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

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Introduction

The Programme for International Student Assessment (PISA), led by the Organisation for Economic Co-operation and Development (OECD), provides participating countries with a snapshot of the science, mathematics and reading abilities of their 15-year-olds that can be compared directly to the performance of 15-year-olds across the world. As well as an international comparison of what 15-year-olds can do, the PISA study also provides contextual information about the schools, teachers and teaching that pupils experience in each of the participating countries. PISA enables us to make international comparisons, benchmark ourselves within the rest of the world, and to spot particular strengths and weaknesses in our education system.

PISA has been conducted every three years since 2000, with Northern Ireland (as part of the United Kingdom) having participated in each round. Over 70 countries participated in the 2015 edition of PISA, including all members of the OECD and all four countries within the UK.

Pupils were assessed in three subjects (science, mathematics and reading) and also in collaborative problem solving[1]. Contextual information was also gathered from all participating pupils and schools. Each time PISA is conducted, one subject is the focus, in 2015, it was the turn of science, having last been the focus of PISA in 2006. In 2015 PISA was administered in the majority of countries as a computer-based assessment (CBA) for the first time.

This national report for Northern Ireland is published simultaneously with the OECD's international report on PISA 2015. It complements the OECD's report by (i) providing a more focused comparison of Northern Ireland with other countries' education systems and (ii) providing analysis of differences within Northern Ireland across school and pupil characteristics.

International comparisons of Northern Ireland in the national report include contrasts with a number of different groups. This includes the average across industrialised countries (the 'OECD average') and the average across the 10 countries with the highest average PISA scores (usually in reference to the science domain). The 10 'high-performing' countries in PISA science are Singapore, Japan, Estonia, Taiwan, Finland, Macao, Canada, Vietnam, Hong Kong and China. The report reveals that pupil attitudes and outcomes, along with principals' views, vary widely amongst these high-performing countries.

Analysis of differences within Northern Ireland is enhanced by linking PISA results to administrative records about pupils and schools. This allows us to consider for the

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

first time how PISA scores differ between different school types (e.g. grammar schools versus non-grammar schools) and by various pupil characteristics such as religion and eligibility for Free School Meals (FSM).

PISA 2015 in Northern Ireland achieved a response rate of 90 per cent for schools and 89 per cent for pupils. This resulted in a final sample of 2,401 pupils in Northern Ireland from across 95 schools. These are high response rates by the standard of school-based studies in Northern Ireland, and meet the strict requirements for participation by the OECD.

While the analysis in each chapter uncovers correlations, it does not establish cause and effect. Moreover, changes in PISA 2015 results from previous cycles should not be taken as providing evidence as to the impact of any previous or ongoing educational reform.

Achievement in science

The average PISA science score for Northern Ireland in 2015 was 500. This is not significantly different to the average in 2006 (508). There are 14 countries where the mean science score is at least 10 points (a third of a year of schooling) ahead of Northern Ireland, and 38 countries where the mean science score is at least 10 points lower. Finland, Wales, Australia and New Zealand are examples of countries where there has been a sustained fall in average science scores since 2006. Portugal and Macao are two of the few countries where there has been a statistically significant and sustained improvement in science achievement over the last decade.

The top-performing 10 per cent of pupils in Northern Ireland achieved a PISA science score of at least 618 points. There are 17 countries where the top 10 per cent of pupils are more than a quarter of a year of schooling ahead of their peers in Northern Ireland. In comparison, the lowest achieving 10 per cent of pupils in Northern Ireland scored below 379 on the PISA science test. However, there were only nine countries where the lowest 10 per cent of pupils were ahead of Northern Ireland pupils by more than a quarter of a year of schooling.

There has been a sustained fall in the PISA science scores of the highest achieving pupils in Northern Ireland over the last decade. In 2006, the top 10 per cent of pupils achieved a PISA science score of at least 652 points. By 2015, this had fallen to 618 points; approximately one year of schooling lower.

Achievement in different aspects of scientific literacy

Pupils in Northern Ireland achieved similar scores in what PISA defines as the ‘living scientific system’ (which roughly equates to biology), the ‘physical system’ (which measures knowledge about matter, motion and forces), and ‘earth and space sciences’ (looking at earth’s history, the earth in space, and the universe). The PISA 2015 test also examined pupils’ skills in three core scientific competencies: ‘interpreting data and evidence scientifically’, ‘evaluating and designing scientific enquiry' and 'explaining phenomena scientifically'. Pupils in Northern Ireland are equally strong across these three areas. However, this finding is not specific to Northern Ireland, and occurs in several other industrialised countries as well.

Achievement in mathematics

The average PISA mathematics score for Northern Ireland in 2015 was 493. The average score has remained stable over the last decade, and is at a similar level in 2015 as it was in 2006 (494). There are 18 countries where the mean mathematics score is at least a quarter of a year of schooling ahead of Northern Ireland, and 36 countries where the mean mathematics score is at least a quarter of a year of schooling behind. The top seven ranked jurisdictions in PISA mathematics are all within East Asia.

Although Northern Ireland's average mathematics score has remained stable, a number of countries have caught up over the last decade, including Italy, Portugal and Russia. On the other hand, the Czech Republic, Australia, New Zealand and Iceland all had similar average PISA mathematics scores to Northern Ireland in 2015, having previously been ahead of this country in 2006.

The lowest performing 10 per cent of pupils in Northern Ireland achieved a PISA mathematics score below 388 points. There are 10 countries where the bottom 10 per cent of pupils in mathematics are more than a quarter of a year of schooling above their peers in Northern Ireland (statistically significant in eight). In comparison, the highest achieving 10 per cent of pupils in Northern Ireland scored above 592 points on the PISA mathematics test. There are 32 countries where the highest achieving pupils are at least a quarter of a year of schooling ahead of the highest achieving pupils in Northern Ireland (statistically significant in 31). In only six OECD countries (Latvia, Wales, Greece, Turkey, Mexico and Chile) is the mathematics performance of the highest achievers lower than in Northern Ireland.

Due to this comparatively low performance of high achieving pupils, inequality in 15-year-olds' mathematics skills is lower in Northern Ireland than almost anywhere else in the industrialised world. Nevertheless, the comparatively low performance of Northern Ireland's high achieving pupils in mathematics is a significant weakness of the education system. More needs to be done to stretch the most able pupils in mathematics.

Achievement in reading

The average PISA reading score for Northern Ireland in 2015 was 497. This has remained stable since 2006 (495). There are 12 countries where the mean reading score is at least a quarter of a year of schooling ahead of Northern Ireland, and 39 countries where the mean reading score is at least a quarter of a year of schooling lower (statistically significant in 37). Countries with a similar average reading score to Northern Ireland include China, Scotland, England and Australia.

Although Northern Ireland's average reading score has remained stable, there have been changes in the performance of a number of other countries over the last decade. Some of the higher-performing countries in 2006 have experienced a decline in PISA reading scores, including South Korea (556 to 517), Finland (547 to 526) and New Zealand (521 to 509). Meanwhile, other countries have caught up with Northern Ireland in reading, including Russia (440 in 2006 to 495 in 2015), Spain (461 to 496) and Portugal (472 to 498).

The lowest performing 10 per cent of pupils in Northern Ireland achieved a PISA reading score below 385 points. There are seven countries where the bottom 10 per cent of pupils in reading are more than a quarter of a year of schooling above their peers in Northern Ireland. In comparison, the top 10 per cent of pupils in Northern Ireland achieve a PISA reading score of more than 605 points. There are 23 countries where the reading scores of the top 10 per cent of pupils are at least a quarter of a school year higher (statistically significant in 21). Consequently, the gap between the highest and lowest achieving pupils in reading in Northern Ireland stands at 220 test points; this is amongst the lowest anywhere in the industrialised world (OECD average 249 points).

