mathematics and 47 to 22 points in reading[56].

15. A significant proportion of independent school pupils in England are amongst the highest-performing 15-year-olds in science anywhere in the world with around a quarter of pupils (23 per cent) in independent schools classified as ‘top-performers’ in science (i.e. achieve Level 5 or 6). This compares to 15 per cent of pupils in converter academies, nine per cent of pupils in community schools and five per cent of pupils who attend a sponsored academy. These results are presented in Figure 7.3, with equivalent findings for mathematics and reading provided in the online data tables.

16. In contrast, sponsored academies have the highest proportion of pupils who are ‘low-achievers’ in science, with around 28 per cent failing to reach the expected standard (Level 2). This compares to only around 10 per cent of pupils within converter academies and five per cent within independent schools.

Figure 7.3 The distribution of science scores by school management type



Source: PISA 2015 matched database.

[56] These results are based upon an Ordinary Least Squares regression model, with PISA science scores as the dependent variable. Controls have been included for gender, parental education, parental occupation, immigrant status and the number of books at home.

Key point

PISA scores are higher in independent schools and academy converters than in other school management groups within England, even after accounting for differences in socio-economic background.

7.3 How do scores vary by school admissions policy?

17. The use of academic selection in school admissions is a contentious issue in England. There are currently 164 grammar schools in England educating just five per cent of secondary pupils across the country as a whole[57]. With the exception of independent schools and sponsored academies, state-funded selective schools (grammars) are found within all of the different school management types analysed in the previous section.

18. Previous research is somewhat divided on the impact that selective education has upon pupils' attainment; whereas some studies have found a positive impact upon test scores amongst those who gain entry[58], others have found no evidence of higher achievement across selective versus non-selective education systems as a whole[59]. By considering performance in PISA, this sub-section provides further evidence regarding the outcomes of pupils who attend academically selective state schools in England.

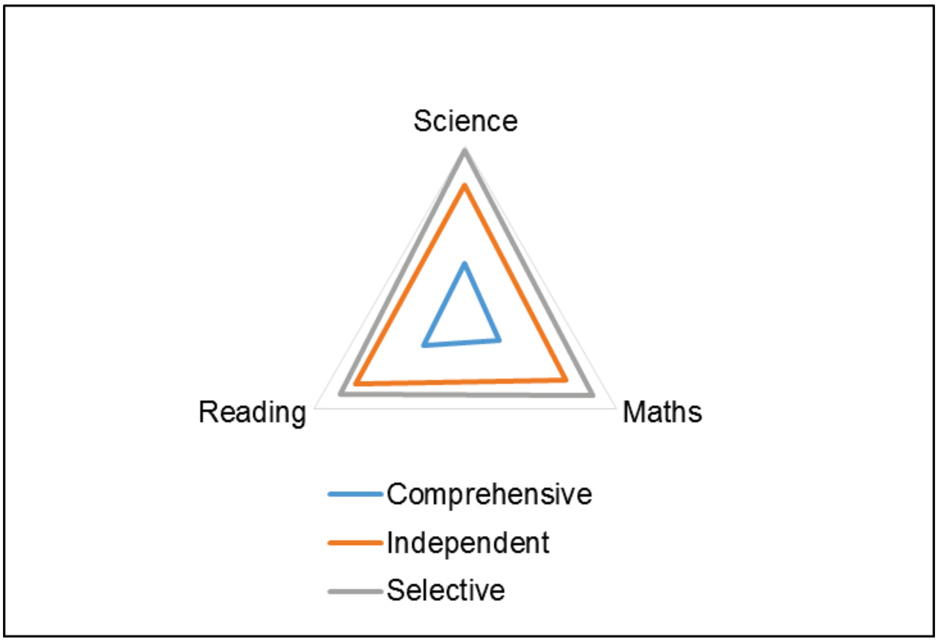
19. On average, Grammar school pupils in England achieve scores that are equal to or above the average pupil score in high-performing countries. In England, pupils who attend grammar schools generally perform significantly better in PISA than their peers in independent schools. The difference between grammar and independent school pupils is around 25 points (almost a year of schooling) in science and mathematics. In reading, although the difference is 16 test points, it is not statistically significant. Grammar school pupils are also up to three years of schooling ahead of pupils at comprehensive schools within each PISA domain. These results are presented in Figure 7.4.

20. Differences in demographic characteristics can explain some - but not all - of the gap in performance between pupils who attend grammar and comprehensive state schools in England. After controlling for a selection of socio-economic and demographic characteristics the difference in scores between grammar and comprehensive school pupils remains significant, falling from 94 points to 58 test points in science, from 90 to 59 test points in mathematics and from 81 to 48 points

[57] Department for Education (2014).
[58] Clark (2010).
[59] Atkinson, Gregg and McConnell (2006).

in reading. Similarly, grammar school pupils continue to achieve significantly higher average PISA scores in science and mathematics than pupils who attend independent schools, even after differences in their socio-economic background have been taken into account. However, these results cannot be interpreted as providing evidence of school effectiveness because no control has been included for pupils' prior achievement.

Figure 7.4 Mean scores by school admissions policy in England



	Science	Mathematics	Reading
Comprehensive	**502***	**483***	**490***
Independent	**566***	**548***	555
Selective (grammar)	595	573	571

Source: PISA 2015 matched database.

Note: Bold font with a * indicates difference compared to the selective (grammar) group is statistically significant at the five per cent level.

21. A third of grammar school pupils in England are classified as a 'top-performer' in science (meaning they achieve Level 5 or 6 in PISA). This compares to a quarter of pupils who attend an independent school (23 per cent) and one-in-eleven who attend a comprehensive school (nine per cent). Almost no pupil in a grammar school is a low-achiever in science (one per cent) however, compared to five per cent of pupils attending independent schools and 19 per cent of those who attend a comprehensive school.

22. Similar differences by school admission policy are evident for pupils' mathematics skills and, to a lesser extent, reading skills. These results therefore

further illustrate the significant differences in achievement that exist in England between pupils who attend schools with different admissions policies.

23. These findings need to be caveated in three respects:

- Firstly, the number of schools in England participating in PISA is limited with only 772 pupils from 28 schools in England with a selective admissions policy and 452 pupils from 18 independent schools took part in PISA. Estimates for these groups will therefore need to be treated with caution.
- Secondly, due to the limited sample size in this analysis independent schools include both those with and without a selective admission policy. However, if selective independent schools could be treated as a separate group, it is likely that their performance would be similar to state-funded selective schools.
- Thirdly, as no control has been included for pupils' prior achievement, these results cannot be interpreted as providing evidence of different rates of pupil progress or of school effectiveness.

Key point

Pupils who attend grammar schools in England achieve higher average scores on the PISA science and mathematics test than those pupils who attend either comprehensive or independent schools. This remains the case even when differences in their socio-economic background have been taken into account. Approximately one-third of 15-year-olds who attend a grammar school in England are considered 'high-achievers' on the PISA science test.

7.4 How do scores vary in England by school-inspection (Ofsted) rating?

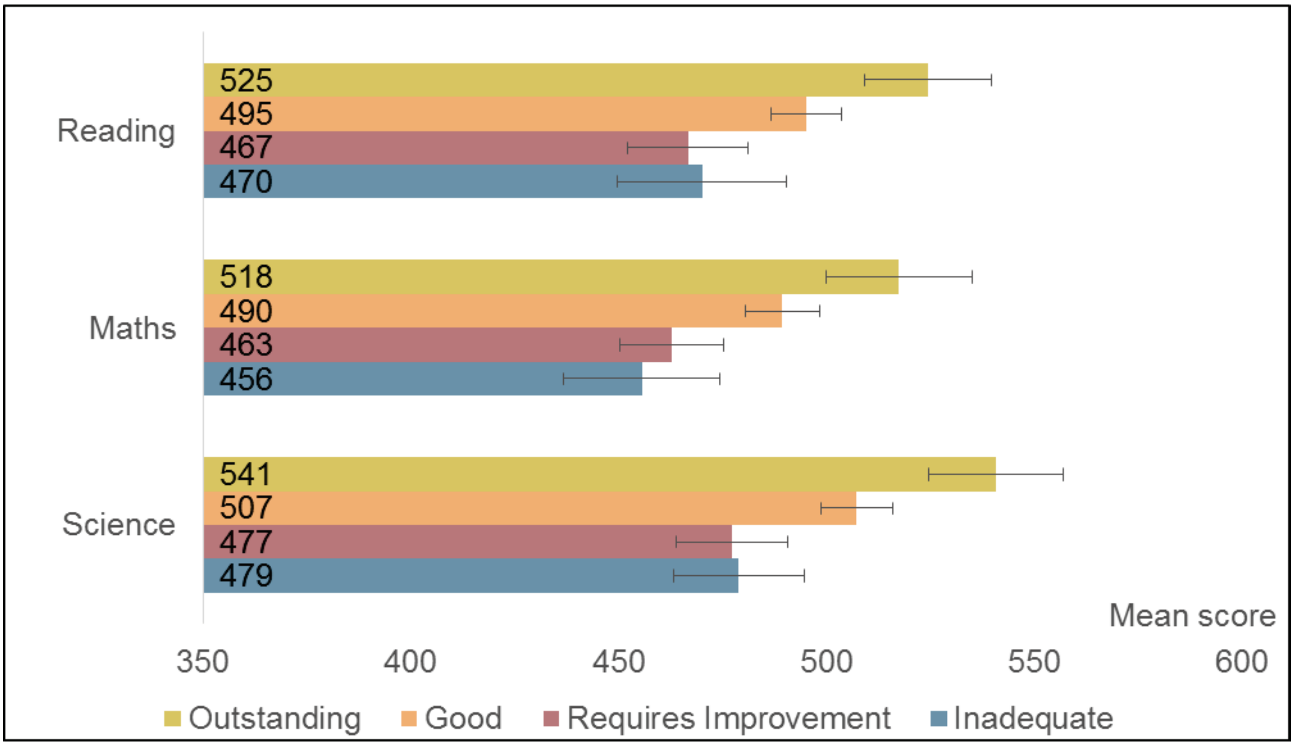
24. Secondary schools in England are regularly inspected by the Office for Standards in Education, Children's Services and Skills (Ofsted) whose goals are to raise academic standards in England and improve the lives of young people. These inspections lead to schools being rated on a four-point scale ('outstanding', 'good', 'requires improvement' and 'inadequate'), however, as with school type, there is currently little evidence as to how pupils' PISA scores vary according to the inspection rating of their school[60].

[60] Schools have been categorised by their school type and Ofsted inspection rating as at the end of 2015. Therefore, some schools may have changed their status only a short time before this date (e.g. only recently converted to an academy), while their latest Ofsted inspection may have occurred a number of years prior to the PISA 2015 study. Where a school has closed or changed status (e.g.

25. Pupils who attend 'outstanding' schools achieve scores similar to the average pupil in some of the high-performing countries. Their average score of 541 in science, 518 in mathematics and 525 in reading is also significantly higher than for young people who attend schools in the bottom two Ofsted categories ('inadequate' and 'requires improvement').

26. Differences in PISA scores between 'good' and 'outstanding' schools are also statistically significant in each of the three PISA domains whilst there is no statistically significant difference in mean scores between pupils who attend schools within the 'inadequate' and 'requires improvement' categories. Figure 7.5 provides further details.

Figure 7.5 Mean scores by school Ofsted rating in England



Source: PISA 2015 matched database.

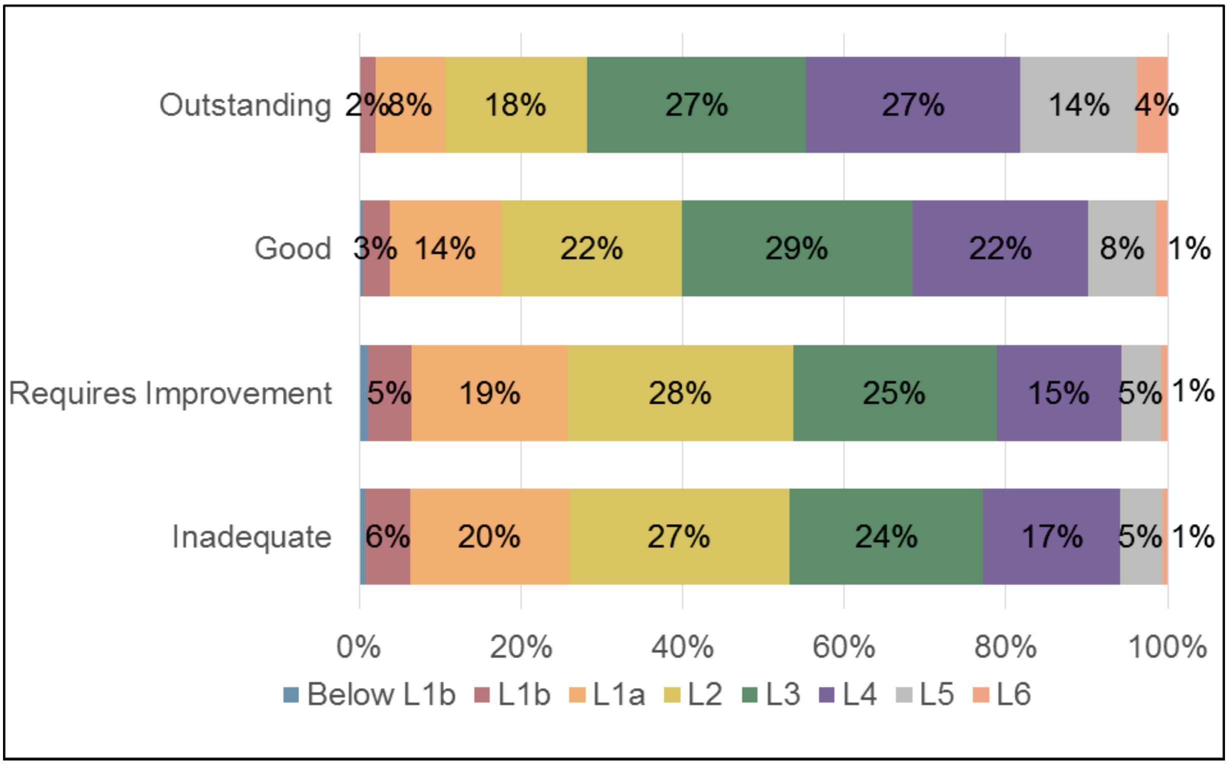
Note: Thin line through centre of each bar refers to the estimated 95 per cent confidence interval. Results reported for schools and pupils where data available.

27. Approximately 10 per cent of pupils in 'outstanding' schools achieve a PISA science score at Level 2 or below, increasing to 18 per cent at 'good' schools and 26 per cent that 'require improvement' or are 'inadequate'. At the other end of the spectrum, 18 per cent of 15-year-olds in 'outstanding' secondary schools are classified as 'high-achievers' (reaching PISA Level 5 or 6) whereas 10 per cent reach at least Level 5 in 'good' schools and six per cent in schools 'requiring

converted to an academy) we use the most recent Ofsted report available for the predecessor school where possible.

improvement 'and/or deemed as 'inadequate'. Indeed, it is more generally the case that the distribution of PISA scores is similar across the bottom two Ofsted categories. Figure 7.6 provides further detail for science, with analogous results for mathematics and reading provided in the online data tables.

Figure 7.6 The distribution of science proficiency levels by Ofsted rating



Source: PISA 2015 matched database.

Key point

The average science score for pupils in 'outstanding' schools is around the same level as the average score across all pupils in some of the highest performing countries. Pupils in schools rated as 'inadequate' and 'requiring improvement' achieve average science scores around 480 points.

Chapter 8. School management and resources

- As part of the PISA study, headteachers from all participating schools were asked to complete a questionnaire on their school environment.

- Headteachers in England report taking a more proactive and collaborative approach to school leadership and management than headteachers in high-performing countries. For instance, headteachers in England are much more likely to regularly use pupils' performance results to develop their school's educational goals (61 per cent versus the top 10 average of 18 per cent).

- The two barriers that headteachers in England are more likely to report compared to the OECD or top 10 average are 'teacher shortages' (45 per cent in England versus around 30 per cent for the OECD and top-performing countries) and 'a lack of good quality physical infrastructure' (almost half in England compared with a third for the OECD and top-performing countries).

- Of the high-performing countries, only two report that a greater proportion of headteachers complain of teacher shortages as a problem: Japan (55 per cent) and China (64 per cent).

- Within England, 'staff not meeting individual pupils' needs' and a 'lack of preparation of teachers for classes' are key concerns for headteachers who run schools with low Ofsted ratings.

- Headteachers in England are more likely to report staff absenteeism as a barrier to pupils learning than headteachers in the average high performing country. Around a quarter of pupils in England are taught in schools where the headteacher deems this to be an issue.

- Headteachers in England are generally positive about the resources available to support science learning within their school; more so than headteachers in the average high performing country. According to headteachers, schools with low inspection ratings would not typically devote any extra funding received to improving teaching in science.

- Extensive quality assurance processes are already in place within England's educational system.

1. A number of factors have an impact upon the functioning of a school, and whether it provides the optimal environment to maximise pupils' well-being and attainment. This includes access to sufficient educational resources, the conduct of staff and the management approach of senior leadership teams[61]. The aim of this chapter is to provide new evidence on such matters for England by drawing upon the PISA headteacher questionnaire.

2. As part of the PISA study, headteachers from all participating schools were asked to complete a questionnaire. This included questions covering a range of topics, including management styles, resources, school climate and quality assurance processes. A total of 170 headteachers completed this questionnaire in England, reflecting an un-weighted response rate of 83 per cent amongst the participating schools.

3. Based upon headteachers' responses, this chapter seeks to answer the following questions:

- *How do headteachers in England manage their staff and their schools?*
- *Do headteachers in England believe they have access to sufficient resources in order to support pupils' learning?*
- *Are schools in England well-equipped to support pupils' learning in science?*
- *How do headteachers in England view the conduct of their staff?*
- *What quality assurance processes are used in England's schools?*

4. As with the preceding chapter, the results need to be carefully interpreted:

- Firstly, sample sizes remain small for particular sub-groups (e.g. schools with an 'inadequate' Ofsted rating) with these estimates therefore subject to a high degree of sampling error.
- Secondly, it should be noted that the analyses presented in this chapter are based upon self-reported information form headteachers. The subjective nature of some questions should also be considered when interpreting the results.

[61] See Woessmann and Hanushek (2011) for an overview of the international evidence on inputs, institutional structure and quality of teachers and Bloom et al. (2015) for evidence on school management.

8.1 How do headteachers in England manage their staff and schools?

5. Effective leadership is an essential ingredient for school effectiveness, with research suggesting pupils make more academic progress in schools with better leadership[62]. There has consequently been a high level of academic and policy interest in the development of effective leaders for schools, and the most effective styles of leadership. The 2013 TALIS report highlighted a number of differences in leadership approaches and activities between headteachers in England and headteachers in a set of nine high-performing countries[63]. This included headteachers in England being more likely to directly observe classroom instruction, to take action to ensure teachers feel responsible for pupils' learning outcomes, and to report greater autonomy over the management of their school[64].

6. In this sub-section we build upon the evidence from TALIS 2013 to provide further insight into school leadership styles in England. Headteachers were asked the following question in the PISA 2015 headteacher questionnaire:

> '*Below are statements about your management of this school. Please indicate the frequency of the following activities and behaviours in your schooling during the last academic year'*

Table 8.1 provides the 13 statements headteachers were asked to respond to, along with the percentage who reported undertaking each activity at least once a month during the last academic year[65]. Based upon the evidence provided in Table 8.1, there are three points of particular note.

7. Firstly, for almost every question the percentage of headteachers who report the activity occurring at least once a month is greater in England than the average across OECD members and the average across the 10 highest performing countries. This includes factors related to setting and achieving the goals of their school (e.g. ensuring professional development activities of staff are consistent with the aims of the school) and in encouraging a collaborative approach to school improvement (e.g. asking teachers to review school management practises, solving classroom problems together). Consequently, it seems that headteachers in England generally report being proactive in the management of their schools; more so than headteachers in other countries (including those with the highest average science scores).

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[62] Day et al. (2009).
[63] Micklewright et al. (2014: chapter 3).
[64] See Tables 3.2 and 3.3 of Micklewright et al. (2014).
[65] Headteachers were asked to respond to each question using a six-point scale, ranging from '*did not occur*' through to occurring '*more than once a week*'. Table 8.1 presents the per cent of teachers who ticked one of the top three categories ('*once a month*', '*once a week' or 'more than once a week'*).

Table 8.1 Headteachers' management of teachers and schools

	England	OECD	H10+
I use pupil performance results to develop the school's educational goals	61%	**23%***	**18%***
I make sure that the professional development activities of teachers are in accordance with the teaching goals of the school	63%	**33%***	**33%***
I ensure that teachers work according to the school's educational goals	88%	**53%***	**48%***
I promote teaching practices based on recent educational research	67%	**41%***	**34%***
I praise teachers whose pupils are actively participating in learning	95%	**63%***	**55%***
When a teacher has problems in his/her classroom, I take the initiative to discuss matters	88%	**68%***	**64%***
I draw teachers' attention to the importance of pupils' development of critical and social capacities	80%	**56%***	**51%***
I pay attention to disruptive behaviour in classrooms	93%	**82%***	**79%***
I provide staff with opportunities to participate in school decision-making	67%	72%	65%
I engage teachers to help build a school culture of continuous improvement	86%	**73%***	**66%***
I ask teachers to participate in reviewing school management practices	47%	**34%***	**36%***
When a teacher brings up a classroom problem, we solve the problem together	88%	**78%***	**76%***
I discuss the school's academic goals with teachers at faculty meetings	70%	**51%***	**49%***

Source: PISA 2015 database.

Notes: Figures refer to the percentage of pupils in schools where the headteacher reports undertaking the activity at least once a month over the past academic year. H10+ refers to the average across the 10 countries with the highest science scores in PISA 2015. Bold with * indicates significantly different from England.

8. Second, there are certain questions where the difference between England and the other comparator countries is particularly pronounced. For instance, headteachers in England are much more likely to regularly use pupils' performance to develop their school's educational goals (61 per cent versus H10 average of 18 per cent), potentially highlighting the important role the accountability system plays in headteachers' management of their school. Indeed, a greater proportion of headteachers in England use pupil performance data in setting their school's

educational objectives than in any of the 10 countries with the highest average science scores. Other differences include headteachers in England being more likely to regularly praise staff when they see pupils actively engaged in learning (95 per cent versus a H10 average of 55 per cent), and being more likely to encourage staff to use an evidence-based approach to develop their teaching practises (67 per cent versus 34 per cent in the H10 countries). It is also interesting that school leaders in England are more likely to encourage teachers to develop pupils' social skills than in the average high-performing countries (80 per cent in England versus 51 per cent H10 average).

9. Finally, although insightful, the averages across OECD and the 10 highest performing countries in Table 8.1 mask the fact that there is substantial variation across these countries. For instance, whereas 72 per cent of Canadian headteachers encourage the development of pupils' social skills, this falls to 55 per cent in Finland and 12 per cent in Japan. Similarly, the proportion of headteachers regularly promoting the use of evidence-based teaching practises is notably higher in Canada (64 per cent) and Singapore (44 per cent) than in Estonia (25 per cent), Japan (12 per cent) and Hong Kong (13 per cent). This illustrates how school leadership and management approaches vary greatly across countries, even when we focus upon only those countries with the highest average scores.

10. In additional analysis, we have also explored variation in headteachers approaches to leadership and management across different types of school within England. Interestingly, there are relatively few differences between headteachers who lead schools with different Ofsted ratings and with different governance structures. (For further details, see Table 8.1b in the online data tables). Consequently, it seems that there may be more variation across countries in the leadership and management approaches of headteachers than there is within England across different types of school.

Key point

Headteachers in England report taking a more proactive and collaborative approach to school leadership and management than headteachers in the highest performing countries. More variation is observed across countries in the leadership and management approaches of headteachers than there is within England across different types of school.

8.2 Do headteachers believe they have access to sufficient resources to support pupils' learning?

11. In order to operate effectively, schools require access to sufficient resources. This includes being able to recruit sufficiently skilled teachers and support staff, and

being able to provide pupils with the educational materials that they need to succeed (such as textbooks, computers, equipment). Previous research has also suggested that the physical environment of a school may have an impact upon pupils' educational attainment[66]. For these reasons, it is important to consider whether headteachers in England feel that their schools are appropriately resourced, and how England compares to other countries in this respect. Table 8.2 therefore details where headteachers feel that they either lack access to educational resources or that they only have access to poor quality educational resources. Specifically, it provides the percentage of headteachers who report that the factor in question hinders the school's capacity to provide instruction either 'to some extent' or 'a lot'.

12. There are two particular concerns which stand out amongst England's headteachers, relative to school leaders from other countries. The first is teacher shortages; headteachers in England are more likely to report a lack of teaching staff as a barrier to pupil learning than the average across OECD or the highest-performing countries (45 per cent in England versus around 30 per cent for the OECD / H10 average). Indeed, of the high-performing countries, in only Japan (55 per cent) and China (64 per cent) do a greater proportion of headteachers report this as a problem than in England. Interestingly, the same does not hold true regarding headteachers' views on the availability of support/assisting staff, where the proportion reporting this as a factor hindering instruction is lower in England (18 per cent) than the average across OECD (36 per cent) and the highest performing (33 per cent) countries.

13. The second issue that stands out amongst headteachers in England is school infrastructure. Almost half of school pupils in England are taught in schools where headteachers see a lack of physical infrastructure (or poor quality infrastructure) as an important barrier to learning. This compares to just over one-third of pupils in the average member of the OECD and the average across the highest-performing countries. However, this again masks some notable cross-country variation, with a greater proportion of headteachers reporting this as a concern in some high performing countries (e.g. 69 per cent in Japan) than in others (e.g. 17 per cent in Canada).

[66] Barrett et al. (2014). Neilson and Zimmerman (2011).

Table 8.2 Headteachers' reports of which resources are lacking within their school

	England	OECD	H10+
A lack of teaching staff	45%	**29%***	**31%***
Inadequate or poorly qualified teachers	22%	20%	26%
A lack of assisting staff	18%	**36%***	**33%***
Inadequate or poorly qualified assisting staff	12%	**19%***	**20%***
A lack of educational material	29%	34%	32%
Inadequate or poor quality educational material	26%	30%	30%
A lack of physical infrastructure	48%	**36%***	**37%***
Inadequate or poor quality physical infrastructure	45%	**35%***	**35%***

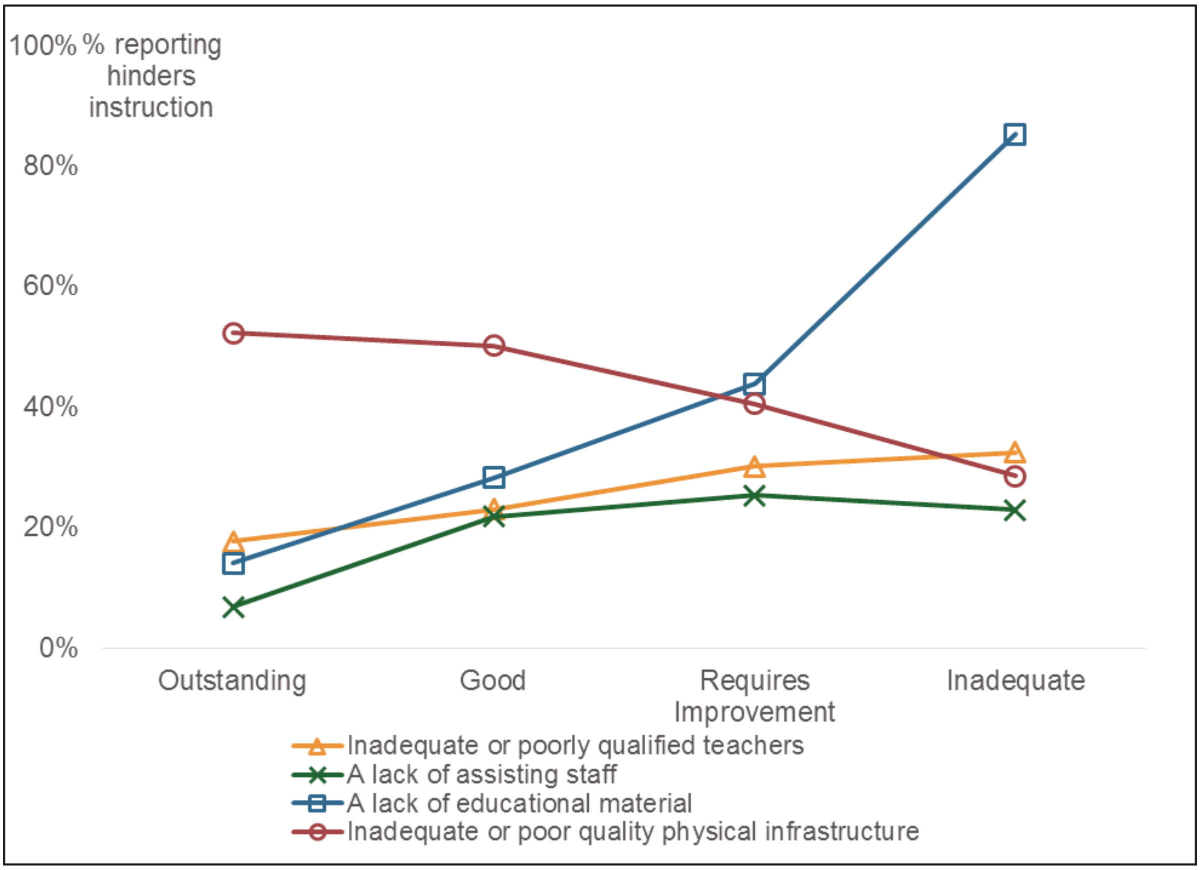
Source: PISA 2015 database.

Notes: Figures refer to the percentage of pupils in schools where the headteacher ticked either the 'to some extent' or 'a lot' categories. H10+ refers to the average across the 10 countries with the highest science scores in PISA 2015. Bold with * indicates significantly different from England.

14. Within England, headteachers in lower-rated secondary schools see a lack of educational resources as a key barrier to improvement. Less than one-in-five (14 per cent) agree with this statement in outstanding schools, compared to 28 per cent rated as good, 44 per cent in those that require improvement and 85 per cent in inadequate schools. The difference between schools in the 'outstanding' group and the bottom two Ofsted categories is therefore 30 percentage points or more, with differences statistically significant. The blue line with square markers in Figure 8.1 illustrates these results.