Variation in scores by pupil characteristics

In Northern Ireland, the difference in average PISA scores between boys and girls is not statistically significant in science or mathematics. This is not an unusual finding; similar results hold in many other OECD countries as well. Girls in Northern Ireland achieve higher average reading scores than boys. However, at around six months of schooling, the gender gap in reading skills in Northern Ireland is actually smaller than in most other developed countries (the average across OECD countries is around 11 months of schooling).

Although there are clear socio-economic differences in 15-year-olds' PISA scores in Northern Ireland, these do not stand out as particularly large or small relative to other countries. In science, the gap between pupils from the most and least advantaged 25 per cent of families in Northern Ireland is around 80 test points (nearly three years of schooling). This is similar to the average across industrialised countries (88 points).

Around 30 per cent of 15-year-olds from disadvantaged socio-economic backgrounds in Northern Ireland manage to achieve a PISA science score that puts them in the top 25 per cent of test takers internationally. When looking across countries, there is little association between the use of academic selection to assign pupils into different post-primary schools and the proportion of disadvantaged pupils who manage to succeed academically against the odds.

There is no evidence that PISA scores differ significantly between pupils from Protestant and Catholic community backgrounds.

Differences in achievement between schools

In Northern Ireland, 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 an unusual finding; a similar pattern occurs across a diverse set of countries within the OECD (e.g. England, Finland, South Korea, United States). However, it is somewhat different to some other countries that use academic selection to determine entry into post-primary schools, such as the Netherlands and Germany, where differences in achievement are just as big between schools as they are within schools.

Pupils who attend grammar schools achieved the highest average PISA scores. Their performance in science, with an average score of 553, puts their achievement on a par with young people in the highest performing PISA countries, such as Singapore. Pupils in non-grammar schools achieved an average PISA score of 457 in the science domain, equivalent to the mean score of countries like Greece and Slovakia. 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

Principals in Northern Ireland are much more likely to regularly use pupil performance data to develop their school's goals than principals in other countries. Within Northern Ireland, principals who lead schools with a greater proportion of disadvantaged pupils are more likely to pay regular attention to disruptive classroom behaviour.

A lack of good-quality school infrastructure stands out as a particular concern of principals in Northern Ireland. There is little evidence that principals are more likely to report a lack of educational resources as a barrier to learning if they lead a school with a high proportion of disadvantaged pupils.

Another key concern of principals in Northern Ireland is the level of absenteeism amongst their staff; almost a third of post-primary pupils are taught in schools where the principal believes that staff absenteeism is hindering pupils' learning. This is also above the OECD average and the average across the 10 countries with the highest average PISA science scores. Within Northern Ireland, staff absenteeism is a particular concern of principals who lead post-primary schools with a large proportion of disadvantaged pupils.

Extensive quality-assurance processes are already in place within the Northern Ireland education system. Principals in Northern Ireland report that external inspections lead to a lasting impetus for change, particularly within schools with a high proportion of socio-economically disadvantaged pupils.

Pupils' aspirations for the future

Most pupils in Northern Ireland believe that the content of their school science lessons is helping to prepare them for the future; 75 per cent agree that it will help them to get a job and 80 per cent that it will improve their career prospects. This is similar to the average across the 10 high-performing countries, and holds true irrespective of pupils' gender, socio-economic status and level of academic achievement.

Almost a third of pupils (31 per cent) in Northern Ireland hope to be working in a science related career by age 30. This is above the average across industrialised countries (24 per cent) and above the average across high-performing countries (22 per cent). Boys are more likely to want to become a scientist, engineer or ICT professional than girls, who are more likely to aspire to work in a heath related field. There is no evidence that countries with higher average PISA science scores have a greater proportion of 15-year-olds who expect to be working in a science career at age 30.

Almost half (45 per cent) of 15-year-olds in Northern Ireland expect to obtain an undergraduate degree. Girls (49 per cent) are more likely to expect to complete university than boys (40 per cent). Two-thirds of Northern Ireland pupils from the most advantaged socio-economic backgrounds expect to complete university, compared to around a quarter of pupils from low socio-economic households. Course content, employment prospects and entry requirements are the most important factors influencing 15-year-olds' thoughts about which university to apply to, while distance from home, fitting-in and academic ranking are the least important. Among the subset of 15-year-olds who plan to apply to university, around a quarter intend to leave Northern Ireland and study overseas, while a third listed Queen's University Belfast as their first choice.

Pupils' experiences of their time in science classes at school

Post-primary school pupils in Northern Ireland report having around four hours of timetabled science lessons per week, which is more than the OECD average (3.5 hours). However, there is no evidence that countries with more hours of instruction in science have higher average PISA scores. In only two out of the 10 high-performing countries are additional study hours (i.e. hours outside of pupils' regular timetable) reported to be much higher than the 18.5 hours in Northern Ireland. These are Singapore (22 hours) and China (27 hours).

There is more frequent low-level disruption in science classrooms in Northern Ireland than in the average high-performing country. For instance, 32 per cent of 15-year-olds in Northern Ireland reported that pupils regularly do not listen what their science teacher says, while 32 per cent of pupils say that there is frequent noise and disorder. This compares to an average across the 10 high-performing countries of around 20 per cent. There is a particularly stark contrast between science classrooms in Northern Ireland and science classrooms in the high-performing East Asian nations in this respect.

Less than half of pupils in Northern Ireland report that their science teacher provides them with regular feedback, such as how they are performing on their course (31 per cent), their areas of strength (31 per cent) and areas for improvement (36 per cent). However, Northern Ireland is not unusual in this respect, with a slightly lower proportion of pupils saying that they receive regular feedback from their science teachers in the average OECD country and the average high-performing country.

PISA across the UK

The average PISA 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 PISA 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.

One-in-three (32 per cent) pupils in Wales lacks basic skills in at least one of the three PISA domains, compared to 29 per cent in England and Scotland, and 25 per cent in Northern Ireland. Across the UK, around 10 per cent of pupils lack basic skills in all three PISA subject areas. In England, 18 per cent of pupils are classified as a high-achiever in at least one of the PISA subjects, compared to 13 per cent in Scotland, 11 per cent in Northern Ireland and eight per cent in Wales.

In Scotland, Northern Ireland and Wales, the science skills of the top 10 per cent of pupils have declined by more than eight months of schooling between 2006 and 2015. The same is not true in England, where the PISA scores of the top 10 per cent of pupils has remained broadly stable over the last decade.

Socio-economic differences in 15-year-olds' PISA scores are smaller in Wales than in the rest of the UK. 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.

A lack of teaching staff and teachers not meeting individual pupils' needs stand out as a particular concern amongst principals in England and Scotland; more so than for principals in Northern Ireland and Wales.

Chapter 1. Introduction

1. The Programme for International Student Assessment (PISA) is a global benchmarking study of pupil performance by the Organisation for Economic Co-operation and Development (OECD)[2]. It provides a comparison of what 15-year-olds within participating countries 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.

2. The inaugural PISA study took place in 2000, and has since been conducted on a three-year cycle. All OECD members participate in PISA, with Table 1.1 providing a list of countries and 'economies' (geographic regions within countries) that took part in 2015[3]. Members of the OECD are highlighted in bold[4].

3. Although 75 countries participated in PISA 2015, four countries have been excluded from the international report due to issues with the sampling frame, failure to meet the OECD response rate criteria, or issues with the marking. These four countries (Argentina[5], Malaysia, Kazakhstan and Cyprus) are excluded from this report, bringing the total number of countries down to 71[6].

4. In Northern Ireland, PISA was conducted between November and December 2015. A total of 95 schools and 2,401 pupils took part. The study was carried out on behalf of the Department for Education by a consortium of RM Education, University College London (UCL) Institute of Education and World Class Arena Limited. Throughout this report, we refer to this consortium as the National Centre.