15. There is relatively little variation in headteachers' reports of the quality of their teaching staff by school inspection rating; around 20 per cent to 30 per cent of headteachers' report this as a factor hindering pupils' learning regardless of the school's Ofsted score (orange line with triangular markers). There is, however, some suggestion that outstanding schools have fewer difficulties with recruiting staff to assist with teaching. Only seven per cent of headteachers in an outstanding school in England report this as a problem compared to around one-in-four headteachers in the other Ofsted groups (green line with cross markers). Overall, it therefore seems that headteachers' views of the adequacy of their staff varies only modestly according to the most recent Ofsted inspection rating of the school. See Figure 8.1 for further details.

Figure 8.1 Headteachers' reports of lacking resources by Ofsted rating



Source: Matched PISA 2015 database.

16. Similarly, there is relatively little evidence of variation in headteachers' responses according to school type. The main exception is in assessing physical infrastructure, with headteachers of sponsored academies and independent schools less likely to report this as a factor hindering instruction than headteachers in other groups of schools (e.g. community schools and academy converters)[67]. Likewise, headteachers who lead independent schools are significantly less likely to report teacher shortages as a factor hindering instruction than other groups.

Key point

Headteachers in England are more likely to report a lack of teaching staff and a lack of good quality physical school infrastructure as important barriers to pupils' learning than headmasters in the average OECD or high performing country. Within England, a lack of educational material is a key concern amongst headteachers leading an 'inadequate' school or a school that 'requires improvement'.

[67] For instance, only 13 per cent of headteachers leading sponsored academies indicate that poor quality infrastructure is an issue hindering instruction. This compares to 52 per cent of headteachers in community schools and 63 per cent in academy converters.

8.3 Are schools in England well-equipped to support pupils' learning in science?

17. Whereas the previous sub-section focused upon headteachers' views of school resources in general, this sub-section pays particular attention to the availability of resources for use in the instruction of science.

Table 8.3 Headteachers' views on the science resources available within their school

	England	OECD	H10+
Compared to other departments, our schools science department is well equipped	86%	**74%***	**75%***
If we ever have some extra funding, a big share goes into improvement of our school science teaching	34%	39%	**47%***
School science teachers are among our best educated staff members	69%	65%	62%
Compared to similar schools, we have a well-equipped laboratory	79%	**62%***	**62%***
The material for hands-on activities in school science is in good shape	85%	78%	**73%***
We have enough laboratory material that all courses can regularly use it	92%	**66%***	**72%***
We have extra laboratory staff that helps support school science teaching	91%	**34%***	**51%***
Our school spends extra money on up-to-date school science equipment	57%	**48%***	49%

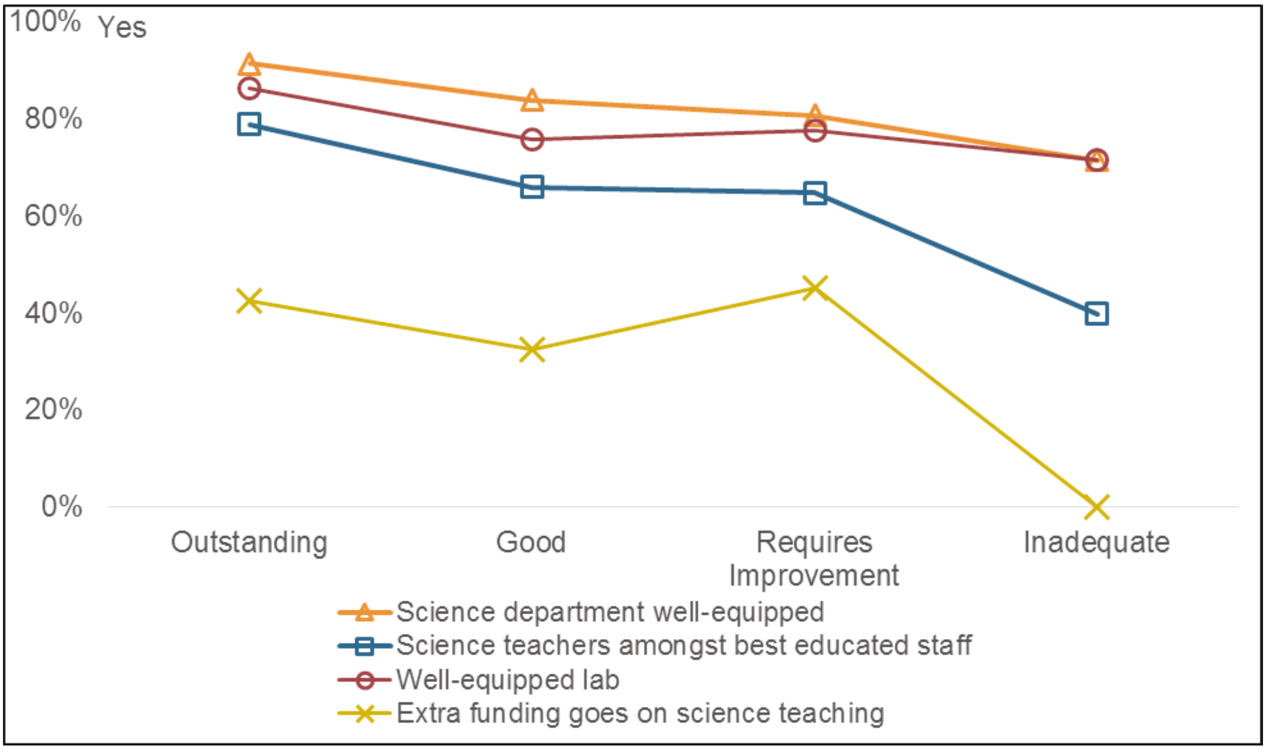
Source: PISA 2015 database.

Notes: Figures refer to the percentage of pupils in schools where the headteacher ticked 'yes'. H10+ refers to the average across the 10 countries with the highest science scores. Bold with * indicates significantly different from England.

18. Headteachers in England are generally positive about the science resources that are available within their school and more so than headteachers in the typical OECD or highest-performing country (see Table 8.3). This is particularly true for the availability of laboratory staff to support science teaching (91 per cent in England versus OECD / H10 averages of 34 per cent and 51 per cent respectively) and the availability of laboratory material (92 per cent in England versus 66 per cent and 72 per cent for the OECD and H10 averages). Likewise, headteachers in England are generally positive about the science equipment that their school has available. Indeed, the only question where the percentage for England is below the average for high-performing and OECD averages is for the use of extra funding; headteachers in England are less likely to report spending extra money received on improving

science teaching than headteachers in the average high performing country (34 per cent versus 47 per cent) indicating additional investment in science teaching is not the highest priority of our headteachers.

Figure 8.2 Headteachers' reports of school science resources by Ofsted rating



Source: Matched PISA 2015 database.

19. Within England, science may take a low priority in schools with lower Ofsted inspection ratings when additional funding is made available. No headteacher leading an inadequate school reports that any extra funding received typically gets spent upon improving teaching in science (yellow line with cross markers in Figure 8.2), compared to a third or more of headteachers in the three higher Ofsted groups. It is also striking that headteachers who lead schools with a lower inspection rating are less likely to report that science teachers are amongst the most educated members of staff (blue line with square markers in Figure 8.2). Specifically, whereas 79 per cent of headteachers who lead 'outstanding' schools respond positively to this statement, this falls to 66 per cent of those in-charge of 'good' / 'requires improvement' schools and around 40 per cent within the inadequate group.

Key point

Headteachers in England are generally positive about the resources available to support science learning within their school; more so than headteachers in the average high performing country. According to headteachers, schools with low inspection ratings would not typically devote any extra funding received to improving teaching in science.

8.4 How do headteachers view the conduct of their staff?

20. A successful school is likely to have teachers who are well prepared for the classes that they teach, and who are able to meet the needs of each individual pupil. On the other hand, frequent absenteeism and unprofessional behaviour of staff are likely to be associated with lower levels of pupil attainment[68]. In this sub-section, we document the extent to which headteachers in England report negative behaviour of staff as hindering progress within their school.

21. Headteachers were asked the following question in the background questionnaire, with responses given on a four-point scale (not at all, very little, to some extent, a lot). Table 8.4 provides the per cent reporting either 'to some extent' or 'a lot'.

In your school, to what extent is the learning of pupils hindered by the following phenomena?

Table 8.4 Headteachers' reports of factors hindering pupils' learning: the conduct of teachers

	England	OECD	H10$^+$
Teachers not meeting individual pupils' needs	30%	23%	31%
Teacher absenteeism	24%	17%	**14%***
Staff resisting change	17%	**30%***	**32%***
Teachers being too strict with pupils	5%	**13%***	**16%***
Teachers not being well prepared for classes	11%	12%	**19%***

Source: PISA 2015 database.

Notes: Figures refer to the percentage of pupils in schools where the headteacher ticked either the 'to some extent' or 'a lot' categories. H10$^+$ refers to the average across the 10 countries with the highest science scores. Bold with * indicates significantly different from England.

22. The negative views of England's headteachers on staff absenteeism is rather different to the situation reported by headteachers in most of the countries with the highest average science scores. Around a quarter (24 per cent) of pupils in England are taught in schools where the headteacher believes that staff absenteeism acts as a barrier to their learning. This is higher than the average across members of the OECD (17 per cent) and the average across the high performing countries (14 per cent). However, these cross-national averages again disguise the substantial cross-

[69] See Sacerdote (2011) for an overview of how pupils may have an impact upon the learning of their peers.

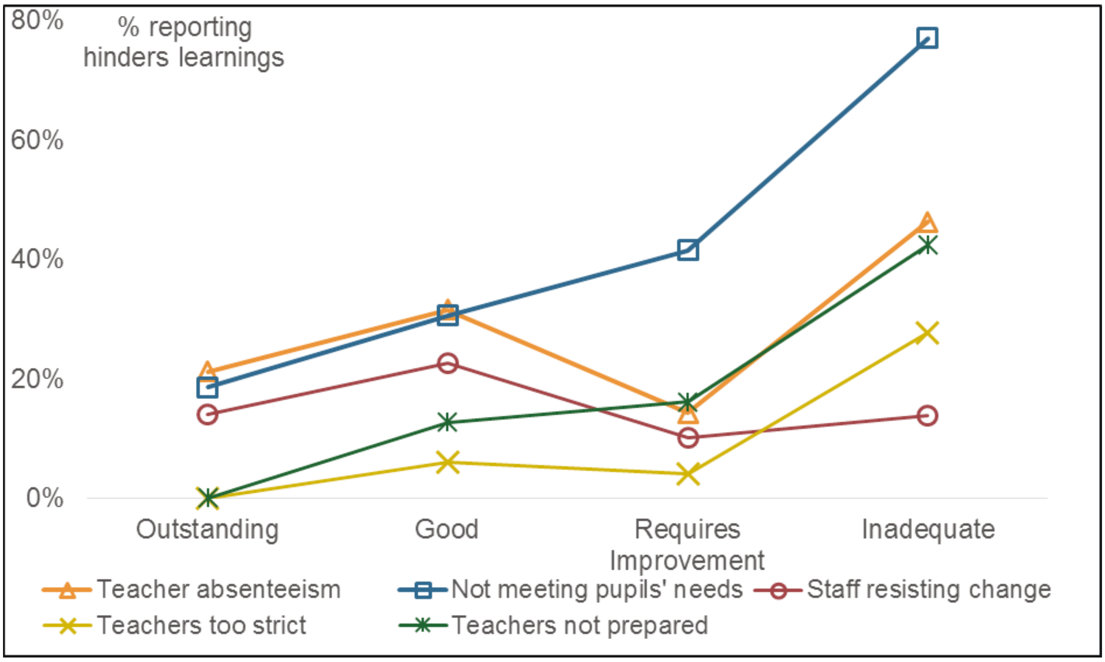
national variation in headteachers' responses. Specifically, whereas less than 10 per cent of headteachers report staff absenteeism to be a problem in some high-performing countries (e.g. Singapore, Japan, Canada), this is certainly not the case in others (e.g. in China and Macao around 35 per cent to 40 per cent of pupils are taught in schools where the headteacher views this as a barrier to instruction).

23. In contrast, headteachers in England are less likely to report that their staff are resistant to change (17 per cent in England versus an H10 average of 32 per cent). Likewise, comparatively few pupils in England are taught in schools where the headteacher believes that their staff are too strict (five per cent versus an H10 average of 16 per cent), or that teachers are not well prepared for class (11 per cent versus H10 average of 19 per cent).

24. Within England, there is a clear pattern whereby headteachers leading schools with lower Ofsted ratings are more likely to report that their staff do not meet individual pupils' needs (blue line with square markers in Figure 8.3). For instance, whereas 19 per cent of headteachers who lead an 'outstanding' school agree that their staff do not meet individual pupils' needs, this increases to 42 per cent in schools that require improvement, and up to 77 per cent for the inadequate group. This therefore seems an issue of particular concern to headteachers who lead lower-performing schools.

25. An emphasis on making sure teachers are well-prepared for the classes that they teach may be a key action in schools rated as 'inadequate' or 'requiring improvement' by Ofsted. For instance, no headteacher of an 'outstanding' school in England reports a lack of teacher preparation as an issue, compared to 16 per cent within the 'requires improvement' category and 42 per cent of those leading inadequate schools. These results are presented in Figure 8.3 (green line with star markers).

Figure 8.3 Headteachers' reports of teachers' conduct by school Ofsted rating



Source: Matched PISA 2015 database.

26. A final interesting feature of Figure 8.3 is the lack of a clear pattern between Ofsted rating and headteachers' views on staff absenteeism (orange line with triangular markers) and whether there is resistance to change (red line with circular markers). There is little evidence to suggest that these are issues specifically of concern to lower performing schools.

27. There is also some interesting variation in headteachers responses by school type, particularly between those leading sponsored academies versus those leading academy converters. For instance, headteachers of sponsored academies are more likely to report staff as not meeting individual pupils' needs than headteachers of academy converters (48 per cent versus 27 per cent) and that teachers are not well prepared for classes (22 per cent versus five per cent). Headteachers in converter academies, however, are more likely to report that their staff are resistant to change than those in sponsored academies (26 per cent versus eight per cent).

Key point

Headteachers in England are more likely to report staff absenteeism as a barrier to pupils learning than headteachers in the average high performing country. Within England, staff not meeting individual pupils' needs and a lack of preparation of teachers for classes are key concerns for headteachers who lead schools with low Ofsted ratings.

8.5 What quality assurance processes are used in England's schools?

28. Robust quality assurance processes are a vital part of any industry. In education, these can take several forms, including external inspections, routine recording of key data, clear specification of the school's goals, and implementing systems to gather regular feedback (from both pupils and their parents). We already know that our education system uses some of these quality assurance processes extensively (e.g. school inspections as a means of external evaluation) however, less is known about the prevalence of others (e.g. to what extent do schools in England have systems in place to receive regular feedback from their pupils?). Table 8.5 therefore provides information on the breadth of the quality assurance processes used in our secondary schools, and how this compares to other countries.

29. Our education system is one in which extensive quality assurance processes are already in place. Almost every headteacher in England reports that self-evaluation, external evaluation, teacher mentoring, systematic recording of pupil data and test results, and written specification of goals and performance standards were used in their school. Indeed, the only areas where less than 90 per cent of headteachers' respond positively are in them undertaking regular consultation with an expert (85 per cent) and in implementation of a standardised policy for science (85 per cent). Consequently, all 10 forms of quality assurance listed are used in most of England's schools.

30. Many of the quality assurance measures listed in Table 8.5 are also extensively used in other industrialised and high performing countries (e.g. self-evaluation, written specification of goals, systematic reporting of pupil attendance and test scores). Yet there is also evidence of greater use of certain measures in England, relative to other countries - this includes more widespread use of consultation with external experts than the average across the high-performing countries (85 per cent versus 48 per cent), greater use of external evaluations (97 per cent versus 80 per cent) and written specification of pupil performance standards (99 per cent versus 81 per cent). It is therefore the breadth of the quality assurance processes used in England's schools that is the stand out feature of Table 8.5.

Table 8.5 Headteachers' reports of the quality assurance processes used in secondary schools

	England	OECD	H10+
Self-evaluation	100%	**93%***	**97%***
External evaluation	97%	**75%***	**80%***
Written specification of the school's curricular profile and educational goals	97%	**89%***	95%
Written specification of pupil performance standards	99%	**79%***	**81%***
Systematic recording of data such as teacher or pupil attendance and professional development	100%	**91%***	**94%***
Systematic recording of pupil test results and graduation rates	100%	**93%***	**95%***
Seeking written feedback from pupils	90%	**69%***	**82%***
Teacher mentoring	99%	**78%***	**89%***
Regular consultation aimed at school improvement with one or more experts over a period of at least six months	85%	**48%***	**49%***
Implementation of a standardised policy for science subjects	84%	**63%***	**75%***

Source: PISA 2015 database.

Notes: Figures refer to the percentage of pupils within schools where the headteacher reports the quality assurance process as taking place. H10+ refers to the average across the 10 countries with the highest science scores. Bold with * indicates significantly different from England.

31. As Table 8.5 illustrates, external evaluations (such as those conducted by Ofsted) are a prominent feature of the quality assurance process used in England. However, to what extent do headteachers in England use the results from these inspections to drive change? Moreover, do headteachers perceive these inspections to have a lasting impact upon their school?

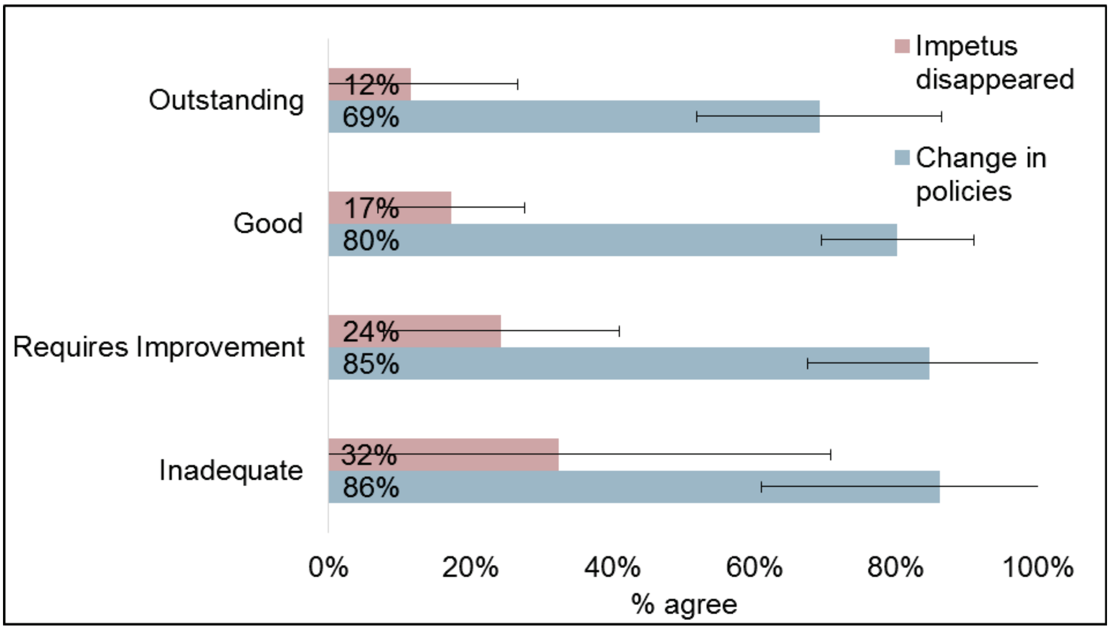
32. To answer these questions, we draw upon headteachers' responses (yes or no) as to the impact external evaluations had upon their school:

- *The results of external evaluations led to changes in school policies*
- *We used the data to plan specific action for school development*

- *We used the data to plan specific action for the improvement of teaching*
- *We put measures derived from the results of external evaluations into practice promptly*
- *The impetus triggered by the external evaluation 'disappeared' very quickly at our school.*

33. There was near universal agreement amongst headteachers in England that the school inspections led to a specific plan of action for school development (95 per cent) and improving teaching (92 per cent), with the measures being put into place promptly (97 per cent). However, more than a fifth of headteachers report no change in school policies as a result of the inspection (23 per cent), while around one-in-six believes the impetus the inspection triggered disappeared quickly (17 per cent).

Figure 8.4 The reaction of schools in England to their last external inspection



Source: PISA 2015 database.

Notes: Figures refer to the percentage of pupils within schools where the headteacher responds 'yes'. Thin line through centre of each bar refers to the estimated 95 per cent confidence interval.

34. Within England, headteachers of schools that received an 'outstanding' Ofsted rating are less likely to report a change in policy due to external inspection than the other three groups, however, none of these differences are statistically significant at the five per cent level. There is also no evidence that headteachers leading a school with a low inspection rating are more likely to report a sustained impetus triggered by the results. If anything, the opposite may hold true, with a quarter of headteachers leading schools 'requiring improvement' reporting that the impetus evaporated quickly, compared to only 12 per cent of those leading

‘outstanding’ schools. However, due to the limited number of participating schools, differences by Ofsted inspection rating do not reach statistical significance.

Key point

Extensive quality assurance processes are already in place within England’s education system. Around three-quarters of headteachers in England altered their school’s policies as a result of their most recent inspection.

Chapter 9. Pupils' experiences of their time in science classes at school

- PISA provides new evidence on pupils' experiences whilst in school, including the activities they complete in the science classroom.
- The results show that 15-year-olds in England report spending more time (five hours) studying science in school per week than young people in most other countries. This is greater than the amount of time for either English (four hours) or mathematics (four hours) in England, and is unlike the case in most other OECD countries, where instruction time is similar across subjects.
- However, there is little evidence that countries with a greater number of timetabled hours for science necessarily achieve higher average PISA scores.
- Indeed, weekly hours as a whole vary substantially by country. In China, the average 15-year-old reports spending 30 hours per week studying in-school, accompanied by 27 hours on additional study. This is notably higher than the 26 hours (in-school) and 17 hours (additional instruction) in England.
- However, China and Singapore are the only high performing countries where total additional study hours are much higher than in England.
- Science teachers in England provide more regular feedback to pupils on their strengths and weakness, including specific areas they can improve, than teachers in many of the countries with the highest average scores.
- Low level disruption is reported to occur more frequently in England's science classrooms than in the high-performing East Asian countries.
- Nevertheless, 15-year-olds in England are more likely than those in the top 10 performing countries to say that their science teacher regularly provides constructive feedback.
- Pupils in England generally perceive their science teachers as supportive. However, lower achieving pupils' report their teachers to be less willing to provide individual help and adapt science lessons to their needs than their higher achieving peers.

1. The time pupils spend in school, learning and interacting with their teachers and their peers, plays a critical role in determining their learning outcomes[69]. Yet important gaps in our knowledge about pupils' experiences whilst in school remain, including the activities they complete in the science classroom. For instance, how much time do pupils in England spend studying science relative to other subject areas per week? Do they receive regular feedback from their teachers as part of their science lessons? Is the environment in the classroom conducive to learning, or do pupils feel that their progress is being hampered due to frequent occurrences of low level disruption?

2. The aim of this chapter is to provide new evidence on these issues for England, and whether the experiences of learning science in school for 15-year-olds in this country are similar to those of young people in other parts of the world. Specifically, this chapter seeks to answer the following questions:

- *How much time do pupils spend studying science in school and outside of school? How does this compare to other subject areas?*
- *What kind of activities take place in science classrooms in England? Does this differ markedly from other countries?*
- *Is low level disruption in science classrooms a more common occurrence in England than in other countries?*
- *How do pupils in England perceive the feedback that they receive from their science teachers?*
- *Do pupils in England feel that they receive sufficient support from their teachers during their science classes?*

3. It should be noted that we attempt to answer these questions by drawing upon information reported by the 15-year-olds who responded to the PISA background questionnaire.

9.1 How much time do pupils spend studying per week?

4. It has been suggested that increasing instruction time in school can, up to a point, improve pupils' learning outcomes (particularly for those from more disadvantaged socio-economic backgrounds) [70]. At the same time, certain forms of additional study (such as intensive one-to-one tuition) are thought to be particularly effective in raising pupils' attainment[71]. It is therefore important to know how much time pupils in England spend studying different subjects, both within their compulsory

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69 See Sacerdote (2011) for an overview of how pupils may have an impact upon the learning of their peers.

70 See Hanushek (2015) for an overview of the evidence on instruction time and pupil performance.

71 Higgins et al. (2014).

timetable at school and beyond. In this sub-section we therefore explore the amount of time pupils' report spending on a selection of subjects (a) within their core timetable and (b) in additional time, before and/or after school.

5. On average, pupils in England receive five hours of science instruction per week[72]. This equates to approximately one fifth of their 26-hour weekly timetable. This is greater than the amount of time for either English or mathematics (four hours each). This is not the case for the average across OECD and top-performing countries, where the average number of hours is the roughly the same for science, language of instruction and mathematics.

Table 9.1 The average number of in-school instruction hours per week

	England	OECD	H10 +
Science	4.8 hours	**3.5 hours***	**4.0 hours***
English/test language	4.1 hours	**3.6 hours***	4.1 hours
Mathematics	3.9 hours	**3.6 hours***	**4.3 hours***
Other	13.8 hours	**16.6 hours***	**15.9 hours***
Total	**26.3 hours**	**26.9 hours***	**28.0 hours***

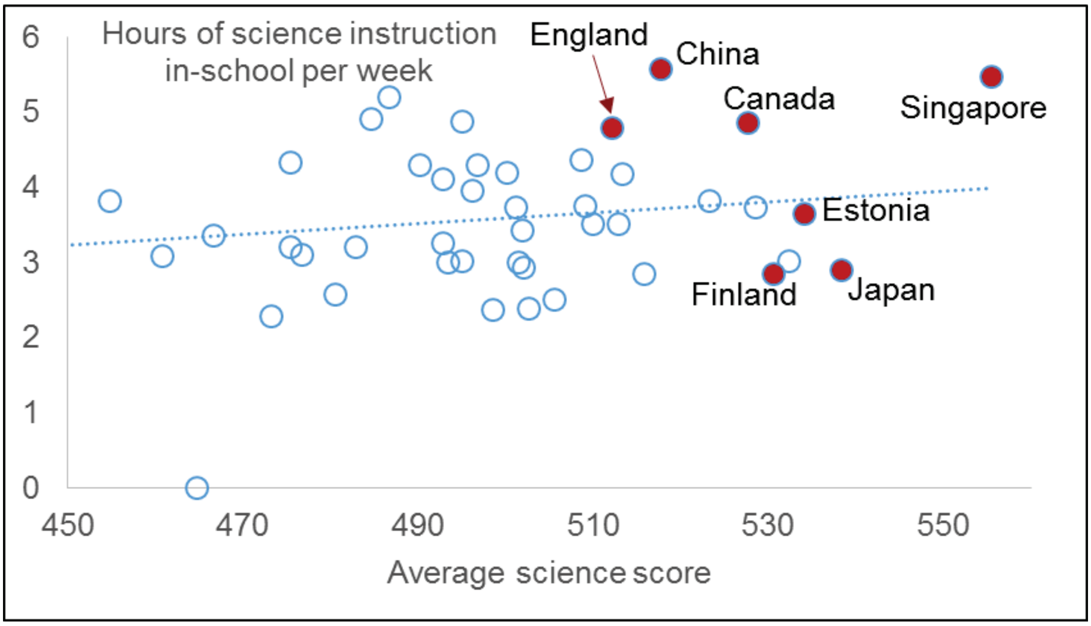
Source: PISA 2015 database.

Notes: Figures refer to the average weekly hours of in-school instruction time, as reported by pupils. H10+ refers to the average across the 10 countries with the highest average scores. Data not available for Vietnam, which has therefore been excluded from the H10 average. Bold font with * indicates significant difference from England. 'Other' is the difference between the sum of reported subjects and the reported total, calculated at the pupil level. Due to missing values, the reported subjects and the 'other' category may not sum to the total.

6. Pupils in England report spending more time studying science in-school than their peers in OECD (one hour and twenty minutes more per week) and high-performing countries (almost 50 minutes more per week). A similar finding holds true for mathematics (nearly 30 minutes per week) and language of instruction (30 minutes per week) relative to the OECD average. However, pupils in England spend substantially less time on 'other' subject areas (13 and a half hours) than the average across OECD and high-performing countries per week (16 hours each). Consequently, the total weekly in-school learning hours in England (26 hours) is lower than the OECD (27 hours) and high-performing (28 hours) averages.

[72] The online data tables provide additional estimates based upon the median number of hours, rather than the mean. These results are less likely to be affected by a small number of pupils who report very large values in response to the questions regarding the time they spend studying inside and outside of school.

Figure 9.1 The relationship between hours of science instruction in-school and average science scores



Source: PISA 2015 database.

Notes: The sample of countries has been restricted to those with an average science score above 450. Data not available for Malta and Vietnam.

7. Although PISA is not directly linked to the curriculum, the amount of time pupils spend learning science in school may nevertheless be associated with their achievement. There are few countries where average weekly science instruction time in school is higher than in England with 15-year-olds in most other countries spending typically at least an hour less time learning science in school per week.

8. There is no indication, however, that there is a relationship between in-school instruction hours and average science scores at the country level (Pearson correlation of the dashed line in Figure 9.1 is 0.19). For instance, in some high-performing countries, pupils report as little as three hours of timetabled science lessons per week (e.g. Japan, Finland), while in others (e.g. Singapore) the average amount of time spent is similar to the five hours that is timetabled in England. Consequently, there is little evidence that countries with a greater number of timetabled hours for science necessarily achieve higher average PISA scores.

9. It is of course possible for pupils to increase the amount of time they spend studying per week via additional learning. This information was also captured in the background questionnaire, with pupils asked, '*approximately how many hours per week do you spend learning in addition to your required school schedule*?'. Pupils

were instructed to include time spent upon homework, additional instruction and private study in their responses[73].

Table 9.2 Average hours spent on additional learning per week

	England	**OECD**	**H10 ⁺**
Science	3.7 hours	**3.1 hours***	**3.4 hours***
English/test language	3.0 hours	3.1 hours	**3.2 hours***
Mathematics	3.5 hours	**3.8 hours***	**4.3 hours***
Foreign language	1.5 hours	**3.1 hours***	**3.1 hours***
Other subjects	4.9 hours	**3.9 hours***	**3.8 hours***
Total	**16.6 hours**	**17.1 hours***	**17.8 hours***

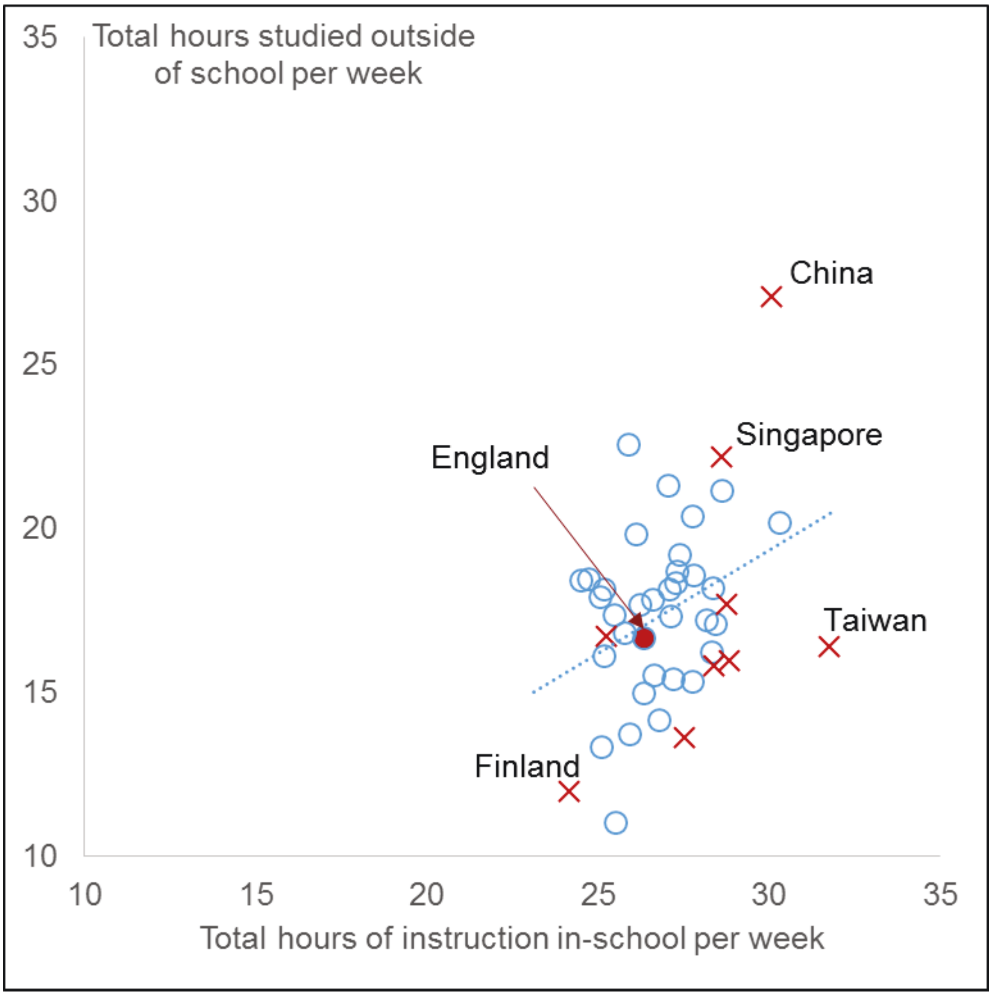
Source: PISA 2015 database.

Notes: Figures refer to the average hours of additional learning time per week, as reported by pupils. Bold font with * indicates significant difference from England at the five per cent level. $H10^+$ refers to the average across the 10 countries with the highest average science scores. Due to missing data, the reported subjects do not necessarily sum to the reported 'total' category. This includes a combination of homework, private tuition and other forms of learning. Data not available for Vietnam, which has therefore been excluded from the H10 average. Analogous results for the median are provided in the online data tables.

10. Although the total number of additional learning hours is similar for both the average pupil in England and those in OECD countries (approximately 17 hours), there are some important differences in how this time is distributed across various subject areas. Specifically, the average number of additional learning hours is higher for England than the OECD and high-performing country averages in science (approximately 30 minutes more) and in the 'other' category (approximately an hour more). In contrast, less additional time in England is spent on learning foreign languages (one and a half hours less - see Table 9.2).

[73] Any pupil reporting more than 70 hours per week on additional study is treated as reporting an illogical value, and therefore excluded from this part of our analysis.

Figure 9.2 The relationship between in-school and out-of-school learning hours per week



Source: PISA 2015 database.

Notes: Figures refer to the total number of weekly hours of in-school instruction (horizontal axis) and the total number of additional hours of study (vertical axis) as reported by the average pupil. Sample restricted to countries with a mean science score above 450. The top 10 performing countries are indicated with a red cross. Data not available for Malta and Vietnam.

11. In every country, the average pupil spends more time studying in school than they do on additional instruction outside of regular school hours (note that all countries in Figure 9.2 sit towards the bottom right hand corner of the graph). There is also substantial cross-national variation in these figures, however, including variation across the high performing countries. When these facts are brought together, they highlight two important points for England:

- the 16.5 hours of additional instruction time reported by the average 15-year-old in England does not stand out as particularly high or low relative to pupils in most other countries, and;

- China and Singapore are the only high performing countries where total additional study hours are much higher than in England.

12. In China, the average 15-year-old reports spending 30 hours per week studying in-school, accompanied by 27 hours on additional study. This is notably higher than the 26 hours (in-school) and 17 hours (additional instruction) in England. Weekly hours are much lower in other countries, such as Finland, where the average 15-year-old reports spending 24 hours learning in school and 12 hours on additional instruction. There are also some notable outliers in Figure 9.2, such as Taiwan, where in-school instruction time is higher than any other country included in the comparison (32 hours), though with additional study time around the international average (16 hours).

13. Pupils do not substitute in-school learning with additional learning; there is little evidence of a trade-off between in-school and additional learning hours at the country level. In fact, the relationship across countries is positive and moderate (Pearson correlation = 0.35), indicating that the average pupil spends slightly more time on additional study in countries with more hours in the weekly timetable.

14. Additional analysis for England suggests that there are few gender differences in additional hours in any subject area, or for total additional study hours overall. The same also holds true for socio-economic status; average additional study hours differ little between 15-year-olds from advantaged and disadvantaged socio-economic backgrounds. These findings are not specific to England and they hold across several other OECD countries as well. The lack of association between additional learning hours and socio-economic status may nevertheless be surprising, given that pupils were explicitly asked to include factors such as private tuition in their responses.

Key point

15-year-olds in England report spending more time studying science in-school per week than young people in most other countries. The total amount of time 15-year-olds in England report spending on additional study is similar to their peers in many other countries, including those with the highest average scores.

9.2 What activities take place in science classrooms in England? Is this similar to other countries?

15. The science curriculum in England is designed to help pupils develop their understanding of scientific phenomena and the principles of scientific investigation[74]. Science teachers have a critical role in helping young people to reach these goals, including through the activities that take place in their classrooms. Yet what are the activities that actually take place in school science lessons in England? Do pupils regularly design and conduct their own experiments? Or is more time spent on activities that require reasoning and constructing an argument, such as class debates? PISA provides us with an opportunity to take a glimpse inside science classrooms in England, allowing us to better understand the types of tasks that pupils complete.

Table 9.3 Percentage of pupils who report the use of different activities and teaching practices within school science classes

	England	OECD	H10 +
Pupils are given opportunities to explain their ideas	75%	**69%***	**63%***
Pupils spend time in the laboratory doing practical experiments	19%	**21%***	**17%***
Pupils are required to argue about science questions	17%	**30%***	**21%***
Pupils are asked to draw conclusions from an experiment they have conducted	49%	**42%***	**35%***
The teacher explains how a school science idea can be applied to a number of different phenomena	61%	59%	**53%***
Pupils are allowed to design their own experiments	9%	**16%***	**13%***
There is a class debate about investigations	14%	**26%***	**17%***
The teacher clearly explains the relevance of science concepts to our lives	47%	**50%***	47%
Pupils are asked to do an investigation to test ideas	30%	**26%***	**19%***

Source: PISA 2015 database.

Notes: Figures refer to the percentage of pupils who report that the corresponding activity or practice happens in 'every' or in 'most' of their science lessons as opposed to in 'some' or never. H10+ refers to the average across the 10 countries with the highest average science scores. Bold font with * indicates significant difference from England.

[74] Department for Education (2013).

16. Pupils in England typically report being given greater opportunities to explain their ideas in science lessons than pupils across the high-performing countries (particularly those within East Asia - see Table 9.3). Specifically, whereas 75 per cent of pupils in England respond positively to this statement, the average across the high-performing countries is 63 per cent. Indeed, in some high-performing countries, the proportion of pupils' reporting that they have the opportunity to explain their ideas is substantially lower than in England (for example, just 47 per cent in Japan). Yet there are others, such as Canada and Finland, where the proportion of positive responses is at approximately the same level as in England.

17. School science classrooms in England may be more interactive than in the average high-performing country along several other dimensions. Similar findings emerge for the statements regarding the opportunity to draw conclusions from an experiment (49 per cent in England versus 35 per cent H10 average), teachers explaining how an idea from science can be applied to a range of phenomena (61 per cent versus 53 per cent) and whether pupils are asked to conduct investigations to test an idea (30 per cent versus 19 per cent).

18. There may be less of an atmosphere of debate in England's science classrooms relative to the average across OECD countries, even though pupils in England generally report having regular opportunities to explain their ideas. Pupils in England report being less likely to argue about science questions (17 per cent in England versus 30 per cent OECD average) and less likely to debate about science investigations (14 per cent versus 26 per cent). Both of these activities involve applying reasoning to scientific fact and constructing arguments. Table 9.3 provides further details.

19. Additional analysis suggests that pupils in academies and community schools may have greater opportunity to express themselves within science lessons, while independent school pupils are more likely to learn and apply practical science skills. Pupils attending academies (76 per cent) and community schools (77 per cent) were five to six percentage points more likely to report having the opportunity to express their ideas in 'every' or 'most' science lessons compared to pupils at independent schools (71 per cent).

20. Similarly, pupils at sponsored academies and community schools are five to eight percentage points more likely to regularly design their own experiments than independent school pupils, and seven percentage points more likely to report regularly having classroom debates. Independent school pupils, however, are around 10 percentage points more likely than their state school peers to regularly spend time doing practical experiments.

Key point

Pupils in England feel they have more opportunities to express themselves and draw conclusions from experiments during their science classes than their peers in OECD and high-performing countries. However, they spend less time constructing arguments and engaging in class debates. Pupils at independent schools are more likely to engage in practical, hands-on science learning than their peers at other school types.

9.3 Is low level disruption in science classrooms more common in England than in other countries?

21. Low-level disruption is thought to be a problem in England's schools[75] and is important as the learning environment in schools is directly linked to pupils' attainment, with evidence suggesting that interventions which aim to improve pupil behaviour (and therefore minimise disruption) can also lead to increases in academic achievement[76]. The PISA background questionnaire allows us to consider the frequency that low-level disruption occurs in school science lessons in England, and how this compares to other countries.

Table 9.4 Percentage of pupils who report frequent occurrences of low level disruption during their school science classes

	England	OECD	H10⁺
Pupils don't listen to what the teacher says	36%	**32%***	**21%***
There is noise and disorder	40%	**33%***	**22%***
The teacher has to wait a long time for pupils to quiet down	34%	**29%***	**18%***
Pupils cannot work well	21%	22%	**15%***
Pupils don't start working for a long time after the lesson begins	24%	26%	**17%***

Source: PISA 2015 database.

Notes: Figures refer to the percentage of pupils who report that this form of disruption occurred in 'every' or in 'most' of their school science lessons. Bold font with * indicates significant difference from England. $H10^{+}$ refers to the average across the 10 countries with the highest average science scores.

22. Low-level disruption in science classrooms stands out as a key difference between England and the high-performing East Asian countries. England, however,

[75] Ofsted (2014).
[76] Education Endowment Foundation (2016).

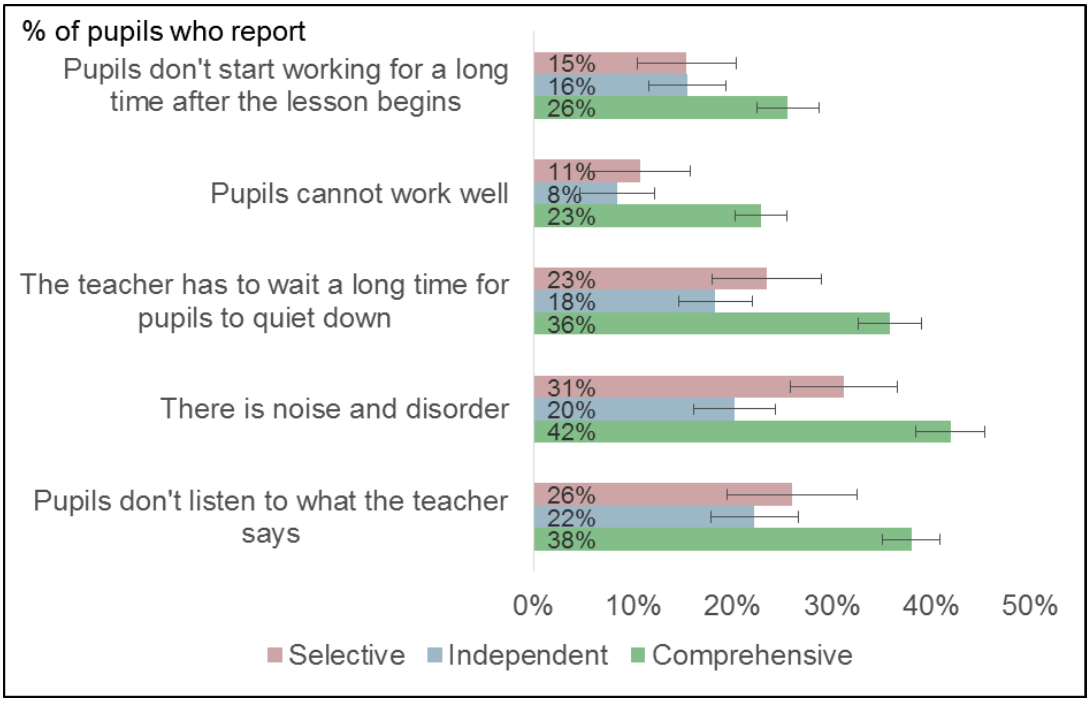
is not particularly different to several other industrialised nations (including those with high average science scores) in this respect.

23. The results for England show that low level disruption is a problem in most or in every lesson for approximately a third of pupils (see Table 9.4). Around 36 per cent of pupils report that their peers do not listen to their teacher (21 per cent in high-performing countries) and 40 per cent report that there is noise and disorder (22 per cent in high-performing countries). This difference can conceal variation across the high-performing countries, however. For instance, issues such as ‘noise and disorder’ are a lot less common in the high-performing East Asian countries (e.g. 11 per cent in Japan, 20 per cent in China) than in high-performing Western countries (e.g. 36 per cent in Canada, 38 per cent in Finland) where the percentage of pupils reporting this to be a frequent problem is similar to the situation in England (40 per cent). Moreover, for most of the five statements presented in Table 9.4, the proportion of pupils in England reporting a regular problem tends to be around or only slightly above the average across members of the OECD.

24. Within England a clear pattern emerges, where low-level disruption is a particular barrier to effective learning in comprehensive state schools yet pupils who attend either an independent or selective state school are significantly less likely to report low level disruption[77]. For example, only eight per cent of pupils at independent schools report that pupils cannot work well in all or most science lessons, compared to over 20 per cent of pupils in comprehensive schools. Similarly, pupils at independent schools (20 per cent) and selective state schools (31 per cent) report fewer issues with noise and disorder than their peers at comprehensive schools (42 per cent). These results are presented in Figure 9.3.

[77] We have also investigated differences between school management types in England (e.g. academies, community schools). The only consistent and pronounced differences to emerge were between pupils in independent schools versus all other school types.

Figure 9.3 Percentage of pupils who report low level disruption in the science classroom by school admissions policy

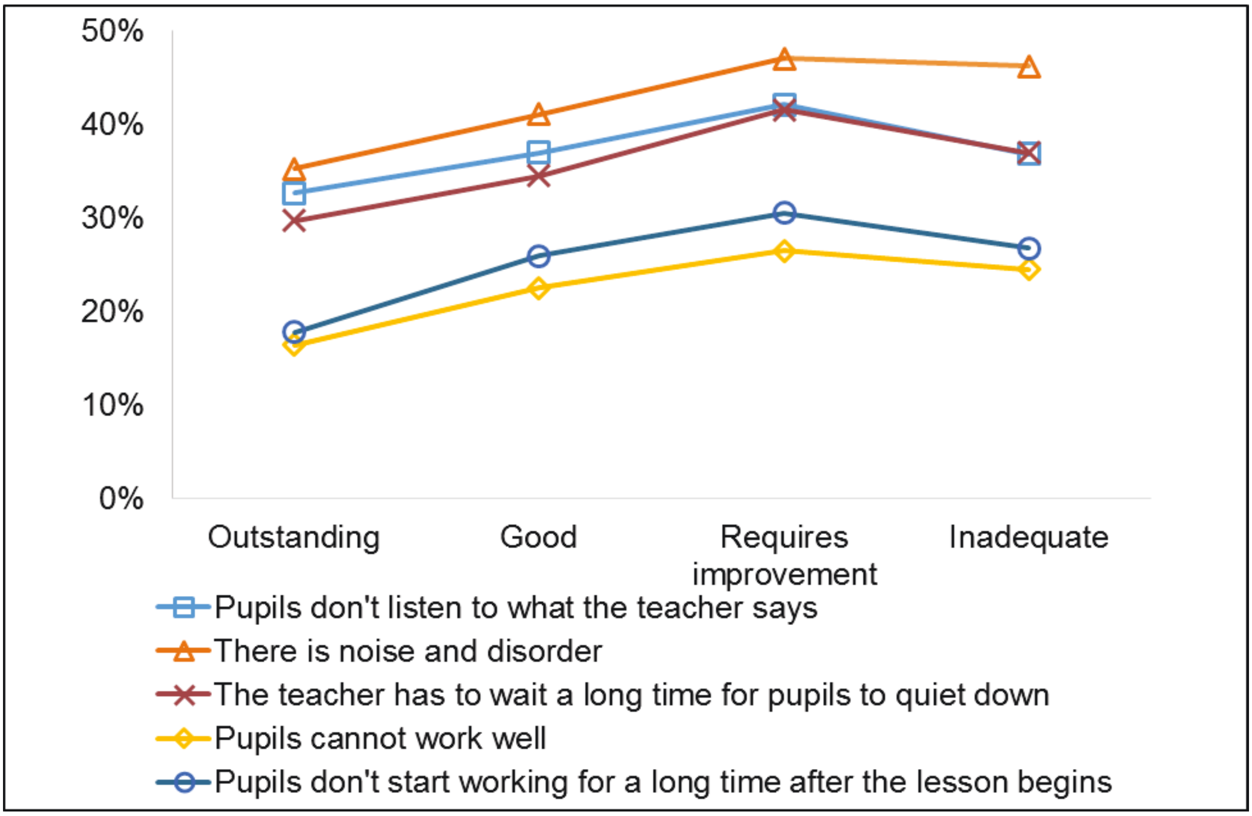


Source: PISA 2015 database.

Notes: Figures refer to the percentage of pupils who report that this form of disruption occurs in 'every' or in 'most' of their school science lessons. Thin line through centre of each bar refers to the estimated 95 per cent confidence interval.

25. Pupils who attend schools rated as outstanding by Ofsted are also less likely to report experiencing low-level disruption than pupils at schools with lower ratings. As the inspection rating declines, low-level disruption during science lessons becomes more of an issue (note the upward sloping lines in Figure 9.4). For instance, 35 per cent of pupils at 'outstanding' schools report noise and disorder in most or all of their science lessons, compared to 46 per cent of pupils at schools with an 'inadequate' rating. Similar results hold for all the other statements, including whether pupils are unable to work well (16 per cent in 'outstanding' schools versus 27 per cent in schools 'requiring improvement') and if pupils do not listen to what the teacher has to say (33 per cent in 'outstanding' schools versus 42 per cent in schools 'requiring improvement'). Interestingly, the frequency of low-level disruption seems to differ little between the 'requires improvement' or 'inadequate' groups (as illustrated by the lines in Figure 9.4 levelling off). In other words, the most pronounced difference seems to be between pupils attending outstanding schools relative to most of the other groups.

Figure 9.4 Percentage of pupils who report low level disruption in the science classroom by Ofsted inspection rating



Source: PISA 2015 database.

Notes: Figures refer to the percentage of pupils who report that this form of disruption occurs in 'every' or in 'most' of their school science lessons.

Key point

Low-level disruption occurs more frequently in England's science classrooms than in the high-performing East Asian countries. Within England, low level disruption is a particular challenge facing comprehensive state schools with low inspection ratings.

9.4 How do pupils in England perceive the feedback they receive from their science teachers?

26. An important part of a teacher's role is to evaluate the strengths and weaknesses of their pupils, and provide feedback as to how they might improve. Indeed, there is evidence to suggest that pupils who receive regular, constructive feedback from their teachers perform better at school[78]. In the 2013 TALIS study, 82 per cent of teachers in England reported that they 'always' or 'frequently' provide

[78] See Airasian (2000) for an overview of the literature on assessment, feedback and pupil performance.

regular feedback to their pupils, compared to an international average of 55 per cent[79]. This, however, was based upon information reported by school teachers themselves and we therefore do not know if pupils in England felt the same way. Moreover, is there any evidence that the type and regularity of feedback provided by school science teachers is different for higher and lower achieving pupils? How does England compare to other countries in terms of pupils' perceptions of teacher feedback?

27. Pupils in England report that they receive more regular feedback about their performance in science than their peers in many other industrialised and high-performing countries. This is particularly true for specific types of feedback, such as helping them to appreciate their strengths as well as specific areas they may try to improve. It is also consistent with the evidence provided on teacher feedback in TALIS 2013.

28. Around 40 per cent of pupils in England report receiving regular feedback from their teachers in 'every' or 'most' science lessons. For certain kinds of feedback, pupils in England were 10 percentage points more likely to report receiving it than their peers in top-performing countries. For instance, as presented in Table 9.5, 15-year-olds in England are more likely to say that their science teacher regularly:

a) tells them how they are performing in their course (36 per cent versus 26 per cent),

b) advises them on their areas of strength (41 per cent versus 26 per cent), and;

c) tells them where they might improve (46 per cent versus 30 per cent).

[79] Micklewright et al. (2014: 136).

Table 9.5 Percentage of pupils who receive feedback from their teachers

	England	OECD	H10 +
The teacher tells me how I am performing in this course	36%	**28%***	**26%***
The teacher gives me feedback on my strengths in this school science subject	41%	**25%***	**26%***
The teacher tells me in which areas I can still improve	46%	**30%***	**30%***
The teacher tells me how I can improve my performance	43%	**32%***	**35%***
The teacher advises me on how to reach my learning goals	41%	**32%***	**36%***

Source: PISA 2015 database.

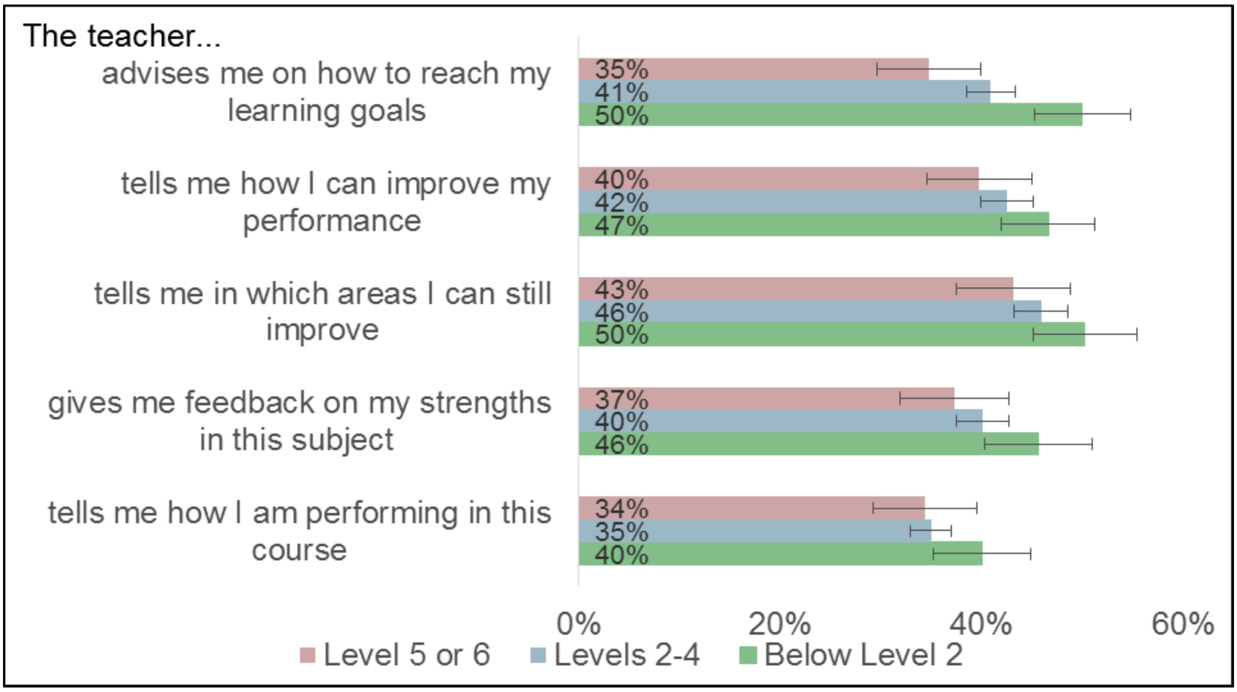
Notes: Figures refer to the percentage of pupils who report that the corresponding activity or practice happens in ‘every’ or in ‘most’ science lessons. Bold font with * indicates significant difference from England. H10+ refers to the average across the 10 countries with the highest average science scores.

29. Although the high-performing country average also tends to be lower than in England, there is variation between the high performing countries. Whereas pupils in Canada report similar frequency of feedback to pupils in England, this is not the case for 15-year-olds from Finland and Japan. For instance, less than 20 per cent of Finnish and Japanese pupils receive regular feedback on their strengths from their school science teacher, compared to 41 per cent of pupils in England.

30. The percentage of pupils in England who report that their science teacher regularly informs them of their strengths and weaknesses is also higher than the average across members of the OECD (41 per cent versus 25 per cent for feedback on strengths and 46 per cent versus 30 per cent for areas for improvement).

31. Low-achieving pupils in England report receiving the most feedback from their teachers. This is true for each of the five statements. Differences between the low-achievers and top-performers are statistically significant on a number of occasions, including for the statements: *‘the teacher advises me on how to reach my learning goal’* (50 per cent for low-achievers versus 35 per cent for top-performers), *‘the teacher gives me feedback on my strengths in this subject’* (46 per cent versus 37 per cent) and *‘the teacher tells me in which areas I can still improve’* (50 per cent versus 43 per cent). Figure 9.5 provides further details.

Figure 9.5 Percentage of pupils who receive regular feedback from their teachers by science proficiency level



Source: PISA 2015 database.

Notes: Figures refer to the percentage of pupils who report receiving the feedback in 'most' or in 'every' science lesson. 'Level' refers to PISA science proficiency level, which have been grouped into: low-achievers (below Level 2), average pupils (Level 2 to Level 4) and top-performers (Level 5 and 6). Thin line through centre of each bar refers to the estimated 95 per cent confidence interval.

32. Boys in England are more likely to report receiving feedback from their teachers than girls, with statistically significant differences of approximately six to eight percentage points. The same pattern also emerges for the average across OECD members and the average across high performing PISA countries. This finding could be driven by: (a) boys perceiving the level of feedback they receive from their science teacher to be more frequent and/or (b) actual differences in how regularly teachers provide feedback to boys and girls. Unfortunately, the data gathered within the PISA background questionnaire are not sufficiently detailed to allow us to disentangle these two potential explanations.

Key point

Science teachers in England provide more regular feedback to pupils on their strengths and weakness, including specific areas they can improve, than teachers in many of the countries with the highest average PISA scores. Within England, low-achieving pupils receive more regular feedback than their high-achieving peers.

9.5 Do pupils feel that they receive regular support from their teachers during their science classes?

33. Pupils spend a considerable amount of time in the classroom, interacting with their peers and their teachers. Yet how exactly do teachers influence their pupils' learning outcomes? Previous research on this matter has been somewhat mixed, and unable to directly identify measures of teacher 'quality'[80]. However, one channel that has not been fully explored is the support that teachers provide to pupils during their time in class. To conclude this chapter, we therefore investigate how school pupils in England interact with their science teachers. This includes whether pupils in England believe that their science teacher is supportive, and is able to adapt their lesson in order to meet the needs of those that they teach.

34. Nearly two thirds of 15-year-olds in England report that classroom practices, which are used to support learning and focus on explanation, demonstration and discussion are used in 'every' or 'most' of their science lessons. This includes the practice of their science teacher regularly explaining scientific ideas (66 per cent), demonstrating an idea (57 per cent) and discussing pupils' questions (58 per cent). On the other hand, whole class discussions occur somewhat less frequently with this result consistent with pupils' reports of infrequent classroom debates (see sub-section 9.2). See Table 9.6 for further details.

Table 9.6 The extent to which teachers use different classroom practices

	England	OECD	H10$^+$
The teacher explains scientific ideas	66%	**55%***	**59%***
A whole class discussion takes place with the teacher	34%	**40%***	**41%***
The teacher discusses our questions	58%	**55%***	**54%***
The teacher demonstrates an idea	57%	**54%***	57%

Source: PISA 2015 database.

Notes: Figures refer to the percentage of pupils in schools who say this happens in 'every' or in 'most' of their science lessons. H10$^+$ refers to the average across the 10 countries with the highest average science scores.

35. There are relatively few substantial points of difference between the results for England, the OECD and high-performing country averages. There are, however, differences between specific countries. For instance, 34 per cent of pupils in England report whole classroom discussions regularly taking place, compared to an average

[80] See Hanushek and Rivkin (2010) for further discussion on the teacher value-added literature and existing evidence.

across high-performing countries of 41 per cent. There is an even bigger difference in the same area between England and other Western countries with high average science scores, such as Canada (51 per cent), Estonia (49 per cent) and Finland (46 per cent). On the whole, pupils' perception of their teacher's use of supportive classroom practises is similar in England to the situation in many other countries.

36. There is little difference between England, the OECD and high-performing country averages on pupils' perception of their teachers as engaged in supportive classroom practises, including providing help, showing interest and making sure all pupils understand the subject matter (see Table 9.7). One notable exception is that pupils in England are 14 percentage points more likely to say that their teachers *'help pupils with their learning'* than their peers in OECD countries (85 per cent versus 71 per cent) and eight percentage points more likely to say that their science teacher regularly *'gives extra help'* (81 per cent versus 73 per cent).

Table 9.7 Percentage of pupils who perceive their teachers as supportive

	England	OECD	H10 $^+$
The teacher shows an interest in every pupil's learning	76%	**69%***	**72%***
The teacher gives extra help when pupils need it	81%	**73%***	**79%***
The teacher helps pupils with their learning	85%	**71%***	**80%***
The teacher continues teaching until the pupils understand	75%	**69%***	**72%***
The teacher gives pupils an opportunity to express opinions	65%	**68%***	**72%***

Source: PISA 2015 database.