[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] Four provinces within China participated in PISA 2015: Beijing, Guangdong, Jiangsu and Shanghai. For convenience, we refer to the results for these four provinces combined as 'China'. However, when interpreting the results, it is important to remember that the PISA sample for 'China' is based upon only these four regions.
[4] See NCES Website for a list of countries that have participated in each round of PISA.
[5] Although the OECD have deemed the data for Argentina to be unrepresentative, the region of Buenos Aires did satisfy the sampling criteria. This region of Argentina has therefore been included in the OECD tables. However, the whole of Argentina (including Buenos Aires) is excluded from this report.
[6] Additionally, in Albania, pupils' responses to the background questionnaire cannot be linked to the PISA test score data. Following the OECD, we will include Albania in all international comparisons of PISA test scores. However, Albania will be excluded from any analysis linking PISA scores to background information, such as gender and socio-economic status.

Table 1.1 Countries participating in PISA 2015

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

Notes: Table includes all countries/economies participating in PISA 2015. Members of the OECD are highlighted in **bold**. + indicates limitations with the data meaning exclusion from the OECD report. * *China* refers to the four Chinese provinces that participated (Beijing, Guangdong, Jiangsu and Shanghai).

5. There are a number of differences between PISA 2015 and previous cycles. First, PISA 2015 was a computer-based assessment (CBA). This is in contrast to the five PISA cycles that took place between 2000 and 2012, which were all paper-based tests. Second, science was the focus of the PISA 2015 study, having last been the focus in 2006[7]. Finally, in 2015 a new 'collaborative problem solving' domain was added to the PISA assessment[8].

[7] Reading was the focus of PISA 2009, and mathematics in 2012.
[8] The results for collaborative problem solving will be released by the OECD in 2017, and are therefore not covered in this report.

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

- *What is the policy background to this report?*
- *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?*

1.1 What is the policy background to this report?

7. The Department of Education in Northern Ireland has over the past period been focussed on enabling all young people to reach their potential, with emphasis upon raising standards for all, and tackling the long tail of underachievement, particularly that arising from social disadvantage.

8. The primary tool for delivering improved educational outcomes has been the school improvement policy *Every School a Good School*. By setting out the qualities of a good school, and making these the basis of schools' own self-evaluation and planning as well as the external evaluation through the Education and Training Inspectorate (ETI), improvement has been seen across the schools in Northern Ireland. There have been effective arrangements to address weaknesses wherever the outcome of inspection is less than good, through obligatory action planning, targeted support and follow-up inspection.

9. Another key aspect of educational policy has been the delivery of a skills-based curriculum and associated assessment arrangements. This has included the setting of a statutory minimum number and range of courses from which learners at Key Stage (KS) 4 and post-16 have an entitlement to choose. Broadening the range of subjects available in these years has had the effect of securing greater commitment amongst learners to following economically relevant and personally engaging courses. It has also brought schools together in collaborative partnerships, including with Further Education, to deliver the curriculum on an area basis.

10. The period has also seen the most significant change in school governance in a generation, with the creation of a single Education Authority from the previous five Education and Library Boards. The process of organisational change is ongoing, with the regionalisation and reorganisation of services in the new environment.

11. The process of area planning in support of the Sustainable Schools Policy (SSP) has also contributed to improved outcomes. The SSP is the policy framework used to ensure that all pupils have access to a broad and balanced curriculum that meets their needs in educationally sustainable and financially viable schools, making the best use of available resources.

12. There have been direct interventions in support of those most at risk of underachieving. The Department sustains long-term and system-based programmes of support to children with special educational needs, newcomers, Traveller and Roma children, looked-after children and others. There have also been programmes of targeted support to children from disadvantaged backgrounds (as measured by entitlement to Free School Meals), both within the classroom and within the community. A system-wide, two-year programme of recruiting newly qualified teachers to supplement the staffing of schools serving a high proportion of disadvantaged children was notably successful, and the learning from that programme is being rolled out.

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

13. The main component of PISA is a two hour test, where participating school pupils across the world are assessed in their ability to address 'real life' challenges involving reading, mathematics and science. PISA is therefore a measure of young people's 'functional competence' in these academic domains. This differentiates PISA from other international pupil assessments, such as the Trends in International Mathematics and Science Study (TIMSS), which aims to measure knowledge of particular curriculum content areas. (The most recent TIMSS study also took place in 2015, with the results published in November 2016[9]). It is also one of the differences between PISA and the General Certificate of Secondary Education (GCSE) exams – see Box 1.1 for further information.

[9] Northern Ireland participated in TIMSS 2015 primary school study. It did not participate in the TIMSS post-primary school study.

Box 1.1. The difference between PISA and GCSEs

PISA tests young people's skills in reading, mathematics and science; subjects that are also assessed in General Certificate of Secondary Education (GCSE) exams. Although there is a strong correlation between young people's PISA scores and GCSE grades[10], there are also important differences in terms of patterns of pupil performance[11]. In this box, we describe some of the key differences between PISA and GCSEs:

Type of skill assessed: Whereas GCSEs examine pupils' knowledge of national curricula, PISA attempts to measure young people's 'functional skills' – their ability to apply knowledge to solve problems in real world situations.

Timing: In Northern Ireland, the PISA tests were sat in November/December 2015. For most of the participating pupils, this was six months before their GCSE exams, which were taken in May/June 2016.

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

Question style: Previous analysis of the PISA test questions found that they typically require a greater amount of reading than GCSE exams (NFER 2006), particularly in science.

Stakes: PISA is a 'low stakes' test for pupils; they 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.

[10] Micklewright and Schnepf (2006).
[11] Jerrim and Wyness (2016).

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

15. In addition to the PISA test, 15-year-olds in all participating countries completed the PISA 'pupil questionnaire'. This asked young people to provide detailed information about their economic and social background, attitude towards school, out-of-school activities and life satisfaction. 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.

16. In all countries, principals 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 this report (see chapter 8).

17. The data for the PISA 2015 study in Northern Ireland has been augmented in two ways. First, each country is allowed to add up to five questions to the pupil background questionnaire. The National Centre took up this option, adding a set of questions asking young people about their plans regarding higher education. This included the likelihood of applying to university, names of universities to which they may apply, the factors that will be important to them when selecting a university, and with whom they have discussed their plans regarding higher education. The resulting data are analysed as part of chapter 9.

18. Second, the PISA 2015 data for Northern Ireland has been linked to national administrative records. At the school level this includes information on type of school (e.g. grammar versus non-grammar), the percentage of pupils who are eligible for Free School Meals (FSM) and the percentage of pupils of Catholic and Protestant community background. At the pupil level, young people's PISA scores and survey responses have been linked to information from the annual Northern Ireland school census. This includes data on religion and eligibility for FSM. The inclusion of this information allows for a much richer analysis of the PISA data for Northern Ireland than would otherwise be possible.

1.3 How was the PISA 2015 sample recruited in Northern Ireland? And how representative is it of the population?

19. PISA 2015 collected information from 95 schools and 2,401 pupils in Northern Ireland. These numbers reflect official response rates in Northern Ireland of 90 per cent for schools and 89 per cent for pupils, meeting the strict response rate requirements of the OECD[12].

20. PISA was conducted in Northern Ireland during November and December 2015. These dates were chosen in order to avoid a clash with national GCSE assessments and to reduce the burden on participating schools. Rather than an assessment of all pupils aged 15 in each country, a two stage survey design is used to select schools and pupils to take part in the study.

21. Schools in Northern Ireland were randomly selected to be representative of the national distributions of school type and location. Table 1.2 provides further information on the schools included in the PISA sample. Summary statistics are provided for the percentage of pupils in each school who are eligible for FSM, the percentage who attended each school type, and location (urban versus rural). Overall, the achieved PISA 2015 sample appears similar to the initially selected sample at the school level. However, as there are only three independent schools in the PISA 2015 sample for Northern Ireland, estimates for this particular type of school will be accompanied by large margins of error. A similar caveat holds for schools in a rural location (13 schools) and schools with more than 75 per cent of Protestant pupils.