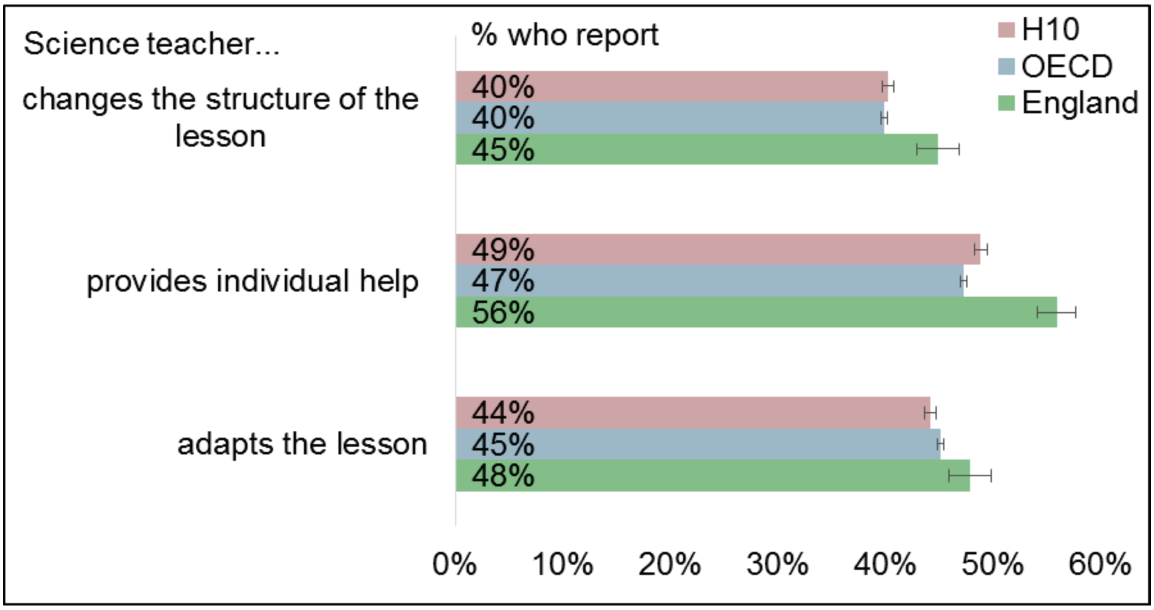
Notes: Figures refer to the percentage of pupils in schools who say this happens in 'every' or in 'most' of their science lessons. Bold font with * indicates significant difference from England. H10$^+$ refers to the average across the 10 countries with the highest average science scores.

37. In order to better support their pupils, teachers may adapt their approach in the classroom depending upon the needs of those whom they teach. Within the background questionnaire, pupils were asked their views of whether they felt their teacher did indeed adapt their lessons when needed. They were asked to say how frequently the following types of adaptation happened in their science classroom:

- *The teacher changes the structure of the lesson on a topic that most students find difficult to understand*
- *The teacher provides individual help when a student has difficulties understanding a topic or task*

- *The teacher adapts the lesson to my class's needs and knowledge.*

Figure 9.6 Pupils' perception of teachers' ability to adapt



Source: PISA 2015 database.

Notes: Figures refer to the percentage of pupils in schools who say this happens in 'every' or 'most' of their science lessons. Thin line through centre of each bar refers to the estimated 95 per cent confidence interval. Data missing for Vietnam, which is therefore not included in the H10 average.

38. More pupils in England are likely to report that their science teacher adapts their lessons depending upon pupils' needs than the average across OECD countries and the average across the high-performing countries (see Figure 9.6). The most pronounced difference is for the second statement, with teachers in England being more likely to provide individual help when a pupil is having difficulties (56 per cent in England versus H10 average of 49 per cent and OECD average of 47 per cent) - this is consistent with the results presented in Table 9.7.

39. Science teachers in England are also five percentage points more likely to change the structure on a topic that most pupils find difficult to understand (45 per cent in England versus 40 per cent for the average across OECD / H10 countries). However, there are some high-performing countries where science teachers' willingness to adapt their lesson is reasonably similar to England, with Canada being a prominent example. Specifically, 62 per cent of Canadian pupils report that their science teacher provides individual help when a pupil has difficulties (compared to 56 per cent in England), with 49 per cent saying that their teacher is able to adapt the structure of the lesson (45 per cent in England).

40. Pupils from different backgrounds do not have different perceptions of their teacher's ability to adapt their lessons. Even though boys are more likely to report

getting feedback from their teachers (see sub-section 9.4), we find little evidence of gender differences in pupils' responses to the three statements on lesson adaption presented above. Likewise, there is no variation in responses between pupils who attend schools with different Ofsted ratings.

41. Low-achieving pupils in England may feel left behind during some of their science lessons, and do not perceive their teacher as being willing and able to adapt to their particular needs. However, this finding is not specific to England; a similar pattern emerges in several other industrialised and high-performing countries where 67 per cent of high-achieving pupils (scoring at Level 5 or 6) report that their science teacher provides individual help during most lessons. This is around 25 percentage points higher than pupils who obtain PISA science scores below Level 2 (46 per cent).

42. Pupils who lack basic science skills are also much less likely to agree that their teachers have '*adapt[ed] the lesson to [their] class's needs and knowledge'* (38 per cent) relative to pupils with high level skills (62 per cent). Finally, low-achieving pupils in England are also 10 percentage points less likely to believe that their science teacher is willing to change the structure of a lesson covering a challenging topic than their high-achieving peers.

Key point

Pupils in England generally perceive their science teachers as supportive. However, lower achieving pupils report their teachers to be less willing to provide individual help and adapt science lessons to their needs than their higher achieving peers.

Chapter 10. Pupils' aspirations and future plans

- PISA allows us to investigate how pupils in England conceive of their lives after finishing school, in terms of future education and career choices.

- There is a concern in the UK that fewer pupils are interested in 'STEM' (science, technology, engineering and mathematics) careers than other fields, with evidence that this particularly holds true for girls and pupils from working-class backgrounds. However, PISA results show that the majority of pupils in England view school science as relevant to their future, irrespective of their gender, socio-economic status and PISA proficiency level.

- Interestingly, the top two careers that 15-year-olds in England most aspire to are science related: 'Engineer' (with six per cent of pupils stating they expect to work in this role by age 30) and 'Medical Doctor' (with five per cent).

- Indeed, the proportion of 15-year-olds who aspire to a career in a STEM field (at 28 per cent) is relatively high. It is around five percentage points above the average across OECD members (24 per cent) and the average across the high-performing countries (22 per cent).

- Whilst there is no gender difference, pupils from disadvantaged backgrounds in England are 10 percentage points less likely to aspire to a STEM career than their peers from advantaged backgrounds.

- Approximately 42 per cent of pupils in England expect to complete a university degree. There are, however, marked socio-economic differences; one-quarter of pupils in England from the least advantaged backgrounds expect to complete university, compared to two-thirds from the most advantaged backgrounds.

- Among those intending to apply to university, cost – though considered important – was not a stand-out issue. However, again, there are differences according to socio-economic status, with those from advantaged backgrounds being less likely to be concerned about costs (80 per cent versus 89 per cent).

1. Young people's aspirations towards future educational and occupational goals are linked to their future attainment[81]. Pupils who aspire to achieve a higher level of education are more likely to do so, even once previous achievement and family background have been taken into account[82]. This means pupils' goals for their lives post-secondary school can have a real impact upon their outcomes. Therefore, in this chapter, we investigate how pupils in England conceive of their lives after finishing school. This includes whether they plan to attend university, what type of career they hope to enter and how this differs between different groups of pupils.

2. As part of the PISA study, pupils were asked about how they view science in relation to future plans, what level of education they expect to attain and what job they expect to have at age 30. In England, Wales and Northern Ireland, several country specific questions were also added to the pupil questionnaire. These asked young people to provide further details on their higher education plans and allow us to gain a better understanding of how pupils in England view their life and goals beyond secondary school.

3. Based upon pupils' responses, this chapter seeks to answer the following questions:

- *Do pupils connect studying science in school with future careers?*
- *What types of careers are pupils in England interested in? To what extent are 15-year-olds interested in pursuing a career in science?*
- *What are the characteristics of pupils who plan to attend university? What factors are associated with their plans?*

10.1 Do pupils connect studying science with future careers?

4. The context in which pupils live shapes their aspirations and expectations for the future[83]. School forms an important part of this context, with pupils learning about their enjoyment of, and ability in, various subjects – something that is likely to determine young people's future career goals. At the same time, there is evidence that fewer pupils are interested in 'STEM' (science, technology, engineering and mathematics) careers than other fields, with this particularly holding true for girls and pupils from working-class backgrounds[84]. For instance, a recent study in the United

[81] See Gutman and Akerman (2008) for an overview of the literature on the determinants of aspirations and attainment.
[82] Strand and Winston (2008).
[83] Lupton and Kintrea (2008).
[84] Archer et al. (2013)

Kingdom found that pupils aged 10-14 have '*high aspirations, just not for science*'[85]. In this sub-section, we investigate this issue by considering whether pupils in England believe that the material they are taught about science in school is relevant for their future careers.

5. Pupils in England make a particularly strong connection between what they learn in school science and their future careers, especially when compared to their peers in OECD countries. Interestingly, the questions where there is the greatest difference between England and the OECD average all explicitly mention words like 'career', 'work' and 'job' (see Table 10.1). Pupils in England are somewhat more likely to report that school science will help to improve their career prospects than the average across OECD countries (77 per cent for England versus 67 per cent OECD average) and will help them to get a job (71 per cent versus 61 per cent). For all four questions relating science to a pupil's future, the proportion of pupils in agreement is usually similar for England and the average across the 10 highest-performing countries. For instance, in 2015, 77 per cent of 15-year-olds in England agree or strongly agree that school science is something that will *'improve career prospects'*, compared to an average across high-performing countries of 76 per cent.

Table 10.1 Percentage of pupils who connect school science subjects with future careers

	England		OECD		H10 +	
	2006	**2015**	**2006**	**2015**	**2006**	**2015**
Making an effort in my school science subject(s) is worth it because this will help me in the work I want to do later on	71%	80%	**63%***	**69%***	-	**77%***
What I learn in my school science subject(s) is important for me because I need this for what I want to do later on	54%	68%	**56%***	**63%***	-	**74%***
Studying my school science subject(s) is worthwhile for me because what I learn will improve my career prospects	71%	77%	**61%***	**67%***	-	76%
Many things I learn in my school science subject(s) will help me to get a job	65%	71%	**56%***	**61%***	-	**69%***

Source: PISA 2006 and PISA 2015 databases.

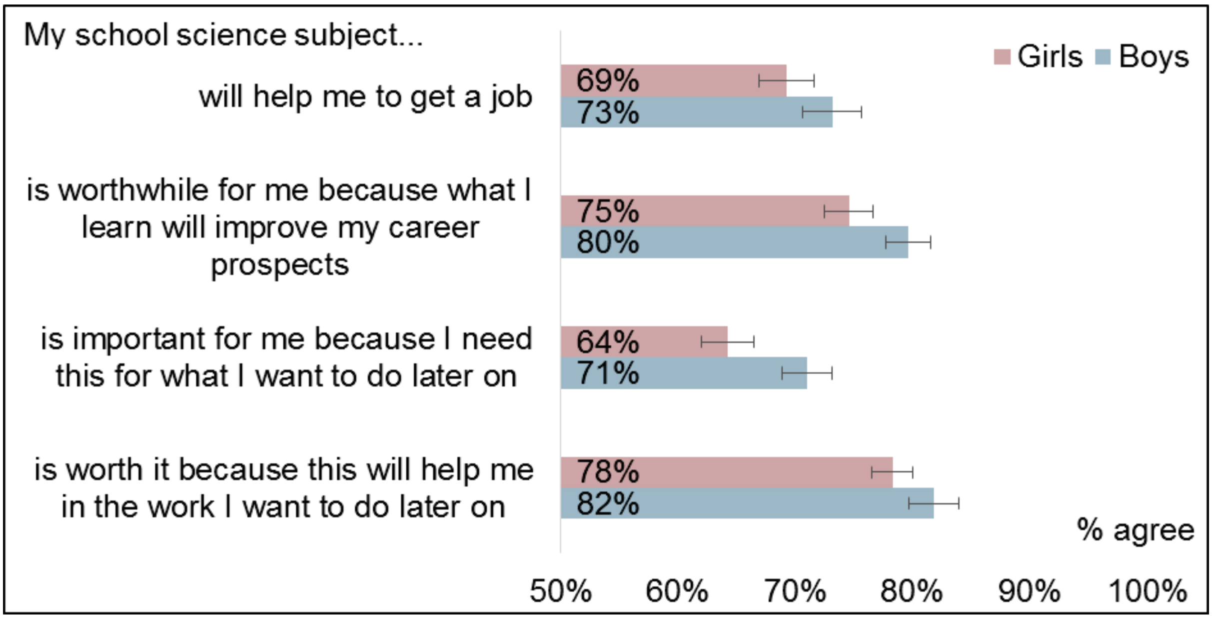
Notes: H10+ refers to the average across the 10 countries with the highest average science scores. Bold font with * indicates significant difference from England. Figures refer to the percentage of pupils in schools who either 'strongly agree' or 'agree' with each statement. The OECD average for 2006

[85] Archer et al. (2013: 1).

includes the 30 OECD members as of 2006 and the OECD average for 2015 includes all 35 OECD members as of 2015. We do not calculate the H10 average for 2006 since different countries were the top science performers in that PISA cycle. In 2006, the second statement was worded slightly differently: "What I learn in my school science subject(s) is important for me because I need this for what I want to *study* later on" [emphasis added].

6. Over the past decade, pupils in England and the OECD have become more likely to view science as relevant for their future careers. In England, pupils in 2015 are approximately 10 percentage points more likely to respond to these statements with 'agree' or 'strongly agree' than in 2006 (when they were still more likely to answer these questions with 'agree' or 'strongly agree' than their peers in the average OECD country). Overall, it therefore seems that similar patterns emerge for England regarding pupils' views on the relevance of school science subjects in 2015 as occurred in 2006.

Figure 10.1 Percentage of pupils who connect school science subjects with future careers: by gender



Source: PISA 2015 database.

Notes: Figures refer to the percentage of pupils in schools who either 'strongly agree' or 'agree' with the associated statements. Thin line through centre of each bar refers to the estimated 95 per cent confidence interval.

7. In PISA 2015, boys in England are slightly more likely to make the connection between school science subjects and future careers than girls; however, the differences are only statistically significant on two occasions:

- 71 per cent of boys 'agree' or 'strongly agree' that science is something they need for what they want to do later on, compared to 64 per cent of girls.

- 80 per cent of boys also feel that studying science is worthwhile because it will improve their career prospects, with 75 per cent of girls responding the same way - these results are presented in Figure 10.1.

8. It should be noted, however, that these results are not specific to England; gender differences in pupils' responses to these statements are also relatively small in terms of magnitude for the average across OECD countries (less than five percentage points).

Table 10.2 Percentage of pupils who connect school science subjects with future careers by science proficiency level

	Below Level 2	Levels 2-4	Levels 5-6
Making an effort in my school science subject(s) is worth it because this will help me in the work I want to do later on	77%	80%	82%
What I learn in my school science subject(s) is important for me because I need this for what I want to do later on	68%	67%	71%
Studying my school science subject(s) is worthwhile for me because what I learn will improve my career prospects	70%	**77%***	**84%***
Many things I learn in my school science subject(s) will help me to get a job	66%	**71%***	**77%***

Source: PISA 2015 database.

Notes: Figures refer to the percentage of pupils in England who either 'strongly agree' or 'agree' with the associated statements. 'Levels' refer to PISA science proficiency levels. 'Below Level 2' includes Levels 1a, 1b and those pupils below Level 1. Bold font with * indicates significant difference from below Level 2 category.

9. Pupils who achieve the highest scores on the PISA science test are more likely than their low-achieving peers to view science as important to their future. Yet, it is also notable that even those pupils in England who are low-achievers in science are still more likely to agree that the material they are taught in their science classes is likely to be relevant for their future employment prospects than not. Indeed, amongst pupils with low science skills, over two thirds respond positively to each statement. Nevertheless, top-performing pupils in England (Levels 5 and 6) are 14 percentage points more likely than their low-achieving peers (below Level 2) to think that science is worthwhile for improving career prospects (84 per cent versus 70 per cent). Similarly, they are 11 percentage points more likely to think that what they learn in their school science subjects will help them get a job (77 per cent versus 66

per cent). In additional analysis, we have found little evidence that pupils' responses to these questions differ markedly by either socio-economic status or school management type.

Key point

Most pupils in England view school science as relevant to their future, irrespective of gender, socio-economic status and PISA proficiency level. There are few notable differences between England and the average across the high-performing countries in this respect.

10.2 To what extent are 15-year-olds interested in a career in science?

10. Adolescence and the end of secondary school represent an important transitional period in an individual's life. Pupils have to make important career-related decisions about the direction in which their lives will go and decide whether to enter vocational training, pursue a university degree or enter directly into the labour market. There is evidence that pupils who set and pursue goals are better equipped to master this transition[86]. The pupils who take PISA find themselves in this crucial period, and were asked, '*What kind of job do you expect to have when you are about 30 years old?'*[87] in relation to their future occupational goals. In this sub-section we use pupils' responses to investigate the types of career young people hope to enter.

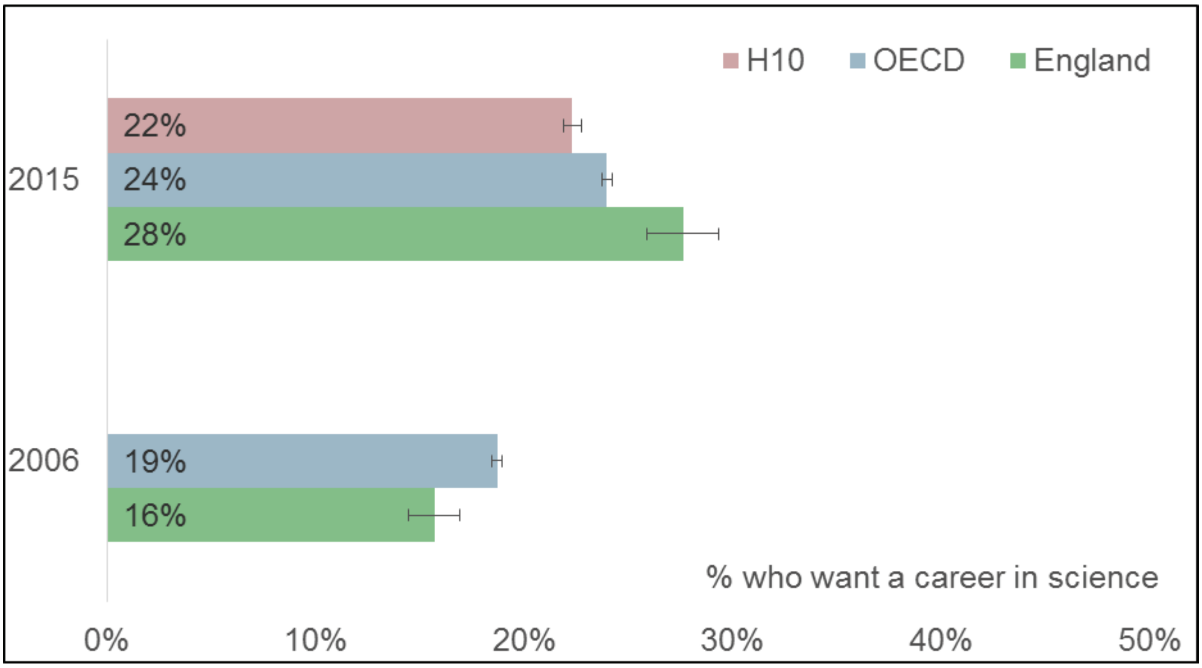
11. Interestingly, the top two most aspired to careers by 15-year-olds in England are science related. The most popular future occupation for pupils in England is 'engineer', with six per cent of pupils stating that they expect to be working in this role at age 30. The second most popular occupation is 'medical doctor', aspired to by approximately five per cent of pupils, followed by those wanting a career in 'creative and performing artists' in third place, also with approximately five per cent. 'Other health professionals' also made it into the top 10 with three per cent of pupils, while four per cent of pupils in England listed a career as a 'finance professional' as their top choice. Pupils in England exhibit some uncertainty in their future career aspirations; 17 per cent either did not answer the question, answered with 'do not know' or provided a vague response.

12. There has been a notable increase in the proportion of pupils in England who are interested in pursuing a STEM career since 2006. Just over a quarter of pupils in

[86] See Weiss et al. (2014) for an overview of the motivational, personal and contextual factors affecting the completion of secondary school and the transition to life post-secondary school.
[87] Pupils provided a free text answer, with these then converted by the survey organisers into International Standard Classification of Occupations 2008 (ISCO-08) codes.

England (28 per cent) expect to work in a STEM career at age 30[88] which is around four percentage points above the average across OECD members (24 per cent) and the average across the highest 10 performing countries (22 per cent). Interestingly, this is somewhat different to the situation in PISA 2006, when science was last the focus of PISA[89]. For instance, only 16 per cent of pupils in England aspired to a science career in 2006, which was slightly below the average across OECD countries (19 per cent)[90]. These results are presented in Figure 10.2.

Figure 10.2 The percentage of pupils who aspire to a career in science: a comparison between PISA 2006 and 2015



Source: PISA 2006 and PISA 2015 databases.

Notes: Figures refer to the percentage of pupils who aspire to a career in science at age 30. H10 refers to the average across the 10 countries with the highest average science scores. We do not compute the H10 average for 2006 since the high performers in that year were different from the high performers in 2015. The OECD average for 2006 is the ‘OECD-30’ (which includes all 30 OECD members as of 2006) and the OECD average for 2015 is the ‘OECD-35’ (which includes all 35 OECD members as of 2015). Thin line through centre of each bar refers to the estimated 95 per cent confidence interval. It should be noted that the 2015 figures presented here for England differ slightly from the OECD international results Table I.3.10. This is because the United Kingdom initially submitted ISCO-08 three digit codes to the OECD for use in their international report, while we were able to use recoded data that included four digit codes in this national report. This is why they report 30 per cent of pupils aspiring to a science career while we report 28 per cent.

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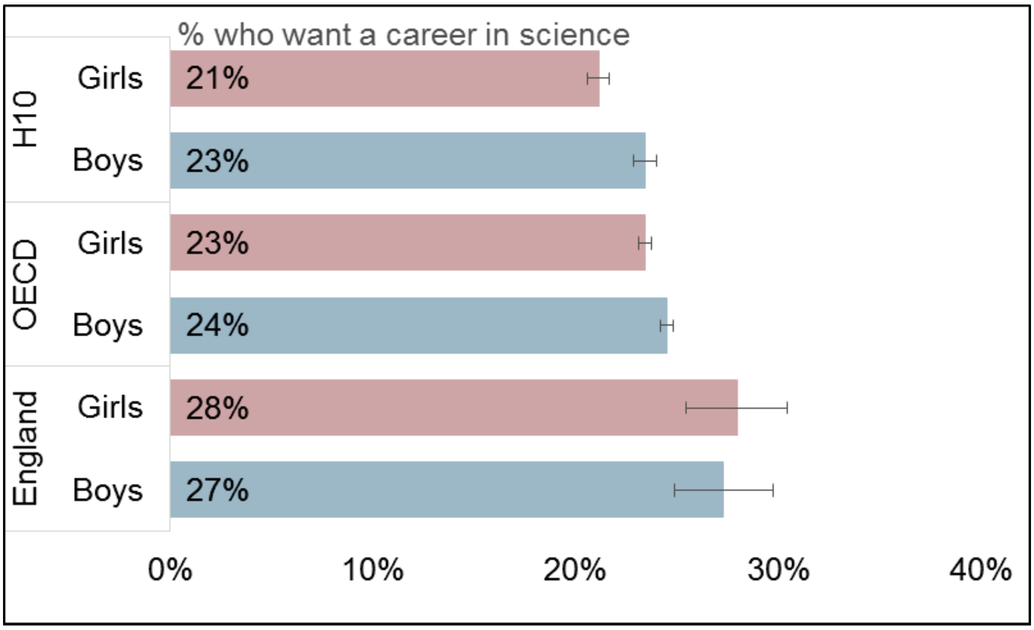
88 We follow the OECD’s definition of a career in science. See Annex A10 in the PISA International Report volume 1, chapter 3 for a list of the included occupations.

89 For the PISA 2006 survey, the older ISCO-88 classification of occupations was used, not the ISCO-08 as in 2015. The ILO has linked the ISCO-88 and the ISCO-08, so that they are comparable, and the OECD has taken this into account in the construction of the science career variable for 2006 and 2015.

90 The OECD average for 2006 is the ‘OECD-30’ (which includes the 30 OECD members as of 2006) and the OECD average for 2015 is the ‘OECD-35’ (which includes all 35 OECD members as of 2015).

13. In England, socio-economic disadvantage translates into different career aspirations and a decreased desire to pursue a career in science. This is despite pupils from disadvantaged socio-economic backgrounds being no less likely to believe that science is relevant for their future (recall sub-section 10.1). Pupils from disadvantaged backgrounds in England are 10 percentage points less likely to aspire to a STEM career than their peers from advantaged backgrounds (24 versus 34 per cent). This gap exists amongst OECD countries on average as well, where there is a 14 percentage point difference between pupils from socio-economically advantaged and disadvantaged backgrounds (18 versus 31 per cent). This might suggest that 15-year-olds in England recognise the importance of what they learn in science for their future, even if they do not plan to work in a science related job.

Figure 10.3 Gender differences in aspirations towards a science career



Source: PISA 2015 database.

Notes: Figures refer to the percentage of pupils who aspire to a career in science at age 30. Thin line through centre of each bar refers to the estimated 95 per cent confidence interval. The figures presented for England differ slightly from the OECD international results Table I.3.10. This is because the United Kingdom initially submitted ISCO-08 three digit codes to the OECD to use in the international report, while we have been able to use recoded data to four digits in this national report.

14. There is little evidence of gender differences in 15-year-olds' aspirations to work in a science career[91]. Specifically, in England, 28 per cent of 15-year-old girls aspire to be working in a STEM career by age 30, compared to 27 per cent of boys (see Figure 10.3). Although a similar finding holds for the OECD average and the average across the 10 highest performing countries, there are some important

[91] See Mau (2003) and Sadler et al. (2012) for an overview of evidence on STEM career choice and gender.

exceptions within these groups. In Taiwan, for example, boys are 10 percentage points more likely to express interest in a science related career than girls (26 versus 16 per cent) and a similar sized gender gap of eight percentage points exists in Singapore (32 per cent of boys versus 24 per cent of girls). In high performing Western countries, there tends to be no gender gap or a small gender gap in favour of girls. For example, there is a five percentage point difference in science aspirations in Canada, but this is in the favour of girls (31 per cent of boys versus 37 per cent of girls).

15. There are, however, pronounced gender differences in the specific types of scientific career 15-year-olds in England hope to enter. This is despite boys and girls having broadly equal skills across the PISA ‘physical’ and ‘living’ scientific system domains (see chapter 3 for further details). We break down the type of science career pupils aspire to into four broad groups: scientist/engineer, health professional, ICT professional and technician.

16. One-in-five (21 per cent) English girls are interested in a career as a health professional, compared to seven per cent of boys. On the other hand, English boys are more likely to aspire to become a scientist/engineer than girls (16 versus 6 per cent). The magnitude of these gender differences are similarly large for the average across OECD members; there is an 11 percentage point gender difference with respect to working in a health related profession, for instance. Table 10.3 provides further details.

Table 10.3 Gender differences in aspirations towards different STEM careers

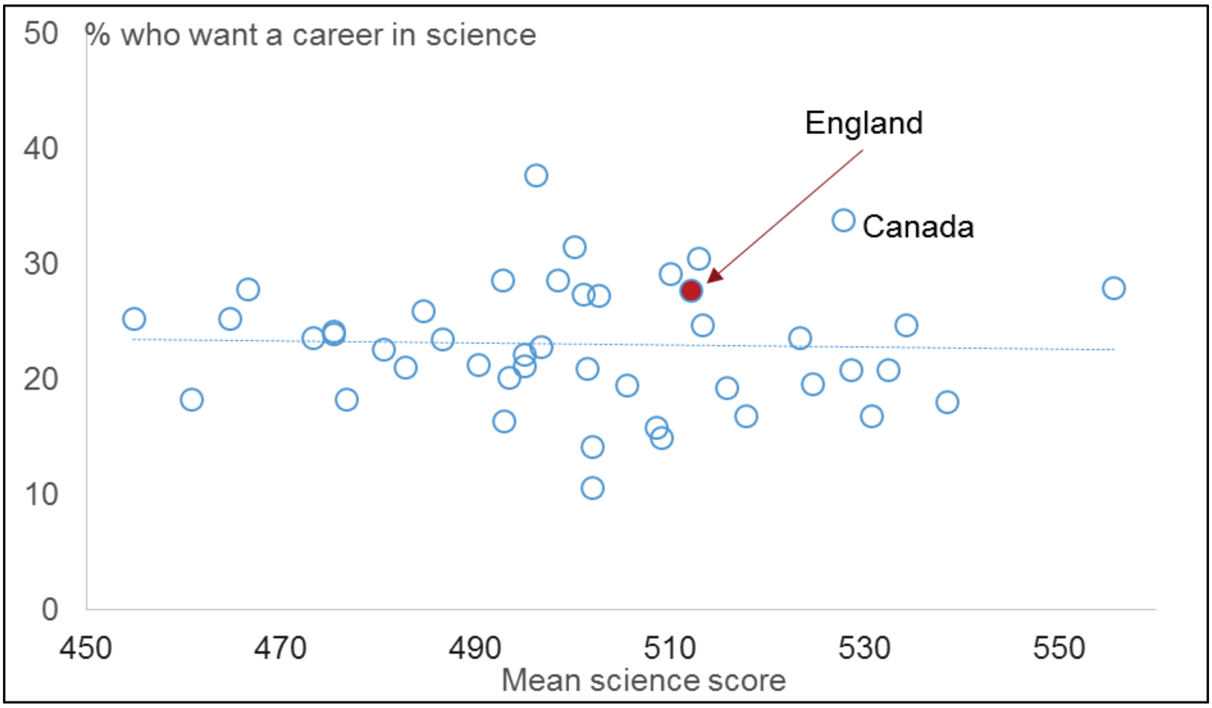
	England			OECD			H10 +		
	Total	**Boys**	**Girls**	**Total**	**Boys**	**Girls**	**Total**	**Boys**	**Girls**
Scientist/engineer	11%	16%	**6%***	9%	12%	**5%***	8%	11%	**4%***
Health professional	14%	7%	**21%***	11%	6%	**17%***	11%	7%	**16%***
ICT professional	3%	5%	**0%***	3%	5%	**0%***	3%	5%	**1%***
Technician	0%	0%	0%	1%	2%	**1%***	1%	1%	**1%***

Source: PISA 2015 database.