22. Within each participating school, a simple random sample of 30 pupils, who met the PISA age definition, were then selected to participate. Further details on this process can be found in Appendix B. In Northern Ireland, this meant an initially selected sample of 2,820 pupils from within the participating schools. A total of 2,401 of these pupils completed the PISA assessment, with 288 pupils absent on the day of the test, 115 pupils excluded from the sample[13], while 16 pupils were ineligible as they did not meet the PISA population definition.

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[12] 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. School level response rate reported after replacement schools included. See Appendix B for further details.
[13] 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 115 pupils excluded from the PISA sample in Northern Ireland, 37 per cent had a Special Educational Need.

Table 1.2 The sample of schools participating in PISA 2015 in Northern Ireland

	Initial sampled schools	Final participating schools
Percentage of FSM eligible pupils (mean)	29	29
Percentage of SEN pupils (mean)	22	22
School type		
Non-grammar	53%	56%
Grammar	39%	41%
Independent	8%	3%
School management		
Controlled	24%	23%
Catholic maintained	28%	31%
Voluntary grammar	31%	34%
Independent	8%	3%
Other	8%	10%
Religion (non-independent schools)		
>75% Protestant	20%	19%
>75% Catholic	53%	54%
Mixed	28%	27%
Location (non-independent schools)		
Rural	13%	14%
Urban	87%	86%
Total number of schools	**106**	**95**

Source: PISA 2015 database.

Notes: Figures based upon unweighted data, and reported only for those schools where the relevant piece of information is available.

23. Table 1.3 compares the background characteristics of three nested groups of pupils:

Column 1 = The 2,401 pupils who completed the PISA assessment

Column 2 = The 2,689 pupils who either completed the PISA assessment or were absent on the day of the test

Column 3 = All 2,820 initially selected pupils (including those who were eventually excluded or deemed ineligible)

24. Overall, there is relatively little difference in the distribution of pupil characteristics across the three groups. For instance, 31 per cent of pupils who

completed the PISA test were Protestant. A very similar figure holds once those pupils who were absent on the test day are also included (32 per cent). Similar findings hold for Free School Meal eligibility (24 per cent versus 25 per cent), Special Educational Needs (18 per cent versus 18 per cent) and average attendance records (94 per cent across all groups). Table 1.3 therefore indicates that the 2,401 pupils who completed the PISA test are similar to the initially selected sample in terms of observable characteristics. This, by inference, means pupils who completed the PISA test were representative of all 15-year-old pupils in Northern Ireland.

25. For many of the demographic groups presented in Table 1.3, sample sizes are relatively small. For instance, only 67 of the pupils who completed the PISA test were non-White. Similarly, a total of 30 pupils who took part in PISA were Newcomers with English as an Additional Language. Although sample sizes are somewhat larger for other groups of interest (581 pupils eligible for Free School Meals took part in PISA in Northern Ireland), there will nevertheless be quite a large degree of sampling error in the results reported for these particular sub-groups.

Table 1.3 The sample participating in PISA 2015 in Northern Ireland

	(1)	(2)	(3)
	Assessed	**Assessed + absent**	**Assessed + absent + ineligible + excluded**
FSM eligible			
No	74%	73%	72%
Yes	24%	25%	26%
Missing data	2%	2%	2%
Newcomer			
No	97%	97%	96%
Yes	1%	1%	2%
Missing data	2%	2%	2%
Gender			
Female	51%	50%	49%
Male	49%	50%	51%
SEN			
No	80%	79%	79%
Yes	18%	18%	19%
Missing data	2%	2%	2%
Ethnicity			
Not White	3%	3%	3%
White	95%	95%	95%
Missing data	2%	2%	2%
Religious group			
Protestant	31%	32%	32%
Roman Catholic	59%	59%	58%
Other or Missing data	10%	10%	10%
Grade			
Year 11	17%	17%	17%
Year 12	83%	83%	83%
Percent attendance			
Mean	94%	93%	93%
MDM rank			
Mean (standard deviation)	293 (171)	291 (172)	290 (172)
Total number of pupils	**2,401**	**2,689**	**2,820**

Source: PISA 2015 matched database.

Notes: Figures based upon unweighted data. MDM rank is the Multiple Deprivation Measure rank of the ward where the pupil resides. Figures reported where data is known. Figures may not sum to 100 per cent due to rounding.

26. Although the PISA 2015 data for Northern Ireland is representative of the target population, the fact that it is based upon a sample (rather than a census) means there will be a degree of uncertainty in all results. It is therefore important that this uncertainty is reflected within our statistical analysis. This is done in one of the following two ways. First, 95 per cent confidence intervals will be presented within many of the graphs (represented using a thin black line). These refer to an upper and lower bound of the impact sampling error is likely to have upon the estimate. Alternatively, we will state whether a difference is 'statistically significant' or not at the five per cent level. This simply means that the difference found (e.g. in average PISA scores between two countries) is unlikely to be due to PISA being based upon a sample from the target population, rather than a census[11]. 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. Rather, such terms are used throughout this report to describe the likely impact of sampling error alone.

27. 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.

1.4 Have there been any important changes since the last PISA wave?

28. A number of changes have been made to PISA in 2015. For instance, 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 upon science 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 proficiency scales. Finally, pupils' collaborative problem solving skills were tested for the first time within the PISA assessment.

29. There are three main implications of science being the focus of PISA 2015. First, the assessment included a greater number of science test questions than in the previous two cycles (when mathematics and reading were the focus of the study). School pupils' science skills are therefore measured with greater precision in PISA 2015 than in previous cycles as a result. 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 young people’s attitudes, expectations and beliefs about science is possible than in either 2009 or 2012.

30. The change to CBA 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 young people use to answer test items. The change also, however, introduces a challenge in comparing performance measured by CBA with performance measured by paper-based assessment. This includes comparisons of PISA test scores across cycles, and between countries who conducted the PISA 2015 assessment on computer and those that conducted the 2015 assessment on paper. (A total of 15 countries participating in PISA 2015 continued to use paper-based assessment)[14]. The performance measure may, for example, be impacted by changes to the administration of the test, or the ways in which pupils interact with the assessment items.

31. To adjust for the change in test administration mode, ensuring 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 as the basis of linking PISA 2015 scores to those from previous cycles. Further details on this methodology are available from the OECD in the annexes to the PISA 2015 international reports.

32. A number of other technical aspects of the PISA study have changed in 2015 from previous rounds. These include 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 that pupils did not have time to complete during the test window are treated. These factors could also potentially lead to changes in the pattern of results from previous cycles. Further details regarding these changes have been provided by the OECD in the annexes to the PISA 2015 international reports.

33. Finally, in May 2015 an issue was discovered with the layout of the 2012 Welsh language pupil questionnaire in Wales. This had a slight impact on the

[14] These countries are Albania, Algeria, Argentina, Georgia, Indonesia, Jordan, Kazakhstan, Kosovo, Lebanon, Macedonia, Malta, Moldova, Romania, Trinidad and Tobago, and Vietnam.

estimated performance scores for pupils in England, Northern Ireland and Wales, altering these estimates by around half a PISA scale point. This report continues to quote the original PISA 2012 results, however Annex F 4 provides further details on this issue and presents the revised estimates for each country.

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

34. PISA provides comparative evidence on the 'functional ability' of 15-year-olds in key academic areas. It allows one to describe the distribution of 15-year-olds' competence in the particular subjects that PISA tests, how this compares to young people in other countries, and how such skills vary by demographic group. For instance, PISA can be used to address questions such as 'how big is the achievement gap between Northern Ireland and the highest performing countries' and 'is the relationship between socio-economic status and achievement stronger in Northern Ireland than in other members of the OECD'?