Notes: Figures refer to the percentage of pupils who aspire to a career in science in one of these four categories at age 30. H10+ refers to the average across the 10 countries with the highest science scores. Bold font with * indicates percentage for girls significantly different to the percentage for boys. The figures presented for England differ slightly from the OECD international results Table I.3.10. This is because the United Kingdom initially submitted ISCO-08 three digit codes to the OECD to use in the international report, while we have been able to use recoded data to four digits in this national report.

17. There is no evidence that the countries with the highest science score have the largest percentage of pupils who aspire to be scientists. In fact, of the 10 countries with the highest average science scores, only Canada has a greater proportion of 15-year-olds who aspire to a science career than England. These results are shown in Figure 10.4.

Figure 10.4 PISA science performance and STEM aspirations



Source: PISA 2015 database.

Notes: Figures refer to the percentage of pupils who aspire to a career in science at age 30. The flat dashed regression line has a slope of -0.04.

Key point

15-year-olds in England are more likely to aspire to a science career than pupils in the average high-performing country. Girls are more likely to aspire to work in a career as a health professional, while boys are more likely to want to become an engineer.

10. 3 What are the characteristics of pupils who plan to attend university?

18. In this sub-section we gain further insight into university aspirations and the university application process in England. There is evidence that although access to university in the United Kingdom has increased over time, enrolment rates for pupils from advantaged backgrounds remain much higher than for those from

disadvantaged backgrounds, especially within higher status degree programmes (e.g. Medicine)[92]. One mechanism that has been proposed to explain this is the university application process, with young people from disadvantaged backgrounds being much less likely to apply to university than their academically equal but more advantaged peers[93]. We use data from the PISA background questionnaire to look at who plans to apply to university and the factors that are associated with their plans.

19. Overall, 15-year-olds in England are just as likely as their peers in the OECD to expect to complete at least an undergraduate degree – see Table 10.4[94]. Still, there is a lot of variation between countries; less than one-in-five German 15-year-olds expects to complete university compared around three-quarters in the United States (76 per cent). Amongst high performers, there are also countries such as Canada (63 per cent), where a much larger proportion of 15-year-olds expect to obtain an undergraduate qualification than in others, such as China (38 per cent).

Table 10.4 The percentage of 15-year-olds who expect to obtain at least an undergraduate degree

	England	OECD	H10$^+$
All pupils	42%	45%	52%
Boys	37%	40%	49%
Girls	**47%***	**49%***	**56%***

Source: PISA 2015 database.

Notes: H10$^+$ refers to the average across the 10 countries with the highest average science scores. Due to lack of data for Slovakia and Vietnam and inconsistencies in the data for Finland and Taiwan, we have excluded these countries from the calculation of the H10/OECD averages. Bold font with * indicates percentage for girls significantly different from the percentage for boys.

20. Analysis of these responses by gender reveals a pronounced gender gap in university aspirations within England, OECD and top-performing countries. Girls in England are 10 percentage points more likely to say they will complete university than boys (37 per cent for boys versus 47 per cent for girls). This difference is statistically significant at the five per cent level, and is consistent with the 2013/14 Higher Education Initial Participation Rate[95], where there is a nine percentage point

[92] Boliver (2011).
[93] Anders (2012).
[94] This corresponds to International Standard Classification of Education (ISCED) level 5A or 6, which is a framework created by the United National Educational, Scientific and Cultural Organisation (UNESCO) to standardise education levels across countries. Level 5A or 6 is at least a bachelor's degree, but also includes master's degrees, doctorates and other graduate degrees.
[95] This is the sum of age specific initial participation rates in the age range of 18-30. Since most people first start university in the UK at age 18, this is the age group that dominates the statistic (Department for Business, Innovation and Skills, 2015).

difference in university enrolment between boys (42 per cent) and girls (51 per cent). The gender gap in university expectations is also of a similar magnitude for the average across OECD members (nine percentage points) and the average across high-performing countries (seven percentage points).

21. Similarly, we also find that pupils from advantaged backgrounds are much more likely to aspire to complete university than their disadvantaged peers. Specifically, two-thirds (65 per cent) of pupils in England from the most advantaged backgrounds expect to complete university, compared to one-quarter (25 percent) of their peers from the least advantaged backgrounds. This difference is similar in size to the equivalent difference in the top-performing countries (33 per cent of disadvantaged pupils versus 78 per cent of advantaged pupils) and the average across OECD members (27 per cent of disadvantaged pupils versus 66 per cent of advantaged pupils). Pupils at independent schools are around 30 percentage points more likely to expect to complete university (67 per cent) than pupils in certain other school management types (e.g. 38 per cent at academies), with these differences statistically significant at the five per cent level[96].

22. Pupils in England also answered a series of questions on the university application process (see Table 10.5)[97] but only pupils who stated that they were likely to apply to university were given the opportunity to respond to these questions. A total of 66 per cent of the full sample indicated that they were ‘fairly likely’ or ‘very likely’ to apply to university. The remaining 34 per cent of the sample was divided between pupils who said they were ‘not very likely’ or ‘not likely at all’ to apply to university (18 per cent) and pupils who skipped this question entirely (16 per cent). This should be kept in mind when interpreting the following results.

23. Young people in England seem to take a pragmatic approach when thinking about which university to apply to, focusing upon the practicalities of the course and the application process, as well as eventual employment outcomes. Course / course content (99 per cent), employment prospects after graduation (97 per cent) and realistic entry requirements (94 per cent) are the three most important factors in 15-year-olds’ higher education plans and this holds true for both boys and girls. Factors related to social life, however, are somewhat less important to the plans of 15-year-olds, as are university costs. For instance, around a fifth of pupils in England do not view cost to be an important factor in their higher education plans. Finally, the least important issue is distance from home, with just over half of 15-year-olds in England

[96] In additional analysis, we continue to find a statistically significant difference of around 10-15 percentage points between pupils at independent schools and pupils at other school management types, after controlling for differences in pupils’ socio-economic status and PISA scores.
[97] These questions were only posed to pupils in England, Wales and Northern Ireland, and not in other countries.

considering this will be an important factor when considering which university they will apply to.

Table 10.5 Percentage of pupils who feel certain factors matter for university application decisions

	Percentage who feel it is fairly or very important				
	Total	**Boys**	**Girls**	**Bottom 25% SES**	**Top 25% SES**
Course / course content	99%	98%	99%	98%	99%
Employment prospects afterward	97%	96%	**98%***	97%	98%
Realistic entry requirements	94%	93%	**94%***	95%	**92%***
Challenging entry requirements	87%	87%	87%	86%	87%
Local employment prospects whilst a student	83%	79%	**86%***	88%	**77%***
Costs (as affected by fees, scholarships and bursaries)	82%	79%	**84%***	89%	**74%***
Academic ranking / 'league table' ranking	82%	79%	**85%***	81%	**85%***
Social life	80%	81%	79%	80%	**84%***
Fitting in	77%	75%	**78%***	78%	**79%***
Distance from home	57%	55%	59%	69%	**46%***

Source: PISA 2015 database.

Notes: Figures refer to the percentage of pupils who responded to these questions, not the entire sample. Bold font with * indicates difference between categories statistically significant.

24. Although there is little variation in how boys and girls respond to these questions, there are differences based upon socio-economic background. Pupils from advantaged backgrounds are less likely to consider the cost of university (there is a 15 percentage point difference between the top and bottom socio-economic groups) and the prospect of local employment whilst at university (the difference is 12 percentage points). Pupils from advantaged backgrounds are also nearly 25 percentage points less likely to state that ‘distance from home’ is an important factor in their university plans than their peers from the least advantaged socio-economic group. These results therefore suggest that cost and financial concerns typically play less of a role in the higher education plans of more advantaged pupils. Yet it is

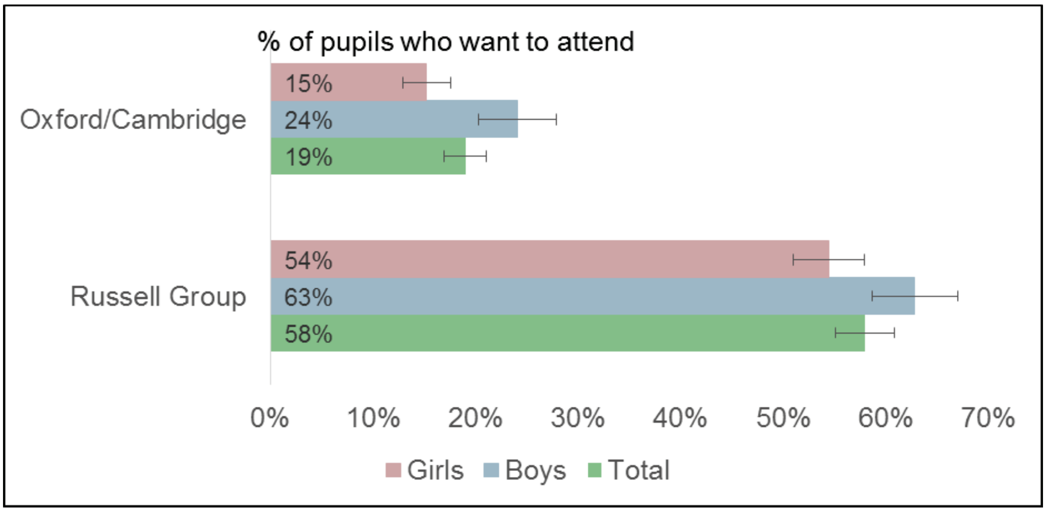
important to note that around 80 per cent of socio-economically advantaged pupils still feel that cost is an important or very important factor.

25. Around 93 per cent of pupils in England who are planning to apply to university list an English university as their first choice. Oxford and Cambridge are the two most popular, with 19 per cent of 15-year-olds who responded listing one of these two institutions as their number one choice. The remainder is evenly split between a university elsewhere in the UK and a higher education institution abroad.

26. Based on pupils' responses to a question asking them to list three universities to which they might apply, there is no evidence of gender differences in pupils' responses (see Figure 10.5) illustrates these results. Answers to this question were entered as free text, so pupils had to draw on their own knowledge of universities to respond. Again, pupils only provided answers to these questions if they stated they were planning on applying to university.

27. It is clear from their responses that many more 15-year-olds aspire to the top universities than the proportion who will go on to attend, with 58 per cent of pupils who plan to apply to university aspiring to attend a Russell Group institution[98]. As a point of comparison, in 2014/15, 23 per cent of undergraduate pupils in the UK were at a Russell Group university, with just one per cent studying at Oxford or Cambridge[99].

Figure 10.5 Percentage of pupils planning to apply to an 'elite' university



Source: PISA 2015 national database.
Notes: Thin line through centre of each bar refers to the estimated 95 per cent confidence interval.

[98] The Russell Group is a network of 24 universities in the United Kingdom committed to 'maintaining the very best research, an outstanding teaching and learning experience and unrivalled links with business and the private sector' (Russell Group 2016).
[99] Based on authors' calculation using Higher Education Statistics Agency (HESA) data on undergraduate university enrolments from 2014/15 (HESA 2016).

28. Despite girls being more likely to expect to complete university than boys (recall Table 10.4), it is boys who are the more likely to aspire to attend a high-status institution (amongst the subset who report that they are likely to apply). For instance, around a quarter of boys (24 per cent) who answered this question list Oxford or Cambridge as their first choice, compared to 15 per cent of girls. A similar finding holds with regards Russell Group institutions; 63 per cent of boys list a Russell Group university as their first choice versus 54 per cent of girls and these differences are statistically significant at the five per cent level. Thus, even though girls are more likely to say they plan to complete university, they are less likely to have 'elite' aspirations.

29. Our analysis finds surprisingly little variation in elite university aspirations by socio-economic background. A total of 22 per cent of pupils from high socio-economic backgrounds who plan to apply to university named Oxford or Cambridge as their first choice. This is only a slightly greater proportion than pupils from the bottom socio-economic group (18 per cent). Although there is more evidence of a difference by socio-economic status when considering plans to apply to a Russell Group university (53 per cent for the most disadvantaged pupils versus 66 per cent for the most advantaged pupils), the magnitude of this difference is nevertheless perhaps lower than one might anticipate. For instance, previous research has found a more than 30 percentage point difference in attendance at high status universities in the UK between young people from socio-economically advantaged and disadvantaged backgrounds[100].

30. Pupils who aspire to higher status universities also tend to achieve higher test scores. In science, 15-year-olds who aspire to study at Oxford or Cambridge achieve an average science score of 571. This is significantly higher than pupils who aspire to attend another Russell Group institution (553), those who aspire to a non-Russell Group university (526) and those who say they are unlikely to apply to university (466).

Key point

The proportion of pupils in England who expect to obtain a bachelor's degree is the same as the average across OECD members. Although girls in England are more likely to expect to complete university than boys, they are less likely to aspire to a high-status institution.

[100] Chowdry et al. (2013).

Chapter 11. PISA across the UK

- The average science score in the UK is highest in England (512) and lowest in Wales (485). Scotland (497) and Northern Ireland (500) fall in-between.
- The comparatively high science scores of pupils in England is the same across all elements of science, rather than in one specific aspect of science literacy.
- There are no significant differences between England, Scotland or Northern Ireland in the mathematics or reading tests. However, in Wales, 15-year-olds score significantly lower than the rest of the UK in all three subjects. In their lowest performing subject, reading, Wales sit on a par with Lithuania and Hungary.
- There has been a sustained decline in average science scores in Wales, from 505 points in 2006 to 485 points in 2015. The same is true for average mathematics scores in Scotland, which have declined from 506 in 2006 to 491 in 2015.
- Almost a third of pupils in the UK is a low-achiever in at least one subject (science, mathematics or reading). Wales has the greatest proportion of low-achieving pupils across the UK.
- Gender differences are similar across the UK with both genders scoring equally in science, boys scoring better in mathematics, and girls doing better in reading across all four countries.
- However, there is a weaker association between socio-economic status and PISA science scores in Wales than the rest of the UK. This is driven by the most advantaged pupils in Wales not achieving as highly as their peers in England, Scotland or Northern Ireland.
- Headteachers in England are more likely to report teacher shortages being a significant problem compared to the rest of the UK.
- Across the UK, 15-year-olds spend more time studying science than English and mathematics. Pupils in Scotland, Wales and Northern Ireland report spending over an hour more time studying outside of school per week (on average) than their peers in England.

1. The United Kingdom is a prime example of how school systems and education policies can vary markedly within a country. For instance, although comprehensive, mixed ability schools are common in England, Wales and Scotland, this is not the case in Northern Ireland, where almost half of 15-year-olds are taught in grammar schools. On the other hand, England takes a somewhat different approach to accountability than the rest of the UK, for example in publishing annual school performance tables. Other more recent policy developments, such as the academies programme, are specific to England and have not been introduced elsewhere. Additionally, differing reforms to the national curricula and assessments are underway in each country. These are just a handful of examples of how education policy and provision varies significantly across England, Northern Ireland, Scotland and Wales.

2. At the same time, many of the issues that complicate international comparisons are (arguably) less of a concern when looking across the four constituent countries of the UK. For instance, there are important similarities in terms of culture, language, economic development and political systems, as well as a shared history. Although some of these factors (e.g. culture) may help to explain differences in achievement between the UK and other parts of the world (e.g. Asia), it is arguably less likely that they will explain differences between England, Northern Ireland, Scotland and Wales.

3. As noted by Taylor, Rees and Davies (2013), within-UK comparisons are therefore interesting from both an academic and education policy perspective. Yet, due to a lack of accessible and comparable national examination data, relatively few 'home international' comparisons have been conducted[101]. PISA is an important exception and by drawing separate samples for England, Northern Ireland, Scotland and Wales, PISA provides a three-yearly update of how academic achievement, pupils' attitudes and headteachers' concerns vary across different parts of the UK.

4. In this concluding chapter, we therefore focus upon differences in PISA scores and background questionnaire responses across these four countries. The following research questions will be addressed:

- *How do average scores compare across the UK?*
- *How many 15-year-olds in the UK are a low-achiever in science, mathematics and reading?*
- *How have average scores changed across the UK since 2006?*

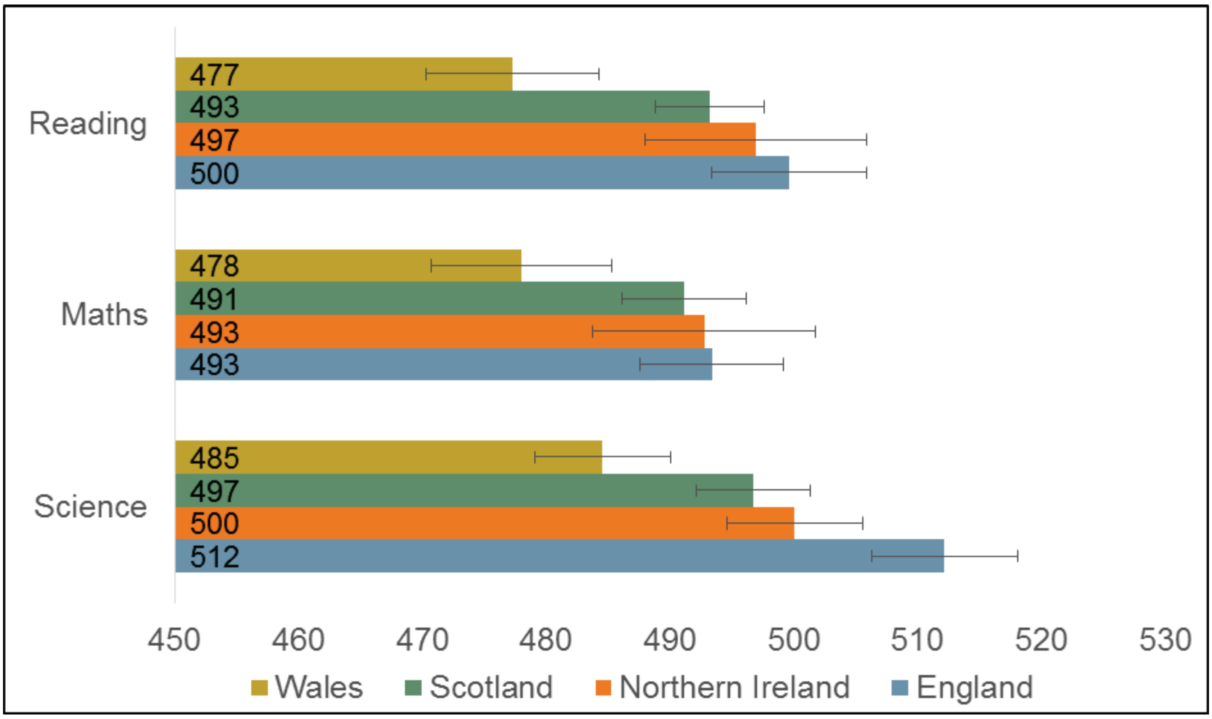
[101] Though see Taylor, Rees and Davies (2013).

- *How has the performance of the highest and lowest achieving pupils changed across the UK since 2006?*
- *Are gender gaps in achievement bigger in some parts of the UK than others?*
- *How does the relationship between socio-economic status and achievement vary across the UK?*
- *Do headteachers' views on the factors hindering instruction within their school differ across the UK?*
- *Are there differences in the amount of instruction 15-year-olds receive – both inside and outside of school?*

11.1 How do average scores compare across the UK?

5. Average science scores are highest in England (512) and lowest in Wales (485) – see Figure 11.1. These two countries are significantly different to both Northern Ireland (500) and Scotland (497) at the five per cent level.

Figure 11.1 Average scores across the UK



Source: PISA 2015 database.

Note: Thin line through the centre of each bar refers to the estimated 95 per cent confidence interval.

6. There is less variation in average mathematics scores across the UK. England (mean = 493), Northern Ireland (493) and Scotland (491) are separated by just two test points, and are statistically indistinguishable at the five per cent significance level. Yet, in contrast, the average mathematics score in Wales is 478

which is significantly lower than the mean score for the other three countries within the UK, with a difference of around 15 test points (equivalent to around half a year of additional schooling). Wales is therefore somewhat of an outlier compared to the rest of the UK in terms of pupils' mathematics skills.

7. There is little evidence of variation in average reading scores across England (mean = 500), Northern Ireland (497) and Scotland (493), with all cross-country differences statistically insignificant at conventional thresholds. However, the mean score is again significantly lower in Wales (477).

Table 11.1 Average scores across the science sub-domains within the UK

Domain	England	Northern Ireland	Scotland	Wales
Scientific systems				
Physical	512	501	499	486
Living	512	498	497	482
Earth and Space	513	498	494	485
Scientific competencies				
Explain phenomena scientifically	512	500	498	486
Evaluate and design scientific enquiry	510	497	498	481
Interpret data and evidence scientifically	512	501	493	483
Knowledge				
Content knowledge	511	499	496	486
Procedural and epistemic knowledge	513	501	496	484
Points difference from England				
0 to 5 points				
5 to 10				
10 to 15				
15 to 20				
20 to 25				
25 or more				

Source: PISA 2015 database.

8. The pattern of achievement across the various science sub-domains is reasonably similar across England, Northern Ireland, Scotland and Wales; the similarities across the UK in Table 11.1 are more striking than the differences. For instance, in all four countries, scores in the living scientific system are similar to those in the physical and earth and space science systems. Likewise, pupils from England, Northern Ireland and Wales are no stronger (or weaker) at ‘interpreting data and evidence scientifically’ than at ‘explaining phenomena scientifically’ and ‘evaluating and designing scientific enquiry’. Finally, in all four countries, average scores for ‘content knowledge’ are similar to the scores for ‘procedural and epistemic’ knowledge, with a difference of less than five points.

Key point

The average science score is significantly higher in England than Scotland, Northern Ireland and Wales. In all three core PISA subjects, Wales has lower average scores than the rest of the UK.

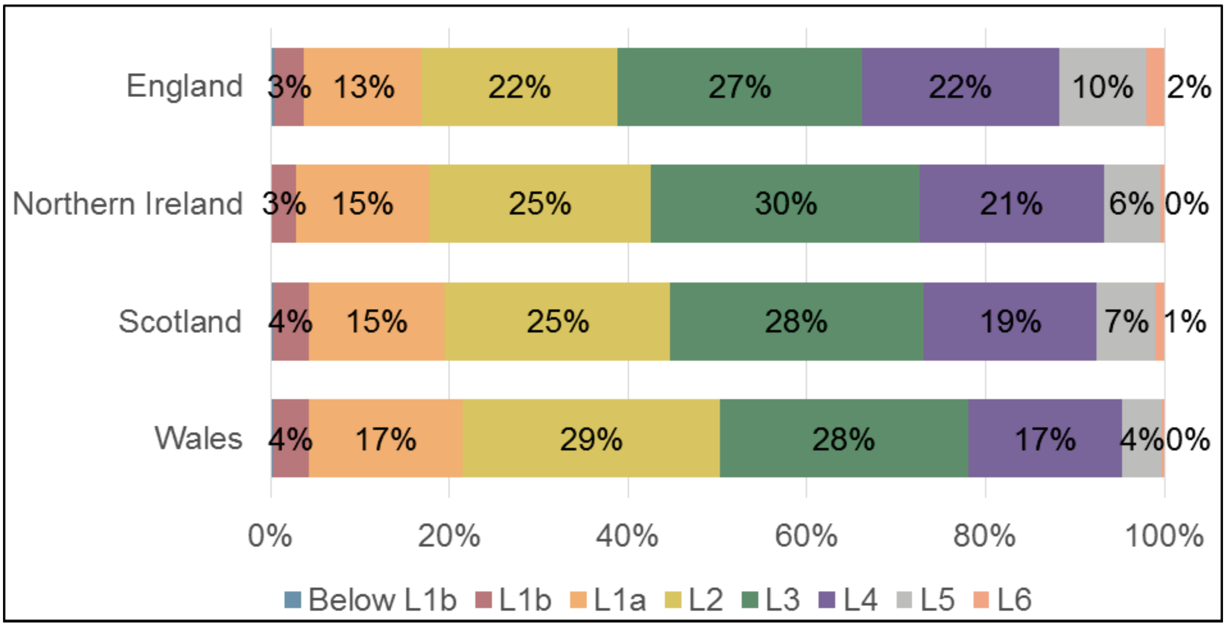
11.2 How many 15-year-olds across the UK are low-achievers in science, mathematics and reading?

9. Around one-in-five young people from across the United Kingdom are low-achievers in science. Wales has the greatest proportion of 15-year-olds operating below Level 2 in science (22 per cent), followed by Scotland (20 per cent), Northern Ireland (18 per cent) and England (17 per cent). These results are presented in Figure 11.2.

10. England has the greatest proportion of top-performing 15-year-olds in science, with 12 per cent of pupils working at Levels 5 or 6. This compares to eight per cent in Scotland, seven per cent in Northern Ireland and five per cent in Wales.

11. Across the United Kingdom as a whole, almost a quarter of 15-year-olds are low-achievers in mathematics. England (22 per cent) and Wales (23 per cent) have the greatest proportion of low-achievers in this subject while Northern Ireland has the least (19 per cent). See Figure 11.3 for further details.

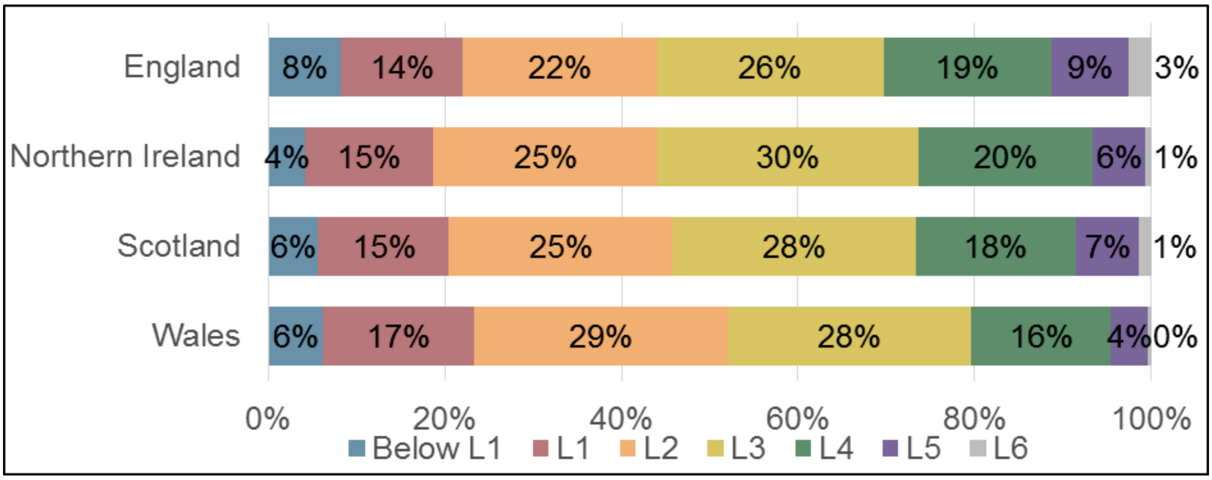
Figure 11.2 The per cent of UK pupils reaching each science level



Source: PISA 2015 database.

12. At the other extreme, around one-in-nine pupils across the UK is a 'top-performer' in mathematics. Wales has the least 15-year-olds reaching the highest mathematics proficiency levels within the UK, with just five per cent of pupils obtaining a mathematics score at Level 5 or 6. This compares to 11 per cent of pupils in England, eight per cent in Scotland and seven per cent in Northern Ireland.

Figure 11.3 The per cent of UK pupils reaching each mathematics level

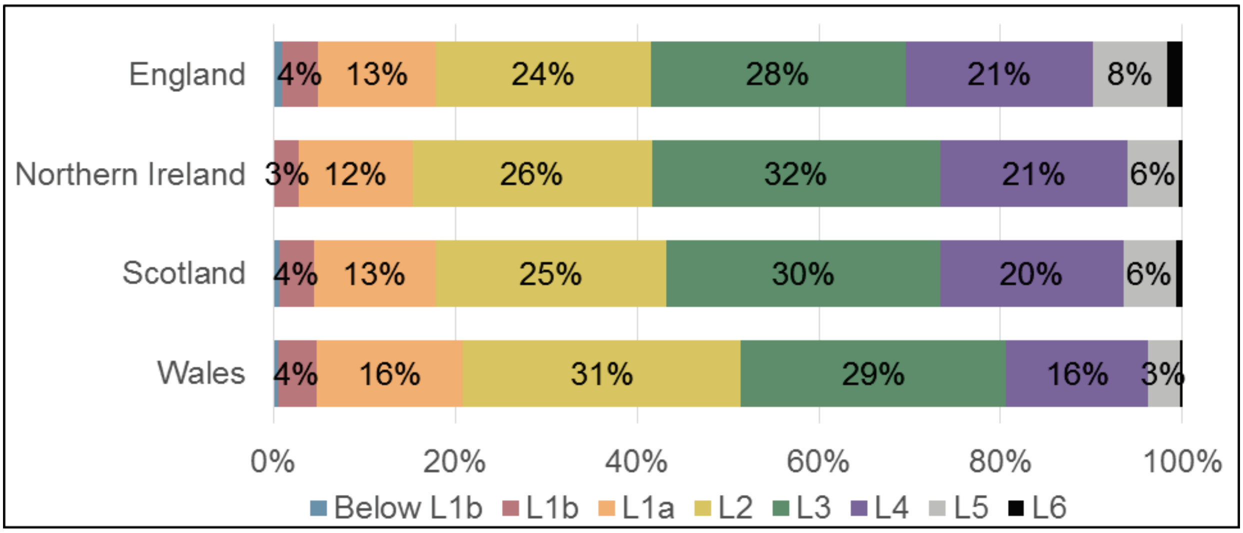


Source: PISA 2015 database.

13. Whereas the most commonly achieved reading level in England, Northern Ireland and Scotland is Level 3, in Wales it is Level 2. Northern Ireland has slightly fewer low performers than England and Scotland (15 per cent versus 18 per cent in England and Scotland), while England has a slightly greater proportion of the highest achievers (10 per cent versus six per cent in Scotland and Northern Ireland). Wales,

on the other hand, has more 15-year-olds with low-level reading skills (21 per cent achieve below PISA Level 2) and fewer top-performers (four per cent reaching PISA Level 5 or 6) than the rest of the UK. These results are presented in Figure 11.4.

Figure 11.4 The per cent of UK pupils reaching each reading level



Source: PISA 2015 database.