35. PISA can also be used to establish the *correlation* between academic achievement and a range of potential explanatory factors. This includes young people's 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.

36. Increasingly, PISA is also providing important contextual information about other aspects of young people's lives. For instance, in addition to testing pupils' skills, PISA 2015 also includes data on their ambitions, anxieties, social interactions, and life satisfaction. It can therefore assist our understanding of young people's well-being in other important dimensions beyond school. Together, this can direct government and educators towards the areas and groups in the most need of assistance.

37. 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.

38. First, 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. In other words, PISA does not measure the value-added of schools (or school-systems). Consequently, it is not possible to establish whether post-primary schools in any particular country (e.g. Northern Ireland) facilitate more academic progress than others (e.g. Canada, Switzerland, the Netherlands).

39. Second, 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 post-primary) 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, macroeconomic 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 schools in Northern Ireland. 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 cause and effect. 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 type). It also provides contextual information on issues such as school organisation and administration.

40. Finally, PISA scores can increase or decrease for many substantive reasons. 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). Changes in PISA 2015 results for Northern Ireland from previous cycles should therefore not be taken as providing evidence as to the impact of any previous or ongoing educational reform.

1.6 How will the rest of the report be structured?

41. The remainder of this report will be structured as follows. Chapters 2 to 5 will focus upon comparisons of Northern Ireland'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' PISA test scores, an overview of how average performance in Northern Ireland has changed over time[15], and how this compares to a selection of other countries.

[15] Although the PISA study began in 2000, Northern Ireland did not participate as a separate benchmarking country until 2003. Moreover, the UK did not meet the strict data requirements of the

42. Chapter 6 then moves to the association between PISA test scores and key demographic characteristics. We start by providing separate PISA score estimates in Northern Ireland for boys and girls, between pupils from advantaged and disadvantaged backgrounds, and examining the size of the gender and disadvantage gaps in Northern Ireland compared to other countries. The latter half of the chapter focuses specifically upon variation between groups of pupils within Northern Ireland, including differences by religious group.

43. In chapter 7, we turn to differences in performance within Northern Ireland at the school level. Following the structure of previous chapters, it begins by focusing upon average PISA test scores, and how this varies according to a set of school characteristics. This includes school type (e.g. Catholic maintained schools, voluntary grammar schools), admissions policy (e.g. grammar versus non-grammar) and the percentage of pupils eligible for Free School Meals.

44. Chapter 8 focuses upon the views of principals in Northern Ireland, as captured by their responses to the PISA school questionnaire. This includes an analysis of principals' 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 principals in Northern Ireland are first compared to the views of principals in other countries, in order to provide an international comparative context for the results. We then explore variation in principals' responses within Northern Ireland, focusing upon differences between those leading schools with a high versus low proportion of socio-economically disadvantaged pupils, and between different types of school. In doing so, chapter 8 will highlight what principals in Northern Ireland believe to be the most significant barriers to learning within their schools.

45. A host of previous research has illustrated the important role young people's aspirations play in shaping their future[16]. Chapter 9 therefore investigates the aspirations and expectations of 15-year-olds in Northern Ireland, 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 Northern Ireland who aspire to a Science, Technology, Engineering and 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

OECD in the first two PISA waves (2000 and 2003). Throughout this report, we therefore focus upon the change in PISA scores in Northern Ireland since 2006.

[16] Morgan (2005).

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 Northern Ireland is first placed into an international comparative context, before further investigation of within-country differences between certain socio-demographic groups (including gender and socio-economic status).

46. Further investigation of pupils' responses to the PISA background questionnaire follows in chapter 10, though now with an emphasis upon how they view science teaching within their school. Northern Ireland is first 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 then turns to how much time 15-year-olds in Northern Ireland spend learning science each week compared to other subject areas, both inside and outside of school.

47. The final chapter focuses upon differences in PISA outcomes between the four constituent countries of the United Kingdom. This includes how PISA 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 principals' responses to the PISA background questionnaires. This includes whether there are differences in principals' views on the factors hindering instruction within their school, and in the amount of time 15-year-olds spend studying science compared to other subject areas.

Chapter 2. Achievement in science

The average PISA science score in Northern Ireland is 500. This is not a statistically significant difference from the mean PISA science score for Northern Ireland in 2006 (508 points).

The mean science score is more than 20 points higher in nine countries than in Northern Ireland. Average PISA scores are between 10 and 20 points higher than in Northern Ireland in a further five countries.

Northern Ireland has a smaller proportion of low-achieving pupils in science (18 per cent) than the average across members of the OECD (21 per cent).

The proportion of 15-year-olds in Northern Ireland reaching the top two PISA science levels is similar to the average across OECD members.

The science skills of the highest achieving pupils in Northern Ireland have declined significantly over the last decade.

The gap between the highest and lowest achieving pupils in science is 239 test points (around eight years of schooling). Although sizeable, there are few countries where the difference between high and low-achieving pupils is significantly smaller.

Box 2.1 Methods for interpreting differences between countries

1. **Country rankings**. This is where countries are ordered by the statistic of interest (e.g. average PISA scores). The position of one country in this ranking is then compared to another. Although easy to communicate, this approach is problematic for at least three reasons. 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. Second, rank order provides no information about the size of the achievement gap between countries. Finally, the position of a country may change over time simply 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 based upon a sample is to report whether differences between countries are 'statistically significant'. A 'significant' difference between countries is then reported when we are almost certain that this is not the result of sampling error. This overcomes one limitation with the use of country rankings. However, it still reveals little about 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 absolute magnitude. An advantage of this approach is that it retains some information about differences in achievement between Northern Ireland 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 four groups, based upon the number of test points they are ahead or behind Northern Ireland. This will also be expressed in terms of 'months of schooling' differences, following the approximate rules of thumb presented in OECD (2010:110):

Group 1: Mean score at least 20 points (eight months of schooling) ahead of Northern Ireland.

Group 2: Mean score between 10 and 20 points (between four and eight months) ahead of Northern Ireland.

Group 3: Mean PISA score within 10 points (four months) of Northern Ireland.

Group 4: Mean score at least 10 points (four months) below Northern Ireland.

A star (*) will then also be placed by any country with a mean score significantly higher or lower than Northern Ireland at the five per cent level.

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

1. Scientific literacy matters as the world faces major challenges in providing sufficient water and food, controlling diseases, generating sufficient energy and adapting to climate change[17]. 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*'[18]. Ensuring sufficient scientific literacy amongst young people is also vital for Northern Ireland's economic prosperity, material well-being and growth[19]. Consequently, it is important to consider how the science proficiency of 15-year-olds in Northern Ireland compares to 15-year-olds elsewhere in the world. Table 2.1 therefore places average PISA science scores for Northern Ireland into an international context, with countries separated into one of four groups.

2. The mean PISA science score in Northern Ireland is 500. Panel (a) refers to those countries where average PISA science scores are at least 20 points higher. A metric occasionally used by the OECD (2010:110) equates differences of this magnitude to at least half an additional year of schooling. A total of nine countries belong to this group; including six East Asian economies, two European countries (Finland and Estonia) and one North American member of the OECD (Canada).

3. Panel (b) of Table 2.1 turns to countries with average PISA science scores between 10 and 20 test points higher than Northern Ireland. According to the OECD (2010:110), this is broadly equivalent to a difference of between a quarter and a half of an additional year of schooling. There are five countries within this group: China (518), South Korea (516), New Zealand (513), Slovenia (513) and England (512).

[17] UNEP (2012).
[18] OECD (2013d).
[19] World Bank (2003). See http://siteresources.worldbank.org/EDUCATION/Resources/278200-1089743700155/content.pdf

Table 2.1 Mean PISA 2015 science scores

(a) Countries more than 20 points ahead of Northern Ireland

Country	Mean	Country	Mean
Singapore	**556***	**Macao**	**529***
Japan	**538***	**Canada**	**528***
Estonia	**534***	**Vietnam**	**525***
Taiwan	**532***	**Hong Kong**	**523***
Finland	**531***		

(b) Countries between 10 and 20 points ahead of Northern Ireland

Country	Mean	Country	Mean
China	**518***	**Slovenia**	**513***
South Korea	**516***	**England**	**512***
New Zealand	**513***		

(c) Countries within 10 points of Northern Ireland

Country	Mean	Country	Mean
Australia	**510***	Norway	498
Germany	**509***	Scotland	497
Netherlands	**509***	United States	496
Switzerland	506	Austria	495
Republic of Ireland	503	France	495
Belgium	502	Sweden	493
Denmark	502	**Czech Republic**	**493***
Poland	501	**Spain**	**493***
Portugal	501	**Latvia**	**490***
Northern Ireland	500		

(d) Countries between 10 and 20 points behind Northern Ireland

Country	Mean	Country	Mean
Russia	**487***	**Luxembourg**	**483***
Wales	**485***	**Italy**	**481***

Source: PISA 2015 database.

Note: Bold font with * indicates mean score significantly different from Northern Ireland at the five per cent level. Table does not include countries with average science scores more than 20 points lower than in Northern Ireland.

4. Panel (c) includes all countries or economies within 10 points of the mean science score in Northern Ireland. Differences of this magnitude are equivalent to less than a quarter of an additional year of schooling, and generally not outside the range one would expect given sampling error[20]. A total of 18 countries are within this group (excluding Northern Ireland). Most of these countries are from within Europe, which includes the Republic of Ireland (503), Poland (501) and Scotland (497). Another notable inclusion within this group is the United States, where the mean score is 496.

5. The last panel of Table 2.1 (panel d) contains countries with average PISA science scores between 10 and 20 points below Northern Ireland. Hence average science skills of 15-year-olds within these nations are around a quarter to a half a year of schooling behind young people in Northern Ireland. Four countries fall within this group: Russia (487), Wales (485), Luxembourg (483) and Italy (481).

6. It is important to note that Table 2.1 does not include any country with an average PISA science score more than 20 points below the score for Northern Ireland. Results have therefore not been presented for 34 countries, including some members of the OECD, such as Greece (455). A full set of average PISA science scores, including all participating countries, is provided in the online data tables.

Key point

The average PISA science score in Northern Ireland is 500. There are 14 countries where the average science score is at least 10 test points higher than in Northern Ireland, and 34 countries where the average science score is at least 10 test points lower.

2.2 How have average PISA science scores in Northern Ireland changed over time? How does this compare to other countries?

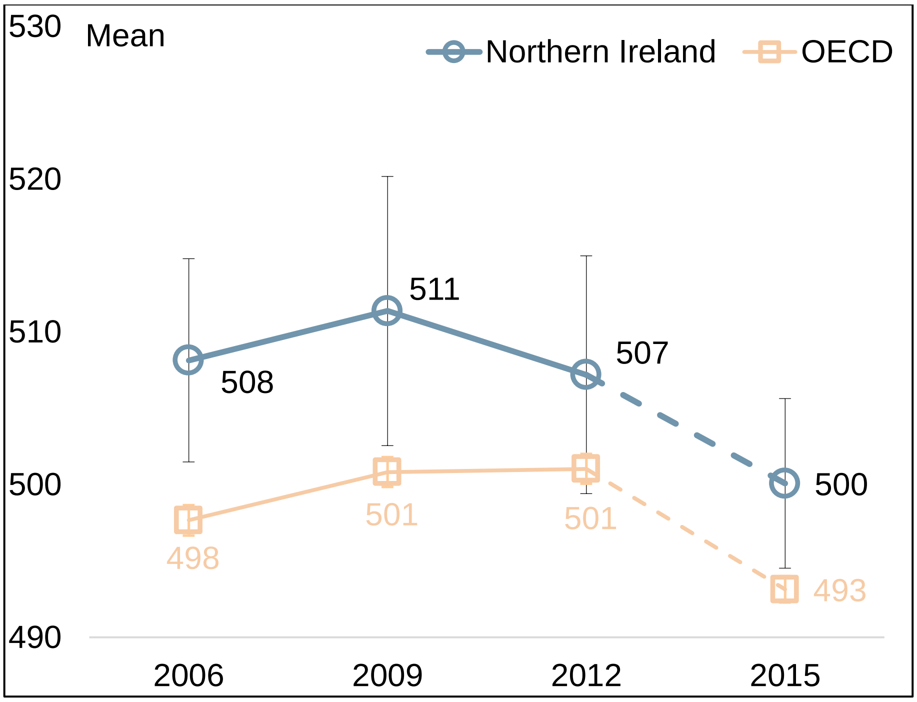
7. The OECD has suggested that countries that manage to increase their average PISA test scores will see significant long-run improvements in their economic growth[21]. Moreover, as the previous sub-section illustrated, average science proficiency in Northern Ireland remains significantly behind some of the top-performing countries, indicating that there is room for improvement. This sub-section

[20] Note that statistical significance, where one can largely rule out a difference between countries occurring due to sampling error, is indicated in Table 2.1 via a star next to the mean score.
[21] OECD (2010:23).

therefore turns to how the mean PISA score has changed since science was last the focus of PISA in 2006, and with respect to the last PISA wave conducted in 2012.

8. Figure 2.1 illustrates how the mean PISA science score in Northern Ireland remained stable between 2006 (508), 2009 (511) and 2012 (507). In 2015, the mean is around 10 points lower (500), but is not significantly different from the 2006 value at the conventional five per cent threshold[22].

Figure 2.1 Mean PISA science scores for Northern Ireland 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 black 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.

9. Table 2.2 compares the change for Northern Ireland to the five 'fastest improving' (red cells) and the five 'fastest declining' (blue cells) countries. In order to facilitate relevant comparisons, any country where the average PISA 2015 science score is below 450 points has been excluded from this table. Results are presented

[22] See Appendix C for further details regarding the calculation of change between 2006 and 2015, and the associated test of statistical significance.

for both the change between 2006 and 2015 (panel a), and between 2012 and 2015 (panel b).

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. The difference between the ‘from’ and ‘to’ column may not equal ‘change’ due to rounding.

10. Starting with panel (a), Portugal has experienced the greatest improvement in mean science scores between 2006 to 2015, gaining approximately 27 PISA test

points (moving from 474 to 501 on the PISA science scale). In contrast, Finland (-33 points, falling from 563 to 531) and Slovakia (-28 points, falling from 488 to 461) have suffered the most pronounced declines. It is notable how very few other countries have managed to substantially increase their average PISA science score over this period; Macao, Israel and Norway are the only other countries with a greater than 10 point (four months of schooling) improvement. In contrast, several other countries have seen a more than 20 test point (eight months of schooling) decline, including Hungary, Wales and the Czech Republic. Indeed, countries with a mean PISA 2015 science score above 450 experienced, on average, a six point decrease in their average science score relative to 2006.

11. Panel (b) of Table 2.2 provides the analogous comparison between PISA 2012 and PISA 2015. A similar pattern emerges. There are very few countries where there is evidence of a substantial increase in mean science scores. On the other hand, the mean score has fallen by more than 20 test points (half a year of schooling) in several countries, including Hong Kong (-32 points from 555 to 523), Poland (-24 points from 526 to 501) and the Republic of Ireland (-19 points from 522 to 503). Indeed, the average country with a mean PISA 2015 science score above 450 points experienced a decline of around eight test points between 2012 and 2015.

Key point

The difference in the mean science score for Northern Ireland between 2006 and 2015 is not statistically significant at the five per cent threshold.