14. Over a quarter (29 per cent) of 15-year-olds in England are low-achievers in at least one of the three core PISA domains (see Table 11.2). Meanwhile, 10 per cent are classified as a low-achiever in all three subjects (reading, mathematics and science). Although similar results occur in Scotland, fewer pupils are low-achievers in at least one subject in Northern Ireland than in England (25 per cent versus 29 per cent). Yet it is Wales that faces the greatest challenge in this respect, with around a third (32 per cent) of pupils not reaching PISA Level 2 in at least one subject, while one-in-eight (13 per cent) 15-year-olds in Wales is a low-achiever in all three.

Table 11.2 The percentage of 15-year-olds who are low-achievers in multiple PISA domains. A comparison across the UK.

Subject(s)	England	Northern Ireland	Scotland	Wales
None	71.0%	75.1%	71.3%	68.4%
Science	1.5%	2.1%	2.3%	2.2%
Mathematics	6.0%	3.8%	4.7%	4.9%
Reading	3.5%	2.1%	3.1%	3.4%
Science and mathematics	3.7%	3.7%	3.7%	3.6%
Science and reading	1.9%	2.0%	2.8%	2.7%
Mathematics and reading	2.5%	1.2%	1.4%	1.7%
Science, reading and mathematics	9.8%	9.9%	10.7%	13.0%
Total	**100%**	**100%**	**100%**	**100%**

Source: PISA 2015 database.

Notes: Figures refer to the percentage of 15-year-olds who achieve a test score below the PISA Level 2 threshold in the given subject area.

15. In England, 18 per cent of pupils are high-achievers in at least one subject, with five per cent a high-achiever in each of reading, mathematics and science (see Table 11.3), which is significantly more than other parts of the UK. For instance, in Northern Ireland (11 per cent) and Wales (eight per cent) a significantly smaller proportion of 15-year-olds are classified as a high-achiever in at least one of the three PISA domains. Similarly, fewer 15-year-olds achieve high PISA scores across all three subjects in Northern Ireland (2.5 percent) and Wales (1.6 per cent) than in England (4.8 per cent).

Table 11.3 The percentage of 15-year-olds who are classified as a high-achiever in multiple PISA domains. A comparison across the UK.

Subject(s)	England	Northern Ireland	Scotland	Wales
None	81.9%	88.9%	86.9%	92.2%
Science	2.3%	1.5%	1.6%	1.3%
Mathematics	3.2%	2.1%	3.2%	1.6%
Reading	2.4%	1.7%	1.8%	1.3%
Science and mathematics	2.6%	1.5%	1.9%	1.2%
Science and reading	2.0%	1.3%	1.1%	0.7%
Mathematics and reading	0.7%	0.5%	0.6%	0.2%
Science, reading and mathematics	4.8%	2.5%	2.9%	1.6%
Total	**100%**	**100%**	**100%**	**100%**

Source: PISA 2015 database.

Notes: Figures refer to the percentage of 15-year-olds who achieve a test score at Level 5 or Level 6 in the given subject area.

Key point

In England, five per cent of 15-year-olds are high-performers within each of the three PISA subjects, compared to three per cent in Scotland, and lower in Northern Ireland and Wales. Around 29 per cent of pupils in the UK lack basic skills in at least one PISA subject area (science, mathematics and reading) and around 10 per cent of pupils in the UK lack basic skills in all three domains.

11.3 How have average scores changed across the UK since 2006?

16. There is evidence of a sustained decline in average scores during the 2006 to 2015 period for Wales in science (see Figure 11.5). In this country, the average science score has gradually fallen from 505 points in 2006 to 485 points in 2015. This represents a statistically significant fall of 20 test points (roughly equivalent to eight months of schooling).

17. There is also evidence of a fall in mathematics scores in Scotland since 2006, with the average falling from 506 (2006) to 499 (2009), 498 (2012) and 491 (2015).

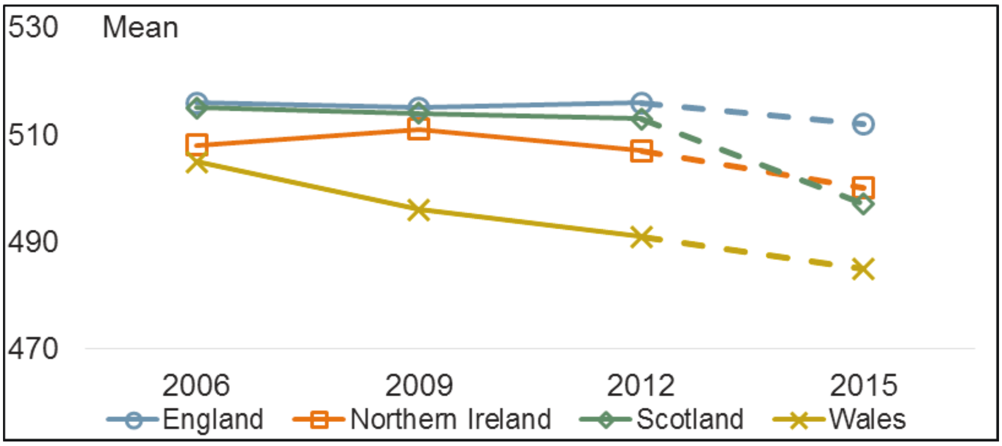
The three-year average trend in Scotland is therefore downwards, and statistically significant at the five per cent level.

18. There has also been a sharp drop in average science scores in Scotland compared to previous PISA rounds. Specifically, while the mean score for Scotland remained largely unchanged between 2006 (515), 2009 (514) and 2012 (513), it dropped by around 18 test points in 2015. Although this is a sizeable and statistically significant difference compared to the last time science was the focus of PISA in 2006, some caution is needed when interpreting this result as (as noted in Chapter 1), a number of changes have been made to the administration of PISA in 2015, particularly within the science domain (e.g. the introduction of computer-based testing, alterations made to the framework and the use of interactive test questions). Furthermore, other countries have previously experienced a ‘blip’ in average scores in one particular wave of PISA, before quickly recovering in the following round (e.g. mean reading and mathematics scores in Ireland dropped sharply between 2006 and 2009 before returning to their previous level in 2012[102]). Evidence from the next round of PISA, due to be conducted in 2018, is therefore needed to provide appropriate context for this result.

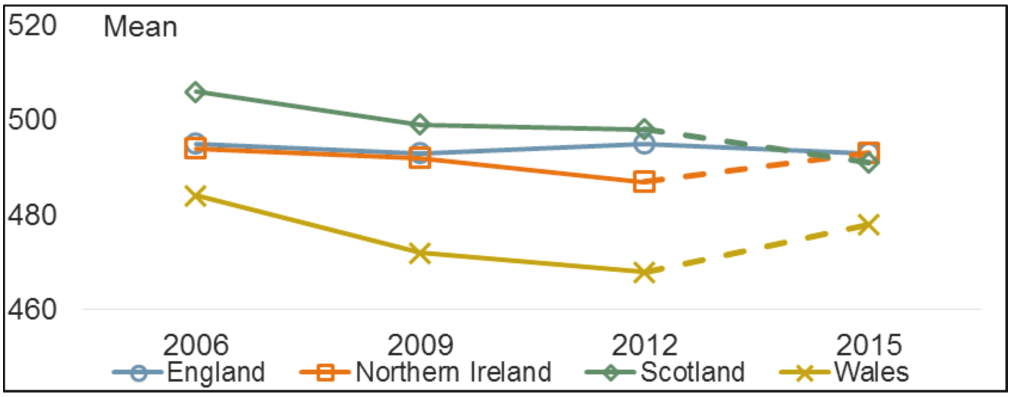
[102] See Cosgrove and Cartwright (2014) for a detailed discussion of the experience of Ireland in 2009.

Figure 11.5 Average scores across the UK from 2006 to 2015

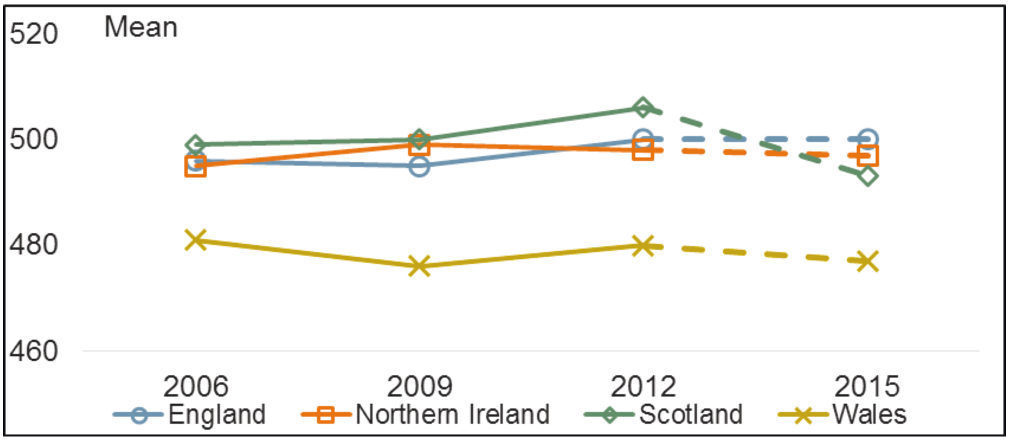
(a) Science



(b) Mathematics



(c) Reading



Source: PISA 2006 to 2015 databases.

See Appendix F for further information on trends in performance over time.

Key point

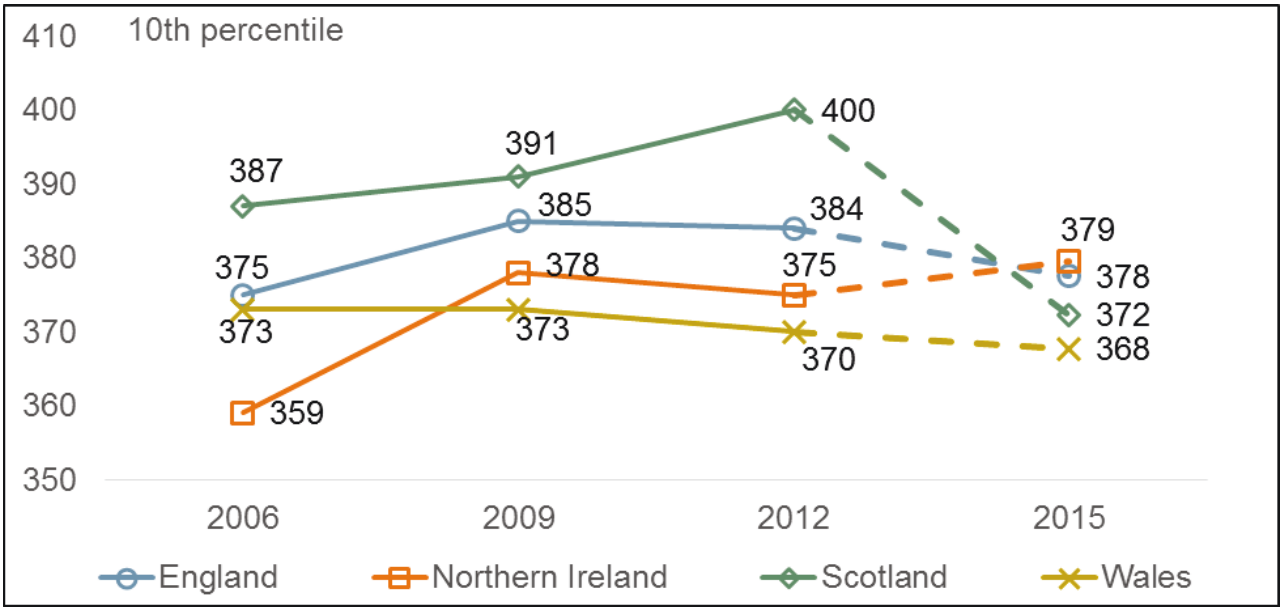
There has been a sustained decline in average science scores in Wales and average mathematics scores in Scotland during the last decade.

11.4 How has the performance of the highest and lowest achieving pupils changed since 2006?

19. The previous sub-section illustrated the change in *average* PISA scores across the UK over the last decade. Now we turn our attention to changes in the *distribution* of achievement over time, paying particular attention to the performance of the highest and lowest achieving pupils. For brevity, our discussion focuses upon science, with analogous results for reading and mathematics provided in the online data tables.

20. There are few clear consistent trends emerging for any part of the UK in terms of the performance of the bottom 10 per cent of pupils in PISA science. Northern Ireland saw a 19 point (eight months of schooling) increase in the scores of lowest achieving pupils between 2006 and 2009, although this has remained at the same level ever since. Scotland, on the other hand, saw the performance of its bottom 10 per cent improve from 387 in 2006 to 400 in 2012, before a marked decline to 372 in 2015 (a difference compared to 2012 of almost a year of schooling). Similarly, the performance of the lowest science achievers in England and Wales has remained stable throughout this period. Overall, there seems to have been some sharp one-off movements in the 10th percentile in certain parts of the UK, although little consistent evidence of a sustained upwards or downwards trend, as detailed in Figure 11.6.

Figure 11.6 The 10th percentile of the science proficiency distribution between 2006 and 2015



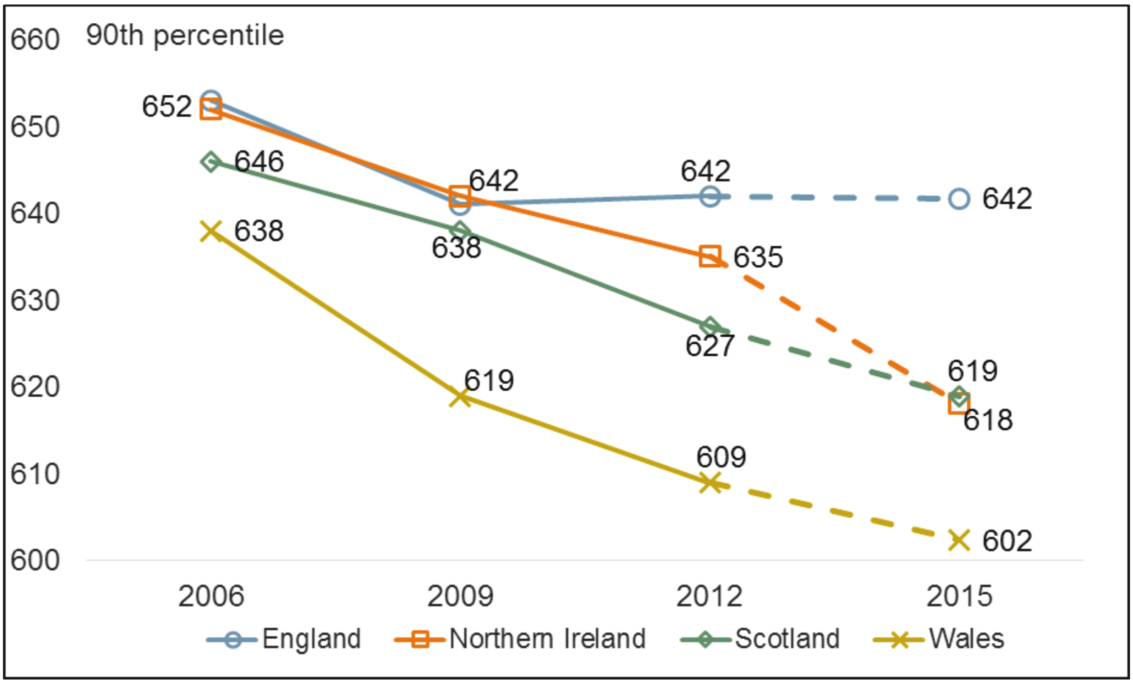
Sources: Bradshaw et al. (2007), Bradshaw et al. (2010), Wheater et al. (2014), PISA 2015 database.
See Appendix F for further information on trends in performance over time.

21. In Scotland, Northern Ireland and Wales, there has been a sustained decline in the science performance of the top 10 per cent of pupils over the last decade. Specifically, the top 10 per cent who took the PISA science test in 2015 are around a year of schooling behind the top 10 per cent of pupils who took the test in 2006. For instance, in 2006 the 90th percentile of the science distribution in Northern Ireland stood at 652 points. This has gradually fallen to 642 points in 2009, 635 points in 2012 and 618 points in 2015. A similar monotonic decline in the 90th percentile has been observed in Scotland (from 646 points in 2006 to 619 points in 2015) and Wales (638 points in 2006 to 602 points in 2015). The same is not true in England, where there is little evidence of sustained change in the science performance of the top 10 per cent of pupils over the last decade, as detailed in Figure 11.7.

22. There has been a marked reduction in inequality of science achievement within certain parts of the UK over the last decade. The gap between the highest and lowest achieving pupils has fallen from 281 points in Northern Ireland in 2006 to 239 points in 2015, and from 267 points to 235 points in Wales. However, this reduction in inequality has been driven less by increasing the skills of low-achievers, and more by a decline in achievement amongst the top-performing pupils. These results can be infered through the patterns observed in Figures 11.6 and 11.7.

23. Figures 11.6 and 11.7 also illustrate how the sizeable change in mean science scores in Scotland between 2012 and 2015 is mainly due to a decline in performance amongst lower achieving pupils. For instance, whereas the performance of the top 10 per cent declined by eight points between 2012 and 2015, the performance of the bottom 10 per cent dropped by around 28 test points. It therefore seems that certain parts of the science achievement distribution in Scotland have changed more in this short period of time than others.

Figure 11.7 The 90th percentile of the science achievement distribution between 2006 and 2015



Sources: Bradshaw et al. (2007), Bradshaw et al. (2010), Wheater et al. (2014), PISA 2015 database. See Appendix F for further information on trends in performance over time.

Key point

The science skills of the highest achieving pupils has steadily declined over the last decade in Northern Ireland, Scotland and Wales.

11.5 Are gender gaps in achievement bigger in some parts of the UK than others?

24. In both mathematics and science, the similarity of the size and direction of the gender gap across the UK is more striking than any difference. There is no statistical significant difference in average science scores between boys and girls in any country within the UK. For both genders, England has the highest average score and Wales the lowest, while Northern Ireland and Scotland fall in-between. In mathematics, boys achieve a higher average score than girls across all parts of the UK, although the gender difference only reaches statistical significance in England and Wales. Nevertheless, the magnitude of the mathematics gender gap is similar across all four countries, standing at 12 test points in England, 10 points in Wales and seven points in Scotland and Northern Ireland. Further details are provided in Table 11.4 panels (a) and (b).

Table 11.4 Gender differences in scores across the UK

(a) Science

	Boys	Girls	Difference
England	512	512	0
Northern Ireland	501	499	3
Scotland	497	496	1
Wales	487	482	5

(b) Mathematics

	Boys	Girls	Difference
England	500	487	**12***
Northern Ireland	496	489	7
Scotland	495	488	7
Wales	483	473	**10***

(c) Reading

	Boys	Girls	Difference
England	488	511	**-23***
Northern Ireland	490	504	**-14***
Scotland	483	504	**-21***
Wales	472	483	**-11***

Source: PISA 2015 database.

Notes: Bold font with * indicates difference significantly different from zero. The ‘difference’ column may not equal the difference between the ‘boys’ and ‘girls’ columns due to rounding.

25. The gender gap in pupils’ reading skills is smaller in Wales (11-point difference in favour of girls) than in England (23-point difference) and Scotland (21-point difference). This can partly be attributed to the particularly low reading skills of Welsh girls, who achieve a reading score around the same level as English, Scottish and Northern Irish boys. Nevertheless, girls achieve significantly higher average reading scores than boys across each of the four constituent countries (see Table 11.4 panel (c) for further details).

Key point

Girls achieve higher average reading scores than boys across all four countries in the UK, although with a bigger difference in England and Scotland than in Wales. In England and Wales, the average mathematics score is significantly higher for boys than girls.

11.6 How does the relationship between socio-economic status and achievement vary across the UK?

26. Socio-economic inequality in 15-year-olds' science achievement is greater in England, Scotland and Northern Ireland than in Wales. In England, Scotland and Northern Ireland a one-unit change in the ESCS index is associated with around a 35 to 40-point increase in science scores, with approximately 11 per cent of the variance in pupils' achievement explained (see Chapter 6 for further details on how these measures are defined).

27. On the other hand, a one-unit increase in ESCS is associated with a 25 test point increase in science scores in Wales, while only around six per cent of the variation in pupils' science scores is explained (around half the amount in England, Northern Ireland and Scotland). These results, referring specifically to science, are presented in Table 11.5. Similar results - although slightly less pronounced - hold for both mathematics and reading (see online data tables for further details).

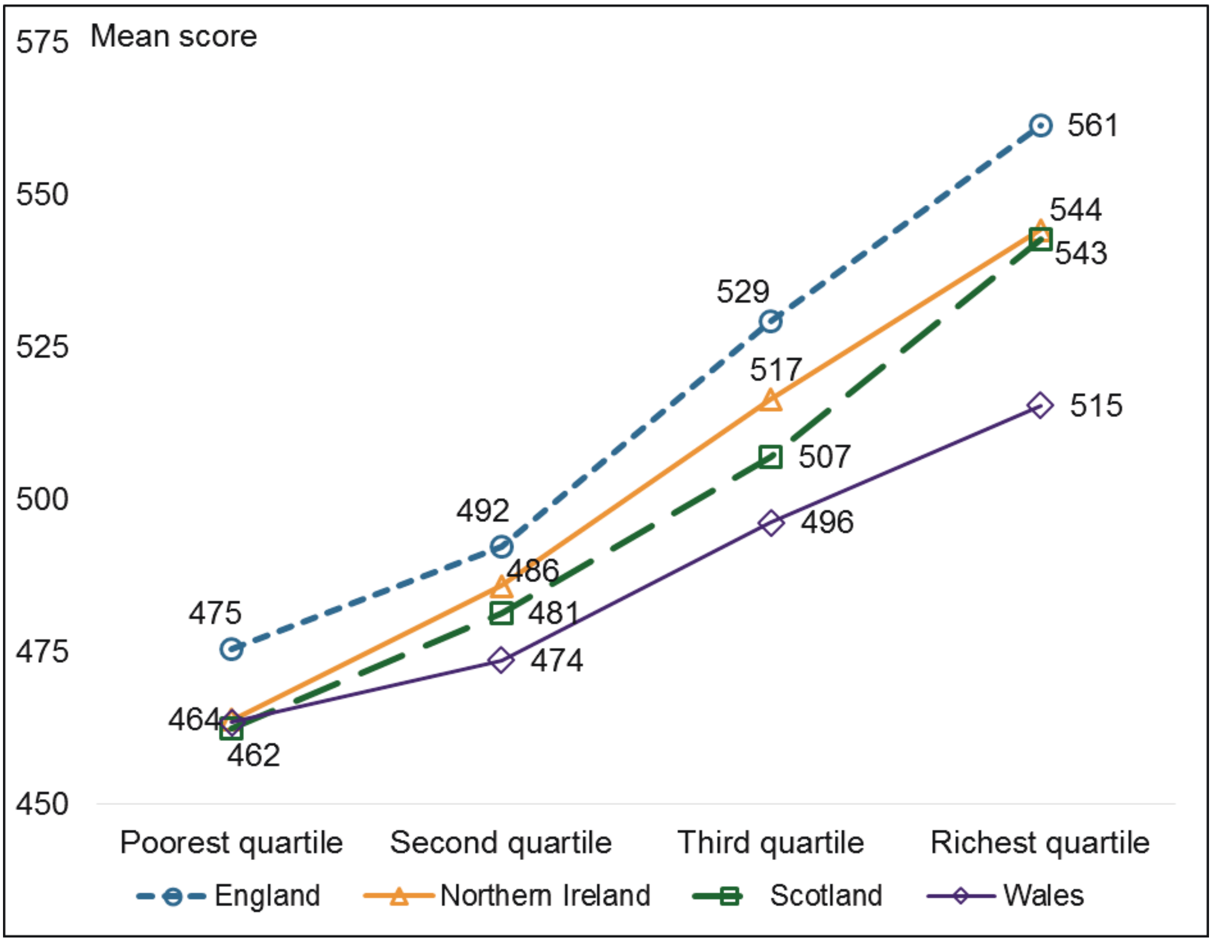
Table 11.5 The 'strength' and 'impact' of socio-economic status upon pupils' science scores

	Impact		Strength	
	Gradient	Standard error	R-Squared	Standard error
England	38.2	2.2	0.11	0.012
Scotland	36.9	2.7	0.11	0.014
Northern Ireland	36.0	2.9	0.11	0.017
Wales	24.8	2.2	0.06	0.009

Source: PISA 2015 database.

Notes: The average value of the ESCS index is 0.16 in Wales, 0.18 in Northern Ireland, 0.21 in England and 0.23 in Scotland.

Figure 11.8 The relationship between socio-economic status quartile and average science scores across the UK



Source: PISA 2015 database.

Notes: Socio-economic groups refer to quartiles of the ESCS index across the UK.

28. England’s comparatively high average science score relative to the rest of the UK is to a certain extent being driven by the strong performance of young people from more advantaged socio-economic backgrounds. Similarly, the comparatively weak science skills of high socio-economic status pupils in Wales is a key reason why the mean score for this country lags behind the rest of the UK. For instance, socio-economically disadvantaged pupils in Northern Ireland, Scotland and Wales achieve roughly the same average science score (around 465) with those in England slightly ahead at 475. The four UK nations therefore differ by around 10 to 15 test points. Yet, for the most advantaged socio-economic group, differences across the four UK countries are a lot more apparent. For instance, the average score for the top socio-economic quartile in England is around 15 points higher than in Northern Ireland and Scotland and 45 points higher than in Wales. These results are presented in Figure 11.8, with differences across the four countries clearly smaller on the left-hand side of the graph (poorest quartile) than on the right-hand side (richest quartile).

Key point

There is a weaker association between socio-economic status and science scores in Wales than the rest of the UK. This is driven by the most advantaged Welsh pupils not achieving as highly as their English, Scottish and Northern Irish peers.

11.7 How do headteachers' views on the factors hindering instruction differ across the UK?

29. A lack of appropriately qualified teaching staff seems to be a particularly pressing concern amongst headteachers in England (compared to the rest of the UK). Almost half of the headteachers in England and Scotland (45 per cent) report this to be a problem - significantly more than in Northern Ireland (27 per cent) and Wales (20 per cent). Similarly, 22 per cent of headteachers' in England agree that 'inadequate or poorly qualified teachers' are a barrier to instruction within their school, compared to 15 per cent in Wales, eight per cent in Scotland and four per cent in Northern Ireland.

30. For most other questions, results across the four constituent countries are similar (see Table 11.6). For instance, just under a third of headteachers across the UK suggest that instruction is hindered by a lack of educational material. One important exception is with regard to physical infrastructure; just under half of headteachers report this to be a challenge in England, Northern Ireland and Wales, compared to around a quarter of headteachers (24 per cent) in Scotland.

Table 11.6 Headteachers' reports of the resources that are lacking within their school: comparison across the UK

	England	Northern Ireland	Scotland	Wales
A lack of teaching staff	45%	27%	45%	20%
Inadequate or poorly qualified teachers	22%	4%	8%	15%
A lack of assisting staff	18%	21%	32%	19%
Inadequate or poorly qualified assisting staff	12%	5%	10%	13%
A lack of educational material	29%	26%	31%	31%
Inadequate or poor quality educational material	26%	23%	26%	28%
A lack of physical infrastructure	48%	45%	24%	44%
Inadequate or poor quality physical infrastructure	45%	45%	24%	48%

Source: PISA 2015 database.

31. Headteachers were also asked about the conduct of staff in their school, and the extent that this hinders learning amongst pupils. For the majority of questions, headteachers' responses are similar across the different parts of the UK (see Table 11.7). The main point of departure is in respect to the statement '*teachers not meeting individual pupils' needs*' where according to headteachers, this is a factor hindering a smaller proportion of pupils in Northern Ireland (11 per cent) than England (30 per cent) and Scotland (26 per cent), with differences statistically significant at the five per cent level.

Table 11.7 Headteachers' reports of teacher conduct hindering pupils' learning within their school: comparison across the UK

	England	Northern Ireland	Scotland	Wales
Teachers not meeting individual pupils' needs	30%	11%	26%	19%
Teacher absenteeism	24%	30%	21%	24%
Staff resisting change	17%	21%	24%	22%
Teachers being too strict with pupils	5%	4%	9%	4%
Teachers not being well prepared for classes	11%	6%	6%	17%

Source: PISA 2015 database.

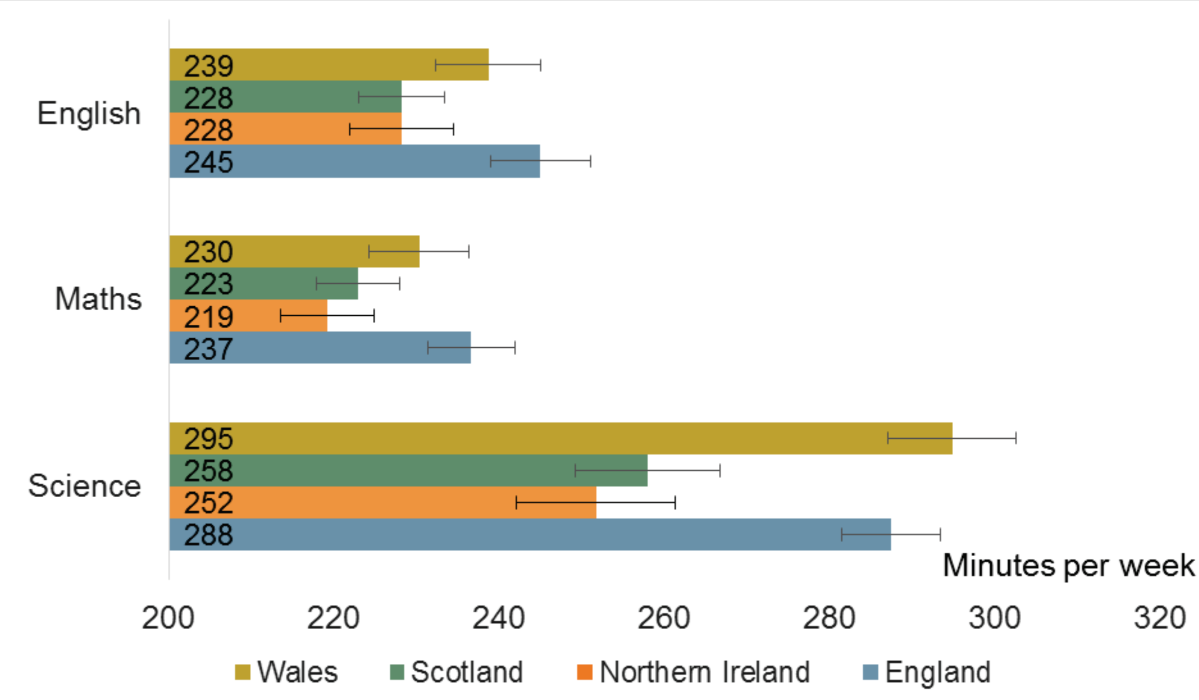
Key point

Headteachers' views on the factors hindering instruction within their school are similar across the UK. However, a lack of teaching staff stands out as a particular concern of headteachers in England.