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

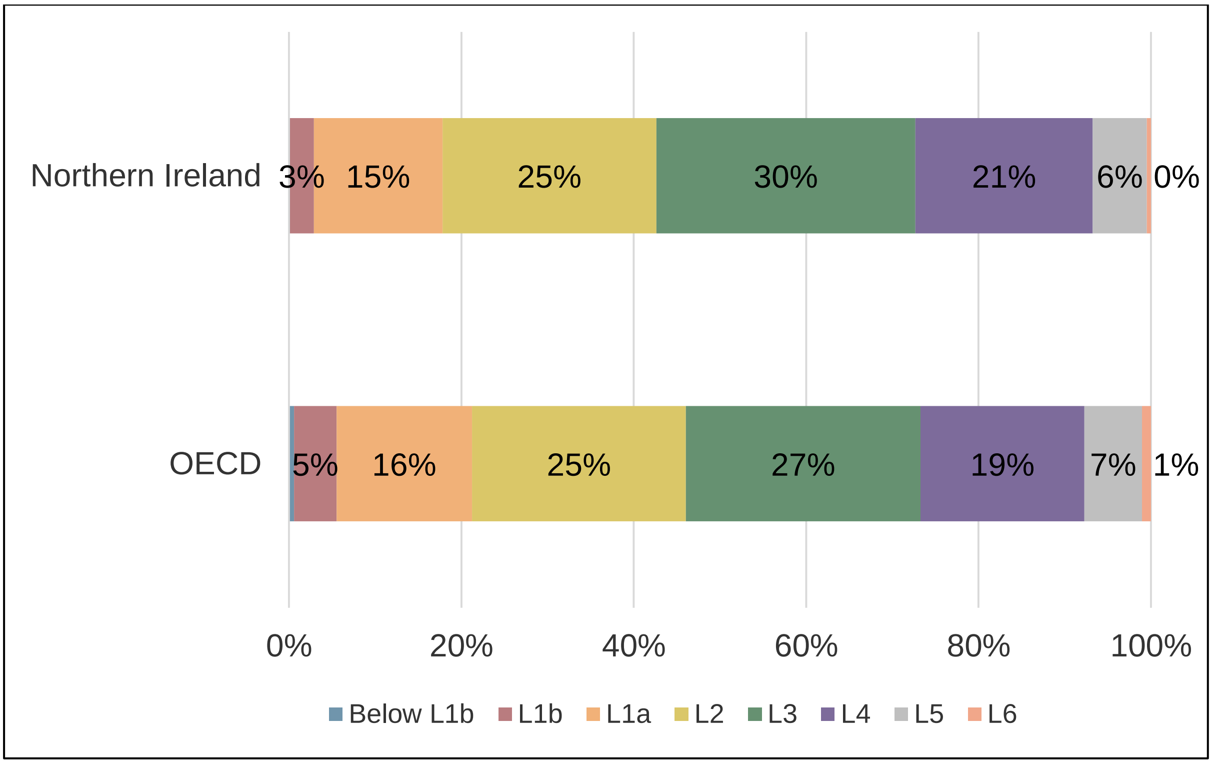
12. Although two countries may have similar average PISA science scores, there could be marked differences in terms of the distribution of pupils' performance. There may, for instance, be important differences between these countries in their share of 'top-performing' pupils and the proportion of 'low-achievers'. 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*'[23]. 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 require to function adequately in later life. This sub-section therefore focuses upon the proportion of 15-year-olds in Northern Ireland who reach each of the PISA science

[23] OECD (2009).

proficiency levels, with a particular focus upon the proportion of ‘low-achievers’ and ‘top-performers’.

13. In order to describe the distribution of pupils’ attainment, the OECD have divided 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). Appendix D provides a description of these achievement levels, along with an explanation of the types of tasks to which they correspond. Throughout this report, ‘low-achievers’ refers to pupils scoring below PISA Level 2, while ‘top-performers’ score at PISA Level 5 or above.

Figure 2.2 The percentage of pupils in Northern Ireland reaching each PISA science level



Source: PISA 2015 database.

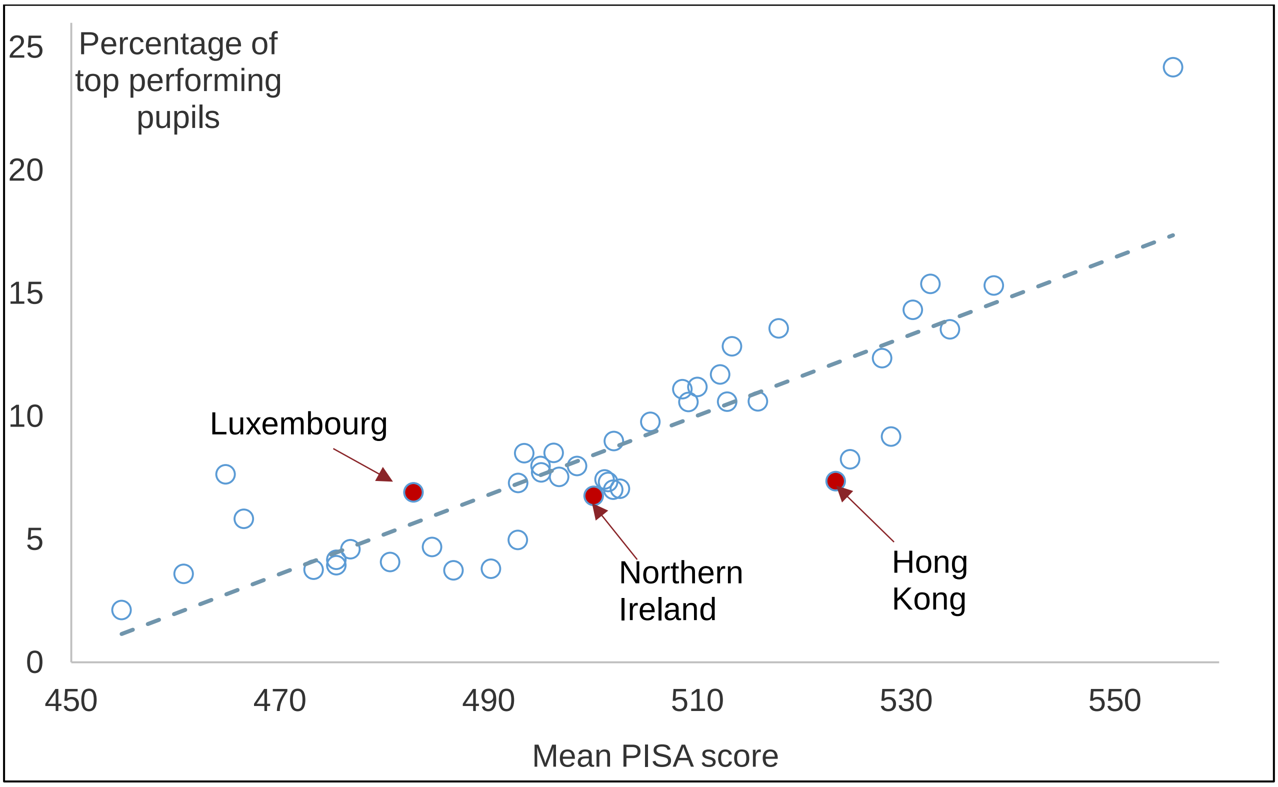
14. Figure 2.2 illustrates the percentage of pupils in Northern Ireland reaching each PISA science level, and compares this to the average across members of the OECD. In Northern Ireland, 15 per cent of 15-year-olds reach PISA science Level 1a, three per cent reach Level 1b, while less than one per cent are below this level. Analogous figures for the average across OECD members are 16 per cent (Level 1a), five per cent (Level 1b) and one per cent (below Level 1b). Therefore, the proportion of ‘low-achievers’ in Northern Ireland (18 per cent) is lower than the average across members of the OECD (21 per cent).