11.8 Are there differences across the UK in the amount of instruction 15-year-olds receive?

32. In all four parts of the UK, young people report spending more time learning science in school than either English or mathematics (see Figure 11.9). The difference is typically between 30 and 60 minutes per week, with 15-year-olds in England and Wales indicating they receive around four weekly hours of in-school instruction in English and mathematics, compared to five hours of science.

Figure 11.9 The amount of time pupils report spending learning science, English and mathematics in school: a comparison across the UK



Source: PISA 2015 database.

33. Pupils in Northern Ireland and Scotland report significantly less instruction time per week across all three subject areas than pupils in England and Wales: Figure 11.9 indicates that they receive around 30 to 40 minutes less instruction in science per week (on average) than their peers in England and Wales. The same holds true (although the difference is less pronounced) in English at around 15 minutes less per week, and mathematics at around 15 minutes less per week.

Table 11.8 Pupils' reports of time spent learning in addition to their required schedule: a comparison across the UK

	England	Northern Ireland	Scotland	Wales
Science	3.7 hours	3.8 hours	3.9 hours	3.9 hours
Mathematics	3.5 hours	4.0 hours	4.0 hours	4.0 hours
English	3.0 hours	3.5 hours	3.9 hours	3.6 hours
Foreign language	1.5 hours	1.8 hours	1.5 hours	1.3 hours
Other	4.9 hours	5.2 hours	6.0 hours	5.1 hours
Mean (all subjects)	**16.6 hours**	**18.4 hours**	**19.2 hours**	**17.9 hours**

Source: PISA 2015 database.

34. Pupils in England report spending significantly less time studying outside of school per week, on average, than their peers in Northern Ireland, Scotland and Wales. Specifically, 15-year-olds in Northern Ireland and Wales report spending around 18 hours on additional study per week, and 19 hours for pupils in Scotland,

compared to around 16 and half hours for pupils in England (see Table 11.8). Note that a similar finding holds if we consider the median number of additional hours rather than the mean (median is 14 hours in England versus 15 hours in Wales, 16 hours in Northern Ireland and 17 hours in Scotland). This finding is therefore not being driven by a small number of pupils reporting a very high number of additional hours.

35. The additional study hours of Scottish, Welsh and Northern Irish pupils (relative to their English peers) is greatest in English and mathematics. Young people in Scotland and Northern Ireland spend over 30 minutes more on average per week studying these subjects in addition to their required schedule than young people in England. For both mathematics and English, additional study time is significantly lower in England than in Scotland, Northern Ireland and Wales.

Key point

Across the UK, school pupils spend more time studying science than any other subject. Scottish, Welsh and Northern Irish pupils spend, on average, over an hour more on additional study per week than pupils in England.

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Appendix A. Background to the PISA study

1. The Programme for International Student Assessment (PISA) is a global benchmarking study of pupil performance led by the Organisation for Economic Co-operation and Development (OECD). The following sections outline the development of the 2015 study, what PISA 2015 measures, how to interpret the PISA scales, how PISA was administered and details of the PISA 2015 sample in England. These sections outline some of the detailed international requirements that countries must meet in order to ensure confidence in the findings.

A1. Development of the study

2. By using standardised survey procedures and tests, the PISA study aims to collect data from around the world that can be robustly compared, despite differences in language and culture. The framework and specification for the study were agreed internationally by the PISA Governing Board, which comprises of representatives from each participating country. Five international contractors designed and implemented the PISA 2015 study on behalf of the OECD. These organisations were the Educational Testing Service (ETS), Westat, cApStAn Linguistic Control, Pearson and the German Institute for International Education Research (DIPF).

3. A field trial was carried out in every participating country in 2014. The outcomes of this field trial were used to finalise the contents and format of the tests and questionnaires for the main survey in 2015. Because most participating countries participated in the computer-based assessment in PISA 2015, a 'mode effect' study was also conducted by ETS as part of this field trial. The purpose of this aspect of the field trial was to establish how the switch from paper to computer assessment influences pupils' responses to the test questions, and to ensure results from PISA 2015 can be linked to previous cycles. Further details on the design of this mode effect study are available from the OECD field trial results[103].

4. Strict international quality standards are applied to all stages of the PISA study to ensure equivalence in translation and adaptation of instruments, sampling procedures and survey administration in all participating countries.

A2. What does PISA measure?

The full assessment and analytical framework for the PISA 2015 study was developed by the OECD and their international contractors in conjunction with panels of expert advisors and representatives from the participating countries. It aims to

[103] OECD (2013b).

build on the initial PISA frameworks developed for the first assessments in 2000, 2003 and 2006. Both the international consortium and participating countries submitted test questions for inclusion in the assessment. After the questions were reviewed by the expert panel, countries were invited to comment on their difficulty, cultural appropriateness, and curricular and non-curricular relevance. The full assessment and analytical framework for each assessment domain in PISA 2015 is available in the PISA 2015 assessment framework[104]. Although PISA also measures a number of contextual factors, the focus of this sub-section is upon the performance measures.

Science

5. Science was the main focus in PISA 2015, as it was in PISA 2006. Therefore, the majority of assessment items within the 2015 test booklets were designed to measure pupil performance against the science competency framework.

6. With the move to computer-based assessment, there has been at least one significant enhancement to the PISA 2015 science framework in comparison to previous cycles. This is the introduction of interactive tasks, where pupils were expected to use the functionality of the assessment software to answer specific questions. They may have been required to manipulate variables in a simulated scientific experiment in order to reach the correct solution, for example. Specific examples have been released from the PISA 2015 field trial, such as the ‘running in hot weather’ unit, available from OECD (2015b:35).

7. PISA aims to measure what 15-year-olds know and can do in relation to the scientific understanding which is needed in adult life – not just science as it may be defined within the curriculum of participating countries. This is defined as the capacity for pupils to identify questions, acquire new knowledge, explain scientific phenomena, and draw evidence-based conclusions about science-related issues. Individuals with this capacity also understand the characteristic features of science as a form of human knowledge and enquiry, are aware of how science and technology shape their lives and environments, and are willing and able to engage in science-related issues and with the ideas of science, as a reflective citizen. Therefore, PISA assessments measure not only scientific knowledge, but also scientific competencies and understanding of scientific contexts.

8. **Scientific ‘knowledge’** in PISA constitutes the links that aid understanding of related phenomena. While the scientific concepts are familiar (relating to physics, chemistry, biological sciences and earth and space sciences), pupils are asked to apply them to the content of the test items, and not simply to recall facts. This

[104] See OECD (2013).

therefore includes both knowledge of the natural world and technological artefacts (*content knowledge*), knowledge of how such ideas are produced (*procedural knowledge*) and an understanding of the underlying rationale for these procedures and the justification for their use (*epistemic knowledge*). The PISA 2015 test was weighted towards the first of these knowledge types. Specifically, content knowledge was targeted in 53 cent of the assessment questions, procedural knowledge in 33 per cent and epistemic knowledge in 14 per cent. The content domains can be further divided into: *living systems*, *physical systems*, and *earth and space* systems. A third of items (33 per cent) covered the physical system, 40 per cent the living system and 27 per cent earth and space sciences.

9. **Scientific competencies** are centred on the ability to acquire, interpret and act upon evidence. Three processes are identified in PISA. These are the ability to:

- <u>Explain phenomena scientifically</u>. To recognise, offer and evaluate explanations for a range of natural and technological phenomena.
- <u>Evaluate and design scientific enquiry</u>. Describe and appraise scientific investigations and propose ways of addressing questions scientifically.
- <u>Interpret data and evidence scientifically</u>. Analyse and evaluate data, claims and arguments in a variety of representations and draw appropriate scientific conclusions.

Among all the science test items, 48 per cent of the total test score points were targeted within the ‘explaining phenomena scientifically’ domain. A total of 30 per cent of total test score points were targeted within ‘interpreting data and evidence scientifically’, with the remaining 22 per cent within ‘evaluating and designing scientific enquiry’.

10. **Scientific contexts** concern the application of scientific knowledge and the use of scientific processes. This includes personal, local, national and global issues, both current and historical, which demand some understanding of science and technology. Test question contexts were spread across personal, local/national and global settings in a roughly 1:2:1 ratio, as was the case in PISA 2006 (the last time science was the focus of PISA).

11. The types of PISA items used to assess the various competencies and knowledge described above also varied. Around a third of PISA 2015 science test items were found within each of the following three categories:

- <u>Open constructed response</u>. These items required pupils to provide written responses, ranging from a phrase up to a short paragraph. A small number of questions also required drawing a simple graph or diagram, using the drawing editor provided on the computer-test platform.

- Simple multiple choice. These questions required pupils to select a single response from a set of four options, or to select a 'hot spot' (i.e. a selectable element) within a graphic or passage of text.

- Complex multiple choice. This includes responses to a series of yes/no questions, selection of more than one option from a list, completion of sentences via drop-down choices, and responses where pupils interact with the computer-testing software to 'drag-and-drop'. It also includes pupils' responses to the new interactive tasks.

Mathematics

12. Mathematics was the main focus in the 2012 and 2003 PISA cycles. It was a minor domain in PISA 2015.

13. PISA aims to assess pupils' ability to put their mathematical knowledge to functional use in different situations in adult life, rather to assess what is taught in participating countries. The OECD defines this ability as:

> '*an individual's capacity to formulate, employ, and interpret mathematics in a variety of contexts. It includes reasoning mathematically and using mathematical concepts, procedures, facts, and tools to describe, explain, and predict phenomena. It assists individuals in recognising the role that mathematics plays in the world and to make the well-founded judgements and decisions needed by constructive, engaged and reflective citizens*'. (OECD 2013)

14. In order to demonstrate this capacity, pupils need to have factual knowledge of mathematics, skills to carry out mathematical operations and methods, and an ability to combine these elements creatively in response to external situations. The PISA mathematics questions are predominantly context-based rather than abstract, requiring the pupil to engage with a real-world situation and decide how to solve the problem using mathematics and appropriate mathematical tools. As a minor domain, each pupil receives fewer mathematics questions compared to science questions. The full assessment framework is covered across the full national and school samples rather than by each pupil who will only be assessed against a selection of mathematics items testing different elements of their mathematical processing ability.

Reading

15. Reading was the main focus in the first PISA study in 2000 and also in 2009. It was a minor domain in PISA 2015.

16. Reading in PISA focuses on the ability of pupils to use information from texts in situations which they encounter in their life. Reading in PISA is defined as

> '*understanding, using, reflecting on and engaging with written texts, in order to achieve one's goals, to develop one's knowledge and potential, and to participate in society*' (OECD 2009).

17. The concept of reading in PISA is defined by three dimensions: the format of the reading material, the type of reading task or reading aspects, and the situation or the use for which the text was constructed.

18. The first dimension, the **text format**, divides the reading material into *continuous* and *non-continuous* texts. Continuous texts are typically composed of sentences which are organised into paragraphs. Non-continuous texts are not organised in this type of linear format and may require, for example, interpretation of tables or diagrams. Such texts require a different reading approach to that needed with continuous text.

19. The second dimension is defined by three **reading aspects**: *retrieval of information, interpretation of texts* and *reflection on and evaluation of texts*. Tasks in which pupils retrieve information involve finding single or multiple pieces of information in a text. In interpretation tasks pupils are required to construct meaning and draw inferences from written information. The third type of task requires pupils to reflect on and evaluate texts. In these tasks pupils need to relate information in a text to their prior knowledge, ideas and experiences.

20. The third dimension is that of **situation** or **context**. The texts in the PISA assessment are categorised according to their content and the intended purpose of the text. There are four situations: *reading for private use (personal), reading for public use, reading for work (occupational)* and *reading for education*.

A3. How is the PISA scale designed?

21. The PISA 2015 test scores are constructed following the procedure set out in the PISA technical report (PISA website). The PISA scores are produced on the same scale as in previous cycles. This scale was initially set to have a mean of 500 and standard deviation of 100 across OECD countries the first time each subject was designated as the 'major domain'. For instance, as science was first the focus of PISA in 2006, the OECD mean and standard deviation were set to 100 in that year.

22. As all subsequent PISA cycles have been linked back to this scale via the use of 'trend questions' (questions that remain in the test each time PISA is conducted) it is possible to compare educational achievement (as measured by PISA) within participating countries over time. To aid interpretation of the results, the OECD roughly equates 30 points on the PISA scale to one additional year of schooling (see Appendix D for further details).

23. PISA uses proficiency levels to describe the types of skills that pupils are likely to demonstrate and the tasks that they are able to complete. Test questions that focus on simple tasks are categorised at lower levels, whereas those that are more demanding are categorised at higher levels. The question categorisations are based on both quantitative and qualitative analysis, taking into account question difficulty as well as expert views on the specific cognitive demands of each individual question. All PISA questions have been categorised in this manner.

24. Pupils described as being at a particular level not only demonstrate the knowledge and skills associated with that level but also the proficiencies required at lower levels. For example, all pupils proficient at Level 3 are also considered to be proficient at Levels 1 and 2. The table below shows the score points for each level in each subject area. The same cut points have been used previous PISA cycles, with the exception of the division of Level 1 in Level 1a and 1b in the science and reading domains, and the introduction of Level 6 in reading. These new divisions were introduced in 2009 for reading and 2015 for science.

Table A1. The correspondence between PISA test points and proficiency levels

Proficiency levels	Science	Mathematics	Reading
Level 6	>707.93	>669.30	>698.32
Level 5	633.33 to 707.93	606.99 to 669.30	625.61 to 698.32
Level 4	558.73 to 633.33	544.68 to 606.99	552.89 to 625.61
Level 3	484.14 to 558.73	482.38 to 544.68	480.18 to 552.89
Level 2	409.54 to 484.14	420.07 to 482.38	407.47 to 480.18
Level 1a / Level 1	334.94 to 409.54	357.77 to 420.07	334.75 to 407.47
Level 1b / below Level 1	260.54 to 334.94	357.77<	262.04to 334.75

Notes: For PISA reading and science, Level 1 can be divided into Level 1a and Level 1b. The same is not true for mathematics.

A4. The PISA test design

25. PISA uses a complex test design. Test questions are first separated into distinct 30 minute 'clusters' and these clusters are then combined to generate a total

of 66 test forms. Each form is made up of four clusters, and thus contains two hours of test questions. Pupils are then randomly assigned, with differing probabilities, to one of the 66 forms. Within each test form, a proportion of the questions are ones used in previous cycles. It is this that facilitates measurement of change in PISA scores over time. A summary of the PISA 2015 assessment design is provided in Figure A1.

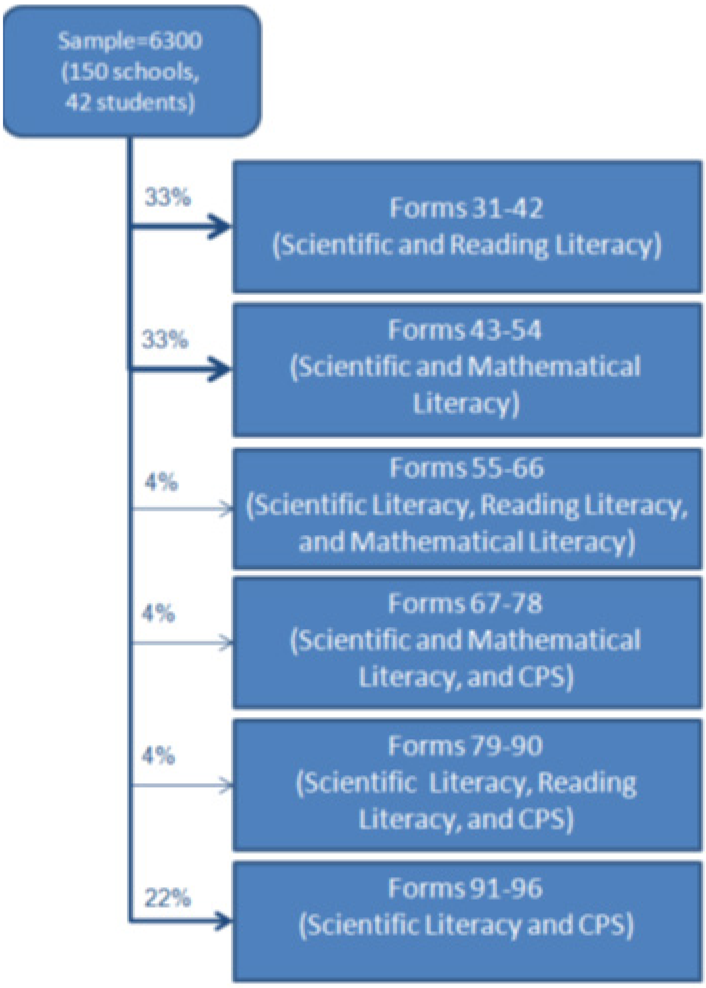
26. Roughly a third of pupils answered one hour of science and one hour of reading test questions (forms 31 to 42). A further third of pupils answered one hour of science and one hour of mathematics questions (forms 43 to 54), while just over a fifth (22 per cent) received one hour of science and one hour of Collaborative Problem Solving (CPS) questions (forms 91 to 96)[105]. The vast majority of pupils (88 per cent) therefore answered test questions covering two out of the four PISA domains. The remaining 12 per cent of pupils were assigned to test forms that covered three out of the four PISA subject areas. These pupils received one hour of science questions, plus two 30 minute clusters of questions covering two out of the three other domains. These combinations were:

- Forms 55-66: One hour science, 30 minutes reading and 30 minutes mathematics;
- Forms 67-78: One hour science, 30 minutes mathematics and 30 minutes CPS;
- Forms 79-90: One hour science, 30 minutes reading and 30 minutes CPS.

[105] The hour of scientific literacy included 30 minutes of 'trend' questions (i.e. those that have been used in previous PISA cycles) with the other 30 minutes consisting of 'new' science items (not used in previous PISA cycles).

27. The main implication of this complex design is that no single pupil is presented with all test questions. Instead, statistical methods are used to estimate the likelihood that the pupil would be able to answer correctly the questions which they have not actually been asked. This is executed using a complex item-response theory (IRT) model, with further details on this process available in Rutkowski, von Davier and Rutkowski (2013) and the PISA 2015 technical report (PISA website).

Figure A1. A summary of the PISA 2015 test design



A5. Administration

28. The survey administration was carried out internationally on behalf of the OECD by a consortium of five organisations (see section A1 above). The consortium worked with the PISA National Centre within each country, through the National Project Manager (NPM). For England the National Centre was formed of three organisations: RM Education, World Class Arena Limited and the UCL Institute of Education.

National Centres were responsible for making local adaptations to test questions, manuals and the background questionnaires, and translation where necessary. National Centres were also responsible for supplying the information necessary for sampling to be carried out. School samples were selected by the PISA consortium, while pupil samples within schools were selected by RM Education using software supplied by the international consortium.

29. In England, Wales and Northern Ireland pupils sat the two-hour PISA assessment in November-December 2015 under test conditions, following the standardised procedures implemented by all countries. In Scotland, the PISA survey was carried out earlier in 2015.

30. Tests and questionnaires were generally administered in a single session. Pupils first completed the two hour PISA assessment. After a short break, they were then asked to complete the pupil background questionnaire (35 minutes), educational career questionnaire (10 minutes) and ICT familiarity questionnaire (10 minutes). The total length of an assessment session was around three and a half hours. The survey was administered by test administrators employed and trained by RM Education.

31. In each country participating in PISA, the minimum number of participating schools was 150. For countries using computer-based assessment and participating in the Collaborative Problem Solving (CPS) study, 42 pupils were then typically randomly selected within each school. Countries using paper-based assessment, or not participating in the CPS study, were required to randomly select 35 pupils per school. The minimum target sample size was 6,300 pupils in countries involved in the CPS study and 5,250 in countries that were not.

32. In the case of the UK and of some other countries, slight variations on this design were allowed. Specifically, a greater number of schools across the UK were sampled than strictly required, while the number of pupils per school was slightly lower (30 pupils as opposed to 42). Consequently, the number of pupils and schools participating in PISA from across the UK exceeds the minimum requirements set by the OECD. Schools and pupils across the UK were over-sampled such that separate PISA estimates for the four constituent parts of the UK could be calculated to be compared to the average scores in other countries. In some countries additional samples were drawn for other purposes, for example to enable reporting of results for a particular sub-group (e.g. indigenous pupils in the case of Australia). In very small countries with less than 150 schools, PISA was completed as a school census (meaning all eligible secondary schools were included). In England, Wales and Northern Ireland, a decision was made to reduce the pupil sample in participating schools to minimise the burden on participating schools and restrict the sampled pupils to one class within one computer suite, where possible.

33. The pupils included in the PISA study are generally described as ‘15-year-olds’, but there is a small amount of leeway in this definition depending on the time of testing. In the case of England, the sample consisted of pupils aged from 15 years and two months to 16 years and two months at the beginning of the testing period.

34. Countries were required to carry out the study during a six-week period between March and August 2015. However, England was permitted to test outside this period because of the problems for schools caused by the overlap with the GCSE preparation and examination period. In England, the study took place between November 5th and December 7th 2015. This is consistent with how PISA has been administered in England since 2006.

35. Each participating school in England was assigned a test date during this period by the National Centre. To assist schools on the day of the PISA 2015, a Test Administrator (TA) was assigned to every school. All TAs were either ex-teachers or had worked within a school environment before, and received training prior to the testing period. Typically, one test administrator was assigned per school. A member of staff within each school was also assigned as the School Co-Ordinator for PISA 2015, with whom the TA and National Centre would liaise before, during and after the test day. TAs worked at the school until mid-afternoon completing administrative duties, including making the packages to be returned to the National Centre by courier.

36. At the end of each test session, the TAs were required to complete a ‘session report form’. This included the following questions:

- Were there any problems with assessment conditions? (e.g. significant disciplinary issues)
- Did you notice any pupil attend the session but not answer any test items at all? (If yes, write the number of pupils affected)
- Were there any pupils that started the test, but were unable to complete it due to computer failure? (If yes, write the number of pupils affected)
- Were there any pupils that started the test, but were unable to complete it for other reasons? (If yes, write the number of pupils affected)
- Were there any pupils unable to start the session at all due to computer failure? (If yes, write the number of pupils affected).

37. In England, 232 test sessions took place across the 208 participating schools. A total of 186 schools (89 per cent) completed the PISA assessment in a single test session, two test sessions were used in 20 schools (10 per cent) and three test

sessions in two participating schools (one per cent). The majority of test sessions progressed with no problems encountered. However, test administrators did report some issues in 16 per cent of test sessions, with many being relatively minor issues (e.g. poor lighting in the room). Around one per cent of pupils had their test interrupted, either due to computer failure or issues with individual pupil behaviour.

Appendix B. Sample design and response rates

Sample design

1. The sampling frame for England, Wales and Northern Ireland was produced using lists of all schools with 15-year-olds in the 2013/14 academic year. A total of three per cent of the target pupil population were excluded from the sampling frame. These were individuals who attended Hospital Schools, Special Schools, Alternative Provision Units, Pupil Referral Units and Prison Schools. After making these exclusions, 4,288 schools remained in the sampling frame.

2. Countries must follow strict international sampling procedures to ensure comparability. This process is formed of several stages. First, each country selects a set of 'explicit stratification' variables. Although these differ across countries, geographic region and school type are amongst the most common choices. Appendix Table B1 provides information on the explicit stratification variables used in England which included funding structure, region and gender. Within each of these explicit strata, schools are then ranked by a variable (or set of variables) that are likely to be strongly associated with PISA scores. This is known as implicit stratification, with historic GCSE performance of the school the most important variable used for this purpose in England.

Appendix Table B1. The variables used to stratify the PISA sample in England

Explicit strata	Implicit strata
Schools Type	**GCSE school performance**
Academy	Band 1 (lowest)
Maintained selective	Band 2
Maintained non-selective	Band 3
Independent	Band 4
Region	Band 5 (highest)
North	Band not known
Midlands	**Local Authority**
South	Varies within region
Greater London	
Gender composition	
Boys school	
Girls school	
Mixed school	

3. The sampling frame (a list of all eligible schools) and their populations was then sent to the international consortium, who drew the sample of schools. Schools

were randomly chosen to participate from within each explicit strata, with probability proportional to size. The international consortium then sent the list of selected schools back to the national project team. In England this list comprised of 228 main study schools but by the time of the test, five schools were dropped. This was mainly due to school closure, having no pupils who met the PISA population definition, or only having pupils with significant special educational needs. The final total of schools chosen and eligible to participate was therefore 223.

4. The schools randomly selected into the PISA sample were then invited to participate in the study. Those that agreed were asked to supply a list of all pupils who met the PISA age definition at the start of the testing period (November 2015). The majority of these pupils were in Year 11.

5. Inevitably, some schools declined to participate. In such instances, PISA uses a system of 'replacement schools'. This means that, if a school declines to participate, a substitute is entered in its place. Two replacement schools are selected by the international consortium per 'main study' school. These are typically the schools that follow the non-participating school on the sampling frame (which has been explicitly and implicitly stratified). This should mean that the replacement schools are similar to the one which declined to take part (at least in terms of the variables used to stratify the sample). For further information on this process, readers are directed to the PISA technical report (PISA website).

6. RM education then used specialist software (Keyquest), provided by the international consortium, to randomly select the 30 pupils from each participating school. These pupils, who all met the PISA age definition, were then invited to participate in the study.

Target response rates

7. PISA has strict rules surrounding school response rates. Countries are set a target of an 85 per cent school level response rate, before replacement schools have been taken into account. If a country meets this criteria, then the use of replacement schools is not strictly necessary (although, in many countries, replacements for non-participating schools are included in any case).

8. Conversely, if the response rate of initially selected schools falls below 65 per cent, the sampled is deemed unacceptable by the international consortium. In such circumstances, the chance of the sample being biased (i.e. no longer nationally representative) is too great. The country will therefore be excluded from the international report, due to poor data quality.

9. If the response rate for initially selected schools is between 65 per cent and 85 per cent, then an 'acceptable' overall response rate can still be achieved through the use of replacement schools. However, the target response rate also moves upwards. For instance, if only 70 per cent of initially sampled schools are willing to participate, then a country must achieve a 94 per cent response rate after the

substitute schools have been entered. If this target is achieved, results for the country will be included in the international report.

10. Finally, a country may achieve a before replacement response rate between 65 per cent and 85 per cent, but then fail to meet the revised target after replacement schools have been included. This is known as the ‘intermediate zone’. If a country falls into this area, their results may still be included in the international report. However, the country is required to provide an analysis of the likely non-response bias to the international consortium. This report will then be scrutinised by referees from the international contractor, who will deem whether the data collected are sufficiently robust for meaningful cross-national comparisons to be made.

11. PISA also enforces strict rules around pupil-level response. First, in order for a school to be considered as ‘participating’, at least 50 per cent of the selected eligible pupils must take part. (I.e. assuming all 30 pupils selected within a school are indeed eligible for the study, at least 15 must complete the test). Second, an overall response rate of 80 per cent amongst selected students within participating schools is required.

Response rates in PISA 2015

12. A total of 206 schools and 5,194 pupils completed the PISA 2015 study in England. Appendix Table B2 provides further details on how the schools were distributed between initially selected schools, first replacement schools, and second replacement schools (along with non-participants[106]). The final response rate for England was 83 per cent of the initially sampled schools and 92 per cent after replacements were considered. This is fully compliant with the required PISA response rate. Appendix Table B3 illustrates that the participating schools are very similar to the initially selected sample at school level.

Appendix Table B2. School response rates

	England
Participating main sample schools	185
Participating first-replacement schools	19
Participating second-replacement schools	2
Non-participating schools	17
Total initially sampled	**223**

Notes: Schools with less than 50 per cent of eligible pupils completing the test are considered non-participants. Figures refer to the number of schools.

13. The international report produced by the OECD includes the United Kingdom as a single country, rather than in its four constituent parts. It is therefore the

[106] Here a ‘non-participant’ refers to where neither the initially selected school, nor its two replacement schools, took part in the PISA study.

response rate for the United Kingdom as a whole that determines entry into the international report, and whether a non-response bias analysis is required. The overall UK response rate is weighted by the population size in each constituent country, as well as by school size. The weighted UK-wide response rate was 84 per cent of main sample schools, and 93 per cent after replacement. This fully met the participation requirements.

Appendix Table B3. The sample of schools participating in PISA 2015 in England

	Initial sampled schools	**Final participating schools**
% FSM (mean)	14%	14%
% ever FSM (mean)	28%	28%
% five good GCSE (mean)	61%	61%
% achieve EBacc (mean)	28%	28%
% English as Additional Language (mean)	16%	16%
School Type		
Academy Converter	35%	35%
Academy Sponsor Led	18%	19%
Community School	19%	18%
Independent	10%	9%
Other	8%	9%
Voluntary	10%	10%
Admissions policy		
Comprehensive	75%	76%
Independent	10%	9%
Other/unknown	1%	1%
Selective	13%	14%
Most recent Ofsted rating		
Outstanding	25%	24%
Good	40%	44%
Requires improvement	18%	19%
Inadequate	6%	4%
Not available	10%	9%
Total number of schools	**223**	**206**

Source: PISA 2015 matched database and DfE Schools, Pupils and their Characteristics (2015).

Notes: Figures based upon unweighted data, and reported only for those schools where the relevant piece of information is available.

Appendix Table B4. Pupil-response rates

	Number of pupils
Assessed	5,194
Absent	704
Excluded	285
Ineligible	71
Total initially sampled	**6,254**

Source: PISA 2015 national data file.

Appendix Table B5. The sample participating in PISA 2015 in England

	1	2
	Assessed	**Assessed + absent**
FSM eligible		
No	80%	80%
Yes	10%	11%
Missing NPD data	10%	10%
Ethnicity		
White	69%	69%
Asian	11%	11%
Black	4%	4%
Mixed	3%	4%
Other	2%	2%
Missing NPD data	10%	10%
Gender		
Female	48%	48%
Male	52%	52%
Special Educational Needs		
No	82%	81%
Yes	8%	9%
Missing NPD data	10%	10%
English as an Additional Language (EAL)		
No	76%	76%
Yes	15%	14%
Missing NPD data	10%	10%
Key Stage 2 scores		

English mean (standard deviation)	62.1 (16.0)	61.6 (16.2)
Mathematics mean (standard deviation)	70.0 (20.0)	69.4 (20.4)
Total number of pupils	**5,194**	**5,898**

Source: PISA 2015 matched database.

Notes: Figures based upon unweighted data. Average Key Stage 2 scores based upon observations with data available.

14. Appendix Table B4 provides details on pupil level response. Of the 6,254 pupils initially selected to participate in England, 5,194 successfully completed the PISA study. A total of 356 pupils were excluded for reasons of SEN, enrolment elsewhere, or ineligibility. Finally, 704 pupils were absent on the day of the test. This represents a final response rate (among eligible pupils) of 88 per cent. This exceeds the 80 per cent threshold required by the international contractors for inclusion in the international report. Appendix Table B5 illustrates how the final sample of 5,194 pupils does not differ in terms of observables characteristics from the 5,898 initially selected pupils who were eligible to participate.

Appendix C. Testing statistical significance in PISA across cycles

38. To test statistical significance across two independent samples (e.g. a comparison of mean scores across countries in PISA) a two-sample t-test can be applied. For instance, if one were to compare the mean score in country A to the mean score in country B, the t-statistic to be used in statistical significance testing would be:

$$T - stat = \frac{(\mu_A - \mu_B)}{\sqrt{SE_A^2 + SE_B^2}} \qquad \text{(C1)}$$

Where:

μ_A = Mean score in country A

μ_B = Mean score in country B

SE_A = Standard error in country A

SE_B = Standard error in country B

39. However, when testing for statistical significance over time in international assessments such as PISA, an extra term has to be added to the denominator of equation C1. This is known as the 'link error'. The link error attempts to capture the fact that there is a degree of uncertainty when equating (or linking) tests together from different cycles. Therefore, to compare mean scores for a country across two time points (e.g. average PISA scores in 2006 and 2015) the following formula for the t-statistic should be applied:

$$T - stat = \frac{(\mu_1 - \mu_2)}{\sqrt{SE_1^2 + SE_2^2 + LE_{1,2}^2}} \qquad \text{(C2)}$$

Where:

μ_1 = Mean score at time point 1 (e.g. 2015)

μ_2 = Mean score at time point 2 (e.g. 2006)

SE_1 = Standard error at time point 1

SE_2 = Standard error at time point 2

$LE_{1,2}$ = The link error for comparisons between time point 1 and time point 2

40. In PISA, a common link error is specified which can be applied in all countries. Details on how this link error is calculated will be provided by the OECD in the PISA 2015 technical report (PISA website). Appendix Table C1 provides the value of the link error to be applied when comparing estimates from PISA 2015 to previous cycles.

Appendix Table C1. The value of the link error when comparing results from PISA 2015 to previous cycles

	Science	Mathematics	Reading
2006	4.4821	3.5111	6.6064
2009	4.5016	3.7853	3.4301
2012	3.9228	3.5462	5.2535

41. We demonstrate the use of these link errors by working through an example. The mean science score for Northern Ireland in 2006 was 508.14 with a standard error of 3.34. In 2015, the mean science score in Northern Ireland is 500.09 with a standard error of 2.79. Finally, as Appendix Table C1 illustrates, the value of the link error for comparing mean PISA 2006 and 2015 science scores is 4.4821. Using equation C2, the t-statistic for the change in the mean score for Northern Ireland between 2006 and 2015 is:

$$\frac{(500.09 - 508.14)}{\sqrt{2.79^2 + 3.34^2 + 4.48^2}} = -1.289$$

42. The correct estimate of the t-statistic is therefore -1.289. As this is smaller in absolute value than the 'critical value' of -1.99[107] (based upon a standard two-tailed test with a five per cent significance threshold), one should fail to reject the null hypothesis that average science scores in Northern Ireland are the same in 2006 and 2015. (Note that, if one were to exclude the link error from this calculation, the estimated t-statistic would become -1.85, which is still be below the critical value in absolute magnitude).

43. A 95 per cent confidence interval can also be constructed for the change between two statistics over time using the following formula:

[107] As the PISA sample design includes 80 replicate weights, the number of degrees to freedom is approximately 79. Consequently, the critical t-value for a two-tailed significance test at the five per cent level is 1.99.

$$(\mu_1 - \mu_2) \mp 1.99.\sqrt{SE_1^2 + SE_2^2 + LE_{1,2}^2} \qquad \text{(C3)}$$

Where:

μ_1 = Mean score at time point 1 (e.g. 2015)

μ_2 = Mean score at time point 2 (e.g. 2006)

SE_1 = Standard error at time point 1

SE_2 = Standard error at time point 2

$LE_{1,2}$ = The link error for comparisons between time point 1 and time point 2

44. Returning to the example of the change in mean science scores in Northern Ireland between 2006 and 2015, the formula in equation C3 becomes:

$$(508.14 - 500.09) \mp 1.99.\sqrt{3.34^2 + 2.79^2 + 4.48^2}$$

Which results in a confidence interval spanning between -4.4 and +20.5. The fact that the 95 per cent confidence interval crosses 0 confirms that the change in mean science scores in Northern Ireland between 2006 and 2015 does not reach statistical significance at the five per cent level.

Appendix D. The conversion of PISA scores into years of schooling

45. The OECD has previously equated 40 PISA points into one year of additional schooling (OECD 2010:110). This was based upon an analysis investigating how PISA scores vary between pupils in different school year groups. The OECD has reviewed the evidence for the conversion between PISA points and years of schooling as part of the PISA 2015 international report (Box I.2.1). They point to the following studies in particular:

- Prenzel et al. (2006), who conducted a follow-up of the PISA 2003 cohort in Germany one year after taking the PISA test. Over this year, pupils gained about 25 score points in PISA mathematics and 21 points in science.
- OECD (2012), where the PISA 2000 cohort in Canada were re-tested at age 24. The average reading score increased by 57 points, from 541 to 598, over this nine-year period.
- Keskpaik and Salles (2013), who compared PISA scores of eighth and ninth grade pupils in France. They found a score point difference of 44 points over the year of schooling, though this is recognised to be an upper-bound.
- Woessmann (2016), who states that learning gains on most national and international assessments during one year is equal to between a quarter and a third of a standard deviation.

46. Based upon this evidence, the OECD have revised their guidance, and now equate 30 PISA test points to a year of additional schooling. However, they note that this must be understood as an approximate rule of thumb, and that variation across subjects and across different countries may occur.

Appendix E. PISA 2015 mean scores

E1. Mean scores in science across countries

Country	Mean	Confidence Interval		Country	Mean	Confidence Interval	
		Lower	Upper			Lower	Upper
Singapore	555.6	553.2	558.0	Italy	480.5	475.5	485.6
Japan	538.4	532.5	544.3	Hungary	476.7	471.9	481.6
Estonia	534.2	530.0	538.4	Lithuania	475.4	470.1	480.7
Taiwan	532.3	527.0	537.7	Croatia	475.4	470.5	480.3
Finland	530.7	525.9	535.4	Iceland	473.2	469.9	476.6
Macao	528.5	526.4	530.7	Israel	466.6	459.7	473.4
Canada	527.7	523.6	531.8	Malta	464.8	461.5	468.0
Vietnam	524.6	516.9	532.4	Slovakia	460.8	455.6	465.9
Hong Kong	523.3	518.2	528.3	Greece	454.8	447.0	462.6
China	517.8	508.6	527.0	Chile	447.0	442.2	451.7
South Korea	515.8	509.6	522.0	Bulgaria	445.8	437.1	454.4
New Zealand	513.3	508.6	518.0	United Arab Emirates	436.7	431.9	441.6
Slovenia	512.9	510.2	515.5	Uruguay	435.4	431.0	439.7
England	**512.2**	**506.2**	**518.2**	Romania	434.9	428.5	441.3
Australia	510.0	506.9	513.0	Moldova	428.0	424.1	431.9
Germany	509.1	503.8	514.5	Albania	427.2	420.7	433.7
Netherlands	508.6	504.1	513.1	Turkey	425.5	417.7	433.3
Switzerland	505.5	499.7	511.3	Trinidad and Tobago	424.6	421.8	427.4
Ireland	502.6	497.8	507.3	Thailand	421.3	415.7	427.0
Belgium	502.0	497.4	506.6	Costa Rica	419.6	415.5	423.7
Denmark	501.9	497.2	506.7	Qatar	417.6	415.6	419.6
Poland	501.4	496.4	506.4	Colombia	415.7	411.0	420.4
Portugal	501.1	496.3	505.9	Mexico	415.7	411.5	419.9
Northern Ireland	500.1	494.5	505.6	Montenegro	411.3	409.3	413.4
Norway	498.5	494.0	503.0	Georgia	411.1	406.3	415.9
Scotland	496.8	492.1	501.5	Jordan	408.7	403.3	414.0
United States	496.2	489.9	502.6	Indonesia	403.1	398.0	408.2
Austria	495.0	490.2	499.9	Brazil	400.7	396.1	405.3
France	495.0	490.9	499.1	Peru	396.7	392.0	401.4
Sweden	493.4	486.3	500.6	Lebanon	386.5	379.7	393.2
Czech Republic	492.8	488.3	497.3	Tunisia	386.4	382.2	390.6
Spain	492.8	488.7	496.9	Macedonia	383.7	381.2	386.2
Latvia	490.2	487.1	493.3	Kosovo	378.4	375.1	381.8
Russia	486.6	480.8	492.4	Algeria	375.7	370.5	381.0
Wales	484.6	479.0	490.1	Dominican Republic	331.6	326.5	336.8
Luxembourg	482.8	480.6	485.0	**OECD average**	**493.2**	**492.3**	**494.1**

E2. Mean score in mathematics across countries

Country	Mean	Confidence Interval		Country	Mean	Confidence Interval	
		Lower	Upper			Lower	Upper
Singapore	564.2	561.3	567.1	Malta	478.6	475.2	482.1
Hong Kong	547.9	542.0	553.9	Lithuania	478.4	473.7	483.0
Macao	543.8	541.6	546.0	Wales	478.0	470.6	485.4
Taiwan	542.3	536.3	548.4	Hungary	476.8	471.8	481.9
Japan	532.4	526.5	538.4	Slovakia	475.2	469.9	480.5
China	531.3	521.6	541.0	Israel	469.7	462.4	476.9
South Korea	524.1	516.7	531.5	United States	469.6	463.3	475.9
Switzerland	521.3	515.4	527.1	Croatia	464.0	458.5	469.6
Estonia	519.5	515.5	523.6	Greece	453.6	446.2	461.1
Canada	515.6	511.0	520.3	Romania	444.0	436.4	451.5
Netherlands	512.3	507.9	516.7	Bulgaria	441.2	433.3	449.1
Denmark	511.1	506.8	515.4	United Arab Emirates	427.5	422.7	432.3
Finland	511.1	506.5	515.7	Chile	422.7	417.6	427.7
Slovenia	509.9	507.4	512.4	Turkey	420.5	412.2	428.7
Belgium	507.0	502.3	511.7	Moldova	419.7	414.8	424.6
Germany	506.0	500.2	511.7	Uruguay	418.0	413.0	423.0
Poland	504.5	499.7	509.2	Montenegro	417.9	415.0	420.8
Ireland	503.7	499.6	507.8	Trinidad and Tobago	417.2	414.4	420.0
Norway	501.7	497.3	506.2	Thailand	415.5	409.4	421.5
Austria	496.7	491.0	502.4	Albania	413.2	406.3	420.0
New Zealand	495.2	490.7	499.7	Mexico	408.0	403.6	412.5
Vietnam	494.5	485.6	503.4	Georgia	403.8	398.3	409.4
Russia	494.1	487.9	500.2	Qatar	402.4	399.9	404.9
Sweden	493.9	487.6	500.2	Costa Rica	400.3	395.3	405.2
Australia	493.9	490.7	497.1	Lebanon	396.2	388.9	403.6
England	**493.4**	**487.5**	**499.3**	Colombia	389.6	385.1	394.2
France	492.9	488.7	497.1	Peru	386.6	381.2	392.0
Northern Ireland	492.8	483.6	501.9	Indonesia	386.1	380.0	392.2
Czech Republic	492.3	487.6	497.1	Jordan	380.3	375.0	385.5
Portugal	491.6	486.7	496.6	Brazil	377.1	371.4	382.8
Scotland	491.2	486.1	496.2	Macedonia	371.3	368.8	373.9
Italy	489.7	484.1	495.4	Tunisia	366.8	360.9	372.7
Iceland	488.0	484.1	492.0	Kosovo	361.5	358.3	364.8
Spain	485.8	481.6	490.1	Algeria	359.6	353.7	365.5
Luxembourg	485.8	483.2	488.3	Dominican Republic	327.7	322.4	333.0
Latvia	482.3	478.6	486.0	**OECD average**	**490.2**	**489.3**	**491.1**

E3. Mean scores in reading across countries

Country	Mean	Confidence Interval		Country	Mean	Confidence Interval	
		Lower	Upper			Lower	Upper
Singapore	535.1	531.8	538.4	Iceland	481.5	477.6	485.5
Hong Kong	526.7	521.3	532.0	Luxembourg	481.4	478.6	484.3
Canada	526.7	522.1	531.2	Israel	479.0	471.4	486.5
Finland	526.4	521.4	531.5	Wales	477.3	470.2	484.4
Ireland	520.8	515.9	525.7	Lithuania	472.4	467.0	477.9
Estonia	519.1	514.7	523.6	Hungary	469.5	464.2	474.8
South Korea	517.4	510.5	524.4	Greece	467.0	458.4	475.7
Japan	516.0	509.6	522.3	Chile	458.6	453.4	463.7
Norway	513.2	508.2	518.2	Slovakia	452.5	446.9	458.1
New Zealand	509.3	504.5	514.1	Malta	446.7	443.1	450.2
Germany	509.1	503.1	515.1	Uruguay	436.6	431.5	441.6
Macao	508.7	506.2	511.2	Romania	433.6	425.5	441.7
Poland	505.7	500.8	510.6	United Arab Emirates	433.5	427.8	439.3
Slovenia	505.2	502.3	508.1	Bulgaria	431.7	421.8	441.7
Netherlands	503.0	498.2	507.8	Turkey	428.3	420.4	436.2
Australia	502.9	499.5	506.3	Costa Rica	427.5	422.2	432.7
Sweden	500.2	493.2	507.1	Trinidad and Tobago	427.3	424.3	430.2
Denmark	499.8	494.8	504.9	Montenegro	426.9	423.7	430.0
England	**499.6**	**493.3**	**506.0**	Colombia	424.9	419.0	430.8
France	499.3	494.3	504.3	Mexico	423.3	418.1	428.4
Belgium	498.5	493.7	503.3	Moldova	416.2	411.2	421.2
Portugal	498.1	492.8	503.5	Thailand	409.1	402.5	415.8
Taiwan	497.1	492.1	502.1	Jordan	408.1	402.3	413.9
Northern Ireland	497.0	487.9	506.0	Brazil	407.3	401.9	412.8
United States	496.9	490.2	503.7	Albania	405.3	397.0	413.5
Spain	495.6	490.9	500.3	Qatar	401.9	399.9	403.9
Russia	494.6	488.5	500.8	Georgia	401.3	395.4	407.2
China	493.9	483.7	504.2	Peru	397.5	391.8	403.3
Scotland	493.2	488.7	497.7	Indonesia	397.3	391.6	403.0
Switzerland	492.2	486.2	498.2	Tunisia	361.1	355.0	367.2
Latvia	487.8	484.2	491.3	Dominican Republic	357.7	351.7	363.8
Czech Republic	487.3	482.1	492.4	Macedonia	351.7	348.9	354.5
Croatia	486.9	481.5	492.2	Algeria	349.9	343.9	355.8
Vietnam	486.8	479.3	494.2	Kosovo	347.1	344.0	350.2
Austria	484.9	479.2	490.5	Lebanon	346.5	337.8	355.3
Italy	484.8	479.4	490.1	**OECD average**	**492.5**	**491.6**	**493.5**

Appendix F. Long-term trends in PISA scores

F1. Trends in science scores across countries

	2006	2009	2012	2015
Singapore	-	542	551	556
Japan	531	539	547	538
Estonia	531	528	541	534
Taiwan	532	520	523	532
Finland	563	554	545	531
Macao	511	511	521	529
Canada	534	529	525	528
Vietnam	-	-	528	525
Hong Kong	542	549	555	523
China	-	-	-	518
South Korea	522	538	538	516
New Zealand	530	532	516	513
Slovenia	519	512	514	513
England	516	515	516	512
Australia	527	527	521	510
Germany	516	520	524	509
Netherlands	525	522	522	509
Switzerland	512	517	515	506
Ireland	508	508	522	503
Belgium	510	507	505	502
Denmark	496	499	498	502
Poland	498	508	526	501
Portugal	474	493	489	501
Northern Ireland	508	511	507	500
Norway	487	500	495	498
Scotland	515	514	513	497
United States	489	502	497	496
Austria	511	-	506	495
France	495	498	499	495
Sweden	503	495	485	493
Czech Republic	513	500	508	493
Spain	488	488	496	493
Latvia	490	494	502	490
Russia	479	478	486	487
Wales	505	496	491	485
Luxembourg	486	484	491	483

Source: OECD international data Table I.04.SCIE

Notes: Blue/red shading refers to a statistically significant decline/improvement in the average three-year trend in science assessments. Countries restricted to those presented in Table 2.1.

F2. Trends in mathematics scores across countries

Country	2003	2006	2009	2012	2015
Singapore	-	-	562	573	564
Hong Kong	550	547	555	561	548
Macao	527	525	525	538	544
Taiwan	-	549	543	560	542
Japan	534	523	529	536	532
China	-	-	-	-	531
South Korea	542	547	546	554	524
Switzerland	527	530	534	531	521
Estonia	-	515	512	521	520
Canada	532	527	527	518	516
Netherlands	538	531	526	523	512
Denmark	514	513	503	500	511
Finland	544	548	541	519	511
Slovenia	-	504	501	501	510
Belgium	529	520	515	515	507
Germany	503	504	513	514	506
Poland	490	495	495	518	504
Ireland	503	501	487	501	504
Norway	495	490	498	489	502
Austria	506	505	-	506	497
New Zealand	523	522	519	500	495
Vietnam	-	-	-	511	495
Russia	468	476	468	482	494
Sweden	509	502	494	478	494
Australia	524	520	514	504	494
England	-	495	493	495	493
France	511	496	497	495	493
Northern Ireland	-	494	492	487	493
Czech Republic	516	510	493	499	492
Portugal	466	466	487	487	492
Scotland	-	506	499	498	491
Italy	466	462	483	485	490
Iceland	515	506	507	493	488
Spain	485	480	483	484	486
Luxembourg	493	490	489	490	486
Latvia	483	486	482	491	482
Malta	-	-	463	-	479
Lithuania	-	486	477	479	478
Wales	-	484	472	468	478
Hungary	490	491	490	477	477
Slovakia	498	492	497	482	475
Israel	-	442	447	466	470
United States	483	474	487	481	470
Croatia	-	467	460	471	464

Source: OECD international data Table I.04.MATH and PISA database.

Notes: Blue/red shading refers to a statistically significant decline/improvement in the average three-year trend in mathematics assessments. Countries restricted to those in Table 4.1. Figures are reported back to 2003, where available, as this was the first time point when mathematics was the focus of PISA. However, figures for the UK countries are reported from 2006 onwards, due to the low response rate in 2003.

F3. Trends in reading scores across countries

Country	2009	2012	2015
Singapore	526	542	535
Hong Kong	533	545	527
Canada	524	523	527
Finland	536	524	526
Ireland	496	523	521
Estonia	501	516	519
South Korea	539	536	517
Japan	520	538	516
Norway	503	504	513
New Zealand	521	512	509
Germany	497	508	509
Macao	487	509	509
Poland	500	518	506
Slovenia	483	481	505
Netherlands	508	511	503
Australia	515	512	503
Sweden	497	483	500
Denmark	495	496	500
England	495	500	500
France	496	505	499
Belgium	506	509	499
Portugal	489	488	498
Taiwan	495	523	497
Northern Ireland	499	498	497
United States	500	498	497
Spain	481	488	496
Russia	459	475	495
China	-	-	494
Scotland	500	506	493
Switzerland	501	509	492
Latvia	484	489	488
Czech Republic	478	493	487
Croatia	476	485	487
Vietnam	-	508	487
Austria	-	490	485
Italy	486	490	485
Iceland	500	483	482
Luxembourg	472	488	481
Israel	474	486	479
Wales	476	480	477
Lithuania	468	477	472

Source: OECD international data Table I.04.READ and PISA database.

Notes: Blue/red shading refers to a statistically significant decline/improvement in the average three-year trend in reading assessments. Countries restricted to those in Table 5.1. The OECD long-term trend measure in reading uses 2009 as the base year due to the small number of 'trend' questions included in earlier cycles in this particular domain.

F4. Revisions to the PISA 2012 scores in England, Northern Ireland and Wales

Due to an error in the layout of the Welsh language version of the PISA 2012 student questionnaire, some of the information on pupil gender within the Wales sample in the PISA 2012 international database for the United Kingdom is incorrect. The error was not large enough to have a detectable impact on the UK's PISA 2012 results. However, it does have a small impact on estimates of overall scores and gender differences for Wales, Northern Ireland and England as pupil characteristics (including gender) are used in the calculations of estimated performance scores for individual pupils.

The tables that follow provide the mean score, variation and gender differences in mathematics, science and reading, for England, Northern Ireland and Wales, based on the corrected data. The data for Scotland is not affected by this revision as data for Scotland was collected, coded and analysed separately.

Appendix Table F4 compares the original scale scores according to the PISA 2012 publication (December 2013) to the revised scores published in May 2015. As the table illustrates, in all three countries, the impact upon mean scores, percentiles and gender differences was minimal; estimates of most of these statistics differed by around one scale score point or less. None of the key substantive findings therefore changed as a result of this anomaly.

For consistency with previously published information, and the fact the rescaling led to minimal changes, we have chosen to present results based upon the original scale scores throughout this report.

Appendix Table F4. A comparison of the original and revised PISA 2012 scale scores across England, Northern Ireland and Wales

(a) England

	Science		Mathematics		Reading	
	Original	**Revised**	**Original**	**Revised**	**Original**	**Revised**
Mean	515.8	515.8	495.2	495.7	499.9	499.8
10th percentile	384.3	384.3	370.5	371.9	370.7	372.1
25th percentile	449.1	449.1	429.8	430.8	438.2	437.7
75th percentile	587.1	587.1	562.2	562.5	568.2	568.7
90th percentile	641.7	641.7	618.5	619.5	621.3	622.7
Results by gender						
Mean boys	522.9	522.9	501.7	502.5	487.3	487.7
Mean girls	509.0	509.0	489.0	489.2	511.8	511.3
Gender gap (b - g)	13.8	13.8	12.7	13.3	-24.5	-23.6

Source: http://www.oecd.org/pisa/keyfindings/PISA-2012-UK-revised%20scores.xlsx

Note: Original refers to the initial scale scores before correction, as published in December 2013. Revised refers to the scale scores after correction, published in May 2015.

(b) Northern Ireland

	Science		Mathematics		Reading	
	Original	**Revised**	**Original**	**Revised**	**Original**	**Revised**
Mean	507.2	507.2	486.9	486.9	497.6	498.0
10th percentile	374.7	374.7	365.3	364.4	373.4	373.8
25th percentile	438.1	438.1	421.8	421.1	435.8	436.9
75th percentile	577.9	577.9	552.9	550.7	565.4	564.5
90th percentile	635.2	635.2	608.5	607.8	617.6	618.6
Results by gender						
Mean boys	509.8	509.8	491.8	491.4	484.5	484.5
Mean girls	504.4	504.4	481.5	482.0	511.9	512.6
Gender gap (b - g)	5.4	5.4	10.3	9.4	-27.4	-28.1

Source: http://www.oecd.org/pisa/keyfindings/PISA-2012-UK-revised%20scores.xlsx

Note: Original refers to the initial scale scores before correction, as published in December 2013. Revised refers to the scale scores after correction, published in May 2015.

(c) Wales

	Science		Mathematics		Reading	
	Original	**Revised**	**Original**	**Revised**	**Original**	**Revised**
Mean	490.9	490.9	468.4	468.7	479.7	479.7
10th percentile	370.1	370.1	359.7	359.9	364.6	363.5
25th percentile	428.1	428.1	409.8	411.9	420.7	421.1
75th percentile	556.3	556.3	526.4	526.1	541.5	541.7
90th percentile	609.2	609.2	577.6	577.2	592.8	593.3
Results by gender						
Mean boys	496.2	496.2	473.0	473.9	466.4	465.4
Mean girls	485.5	485.5	463.7	463.6	493.1	493.6
Gender gap (b - g)	10.7	10.7	9.3	10.3	-26.7	-28.2

Source: http://www.oecd.org/pisa/keyfindings/PISA-2012-UK-revised%20scores.xlsx

Note: Original refers to the initial scale scores before correction, as published in December 2013. Revised refers to the scale scores after correction, published in May 2015.

Appendix G. Mean scores in the science sub-domains

Country	Physical	Living	Earth and Space
Singapore	**555***	**558***	**554***
Japan	**538***	**538***	**541***
Estonia	**535***	**532***	**539***
Taiwan	**531***	**532***	**534***
Finland	**534***	**527***	**534***
Macao	**533***	**524***	**533***
Canada	**527***	**528***	**529***
Vietnam	-	-	-
Hong Kong	**523***	**523***	**523***
China	520	517	516
South Korea	517	511	521
New Zealand	515	512	513
Slovenia	514	512	514
England	512	512	513
Australia	511	510	509
Germany	505	509	512
Netherlands	511	**503***	513
Switzerland	503	506	508
Ireland	507	**500***	**502***
Belgium	**499***	**503***	**503***
Denmark	508	**496***	**505***
Poland	**503***	**501***	**501***
Portugal	**499***	**503***	**500***
Northern Ireland	**501***	**498***	**498***
Norway	**503***	**494***	**499***
Scotland	**499***	**497***	**494***
United States	**494***	**498***	**496***
Austria	**497***	**492***	**497***
France	**492***	**496***	**496***
Sweden	**500***	**488***	**495***
Czech Republic	**492***	**493***	**493***
Spain	**487***	**493***	**496***
Latvia	**490***	**489***	**493***
Russia	**488***	**483***	**489***
Wales	**486***	**482***	**485***
Luxembourg	**478***	**485***	**483***
Italy	**479***	**479***	**485***
Hungary	**481***	**473***	**477***
Lithuania	**478***	**476***	**471***
Croatia	**472***	**476***	**477***
Iceland	**472***	**476***	**469***
Israel	**469***	**469***	**457***
Malta	-	-	-
Slovakia	**466***	**458***	**458***
Greece	**452***	**456***	**453***

Notes: Table only includes countries with an average score above 450 points on the overall PISA science scale. Countries ordered by average score on the overall PISA science scale. Information on sub-domain scores is not available for Malta and Vietnam. Green/red cells indicate where the mean score for the country is at least five points higher/lower than for the mean score for the 'living' system. Information on sub-domain scores is not available for Malta and Vietnam. * and bold indicate significant difference from England.

Country	Explain phenomena scientifically	Evaluate and design scientific enquiry	Interpret data and evidence scientifically
Singapore	**553***	**560***	**556***
Japan	**539***	**536***	**541***
Estonia	**533***	**535***	**537***
Taiwan	**536***	**525***	**533***
Finland	**534***	**529***	**529***
Macao	**528***	**525***	**532***
Canada	**530***	**530***	**525***
Vietnam	-	-	-
Hong Kong	**524***	**524***	**521***
China	520	517	516
South Korea	510	515	**523***
New Zealand	511	517	512
Slovenia	515	511	512
England	512	510	512
Australia	510	512	508
Germany	511	506	509
Netherlands	509	511	506
Switzerland	505	507	506
Ireland	505	**500***	**500***
Belgium	**499***	507	**503***
Denmark	**502***	504	**500***
Poland	**501***	502	**501***
Portugal	**498***	502	**503***
Northern Ireland	**500***	**497***	**501***
Norway	**502***	**493***	**498***
Scotland	**498***	**498***	**493***
United States	**492***	**503***	**497***
Austria	**499***	**488***	**493***
France	**488***	**498***	**501***
Sweden	**498***	**491***	**490***
Czech Republic	**496***	**486***	**493***
Spain	**494***	**489***	**493***
Latvia	**488***	**489***	**494***
Russia	**486***	**484***	**489***
Wales	**486***	**481***	**483***
Luxembourg	**482***	**479***	**486***
Italy	**481***	**477***	**482***
Hungary	**478***	**474***	**476***
Lithuania	**478***	**478***	**471***
Croatia	**476***	**473***	**476***
Iceland	**468***	**476***	**478***
Israel	**463***	**471***	**467***
Malta	-	-	-
Slovakia	**464***	**457***	**459***
Greece	**454***	**453***	**454***

Notes: Table only includes countries with an average score above 450 points on the overall PISA science scale. Countries ordered by mean score on the overall PISA science scale. Green/red cells indicate where the mean score for the country is at least five points higher/lower than the mean score for ‘evaluating and designing scientific enquiry’. Information on sub-domain scores is not available for Malta and Vietnam. * and bold indicate significant difference from England.

Country	Content knowledge	Procedural and epistemic knowledge
Singapore	**553***	**558***
Japan	**539***	**538***
Estonia	**534***	**535***
Taiwan	**538***	**528***
Finland	**534***	**528***
Macao	**527***	**531***
Canada	**528***	**528***
Vietnam	-	-
Hong Kong	**526***	**521***
China	520	516
South Korea	513	519
New Zealand	512	514
Slovenia	515	512
England	511	513
Australia	508	511
Germany	512	507
Netherlands	507	509
Switzerland	506	505
Ireland	504	**501***
Belgium	**498***	506
Denmark	**502***	**502***
Poland	**502***	**501***
Portugal	**500***	**502***
Northern Ireland	**499***	**501***
Norway	**502***	**496***
Scotland	**496***	**496***
United States	**490***	**501***
Austria	**501***	**490***
France	**489***	**499***
Sweden	**498***	**491***
Czech Republic	**499***	**488***
Spain	**494***	**492***
Latvia	**489***	**492***
Russia	**488***	**485***
Wales	**486***	**484***
Luxembourg	**483***	**482***
Italy	**483***	**479***
Hungary	**480***	**474***
Lithuania	**478***	**474***
Croatia	**476***	**475***
Iceland	**468***	**477***
Israel	**462***	**470***
Malta	-	-
Slovakia	**463***	**458***
Greece	**455***	**454***

Notes: Table only includes countries with an average score above 450 points on the overall PISA science scale. Countries ordered by mean score on the overall PISA science scale. Green/red cells indicate where the mean score for the country is at least five points higher/lower than for the mean score on the content knowledge scale. Information on sub-domain scores is not available for Malta and Vietnam. * and bold indicate significant difference from England.

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