15. At the other end of the distribution, Northern Ireland seems to have around the same proportion of high science achievers as the average member of the OECD. For instance, around seven per cent of pupils in Northern Ireland reach one of the top two PISA science levels, compared to an OECD average of eight per cent.

16. Figure 2.3 provides further insight into how Northern Ireland compares to other countries in terms of the proportion of high-performing pupils. The horizontal axis plots the average PISA science score, while the vertical axis presents the proportion of pupils in each country achieving PISA Level 5 or Level 6. The dashed regression line then illustrates the cross-country relationship between these variables. In this figure, the sample of countries has been restricted to those with a mean science score above 450 points.

17. Northern Ireland sits close to the dashed regression line; it is a country with around the proportion of high science achievers (seven per cent) one would expect given its mean score of 500. Nevertheless, it is interesting to compare Northern Ireland to Luxembourg and Hong Kong in this respect. As Figure 2.3 illustrates, the mean score in the former (483) is significantly lower than in Northern Ireland, while in the latter the mean score is significantly higher (523). Yet the proportion of pupils who reach PISA Level 5 or Level 6 in these countries is almost identical (around seven to eight per cent in each). This further illustrates how the distribution of science achievement (including the share of high-performing pupils) can differ substantially, even amongst countries with similar mean scores.

Figure 2.3 The percentage of top-performing science pupils compared to mean PISA 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 points.

Key point

Northern Ireland has fewer pupils who lack basic science skills (18 per cent) than the average across members of the OECD (21 per cent).

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

18. The previous sub-section highlighted how Northern Ireland has a similar share of high-performing pupils in science as the average across members of the OECD. We now provide further insight into this issue by comparing the PISA test scores of the highest achieving Northern Ireland pupils internationally, and considering how the performance of the highest achievers in science has changed over the last decade. Table 2.3 therefore presents the value of the 90^{th} percentile of the science achievement distribution for Northern Ireland. (A percentile is a measure used in statistics indicating the value below which a given percentage of observations in a group of observations fall. For example, the 90th percentile is the value below which 90 per cent of the observations may be found). As per section 2.1, countries have been divided into different groups depending upon how far ahead or behind Northern Ireland they are, but now in terms of the 90^{th} percentile.

19. In PISA 2015, the 90^{th} percentile of the science proficiency distribution in Northern Ireland was 618. This means that the top-performing 10 per cent of 15-year-olds in this country achieved a score of 618 test points or more. There are 11 countries where the 90^{th} percentile is more than 20 points above the value for Northern Ireland, and a further six countries where the 90^{th} percentile is between 10 and 20 points higher. In other words, the science skills of the top 10 per cent of 15-year-olds in Northern Ireland are significantly below those of the highest performing pupils in a number of other countries. This includes several European countries (e.g. Finland, England, Germany) and English-speaking members of the OECD (e.g. Canada, New Zealand, Australia).

Table 2.3 The 90th percentile of PISA 2015 science scores

(a) Countries more than 20 points ahead of Northern Ireland

Country	90th percentile	Country	90th percentile
Singapore	**683***	**New Zealand**	**647***
Taiwan	**655***	**Canada**	**644***
Japan	**655***	**England**	**642***
Finland	**651***	**Australia**	**639***
China	**649***	**Netherlands**	**638***
Estonia	**648***		

(b) Countries between 10 and 20 points ahead of Northern Ireland

Country	90th percentile	Country	90th percentile
Slovenia	**636***	**Switzerland**	**632***
Germany	**636***	**Macao**	**630***
South Korea	**636***	**Belgium**	**629***

(c) Countries within 10 points of Northern Ireland

Country	90th percentile	Country	90th percentile
United States	626	Scotland	619
Sweden	625	Poland	619
Vietnam	624	Northern Ireland	618
France	623	Czech Republic	618
Hong Kong	622	Malta	618
Norway	622	Republic of Ireland	618
Austria	621	Denmark	617
Portugal	620	Luxembourg	615

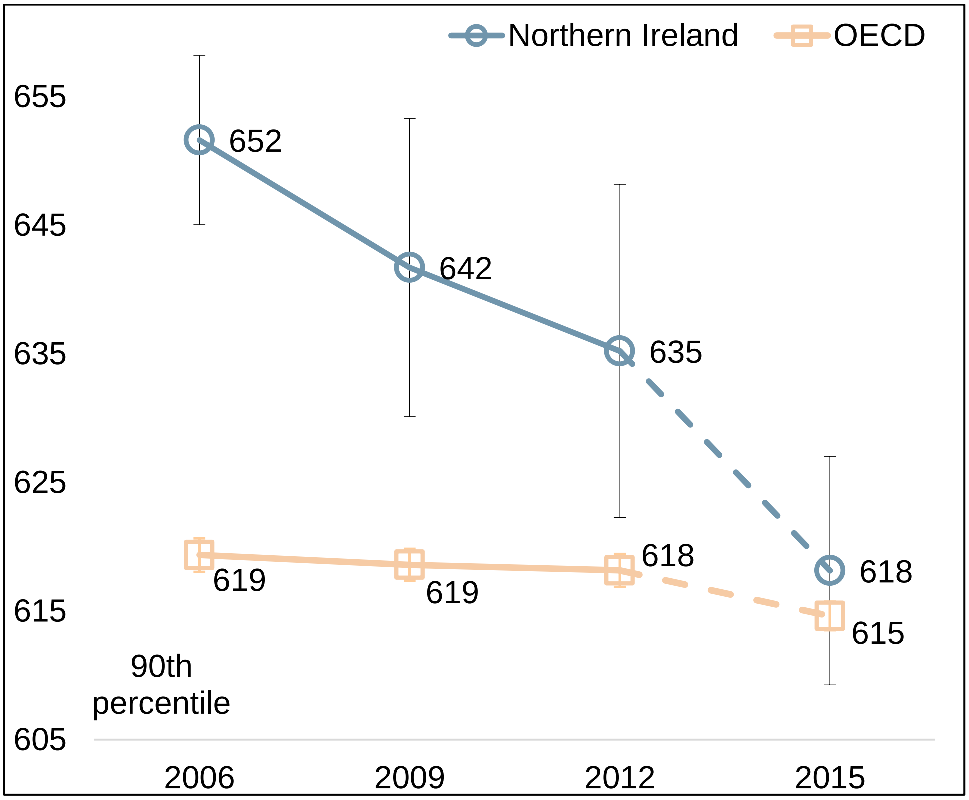
(d) Countries between 10 and 20 points behind Northern Ireland

Country	90th percentile	Country	90th percentile
Israel	**606***	**Hungary**	**601***
Spain	**605***	**Italy**	**599***
Wales	**602***		

Source: PISA 2015 database.

Note: Bold font with * indicates significantly different from Northern Ireland at the five per cent level. Table does not include countries where the 90th percentile of the science proficiency distribution is more than 20 points below Northern Ireland.

Figure 2.4 The 90th percentile of PISA science scores for Northern Ireland 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 black 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.

20. How have the science skills of the highest achieving pupils in Northern Ireland changed over time? Figure 2.4 provides the answer by plotting the 90th percentile of the PISA science distribution from 2006 to 2015, accompanied by the estimated 95 per cent confidence interval. There is evidence of a decline in this statistic over the past decade. In particular, the 90th percentile of the science distribution stood at 652 in 2006. This has then steadily declined to 642 in 2009, 635 in 2012 and 618 in 2015. There is hence a statistically significant difference between 2006 and 2015 of 34 test points, with evidence of a sustained downward trend over the last four PISA cycles.

Key point

There has been a decline in the science skills of Northern Ireland’s highest achieving 15-year-olds over the last decade.

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

21. Although the science skills of Northern Ireland’s highest achievers may have declined since 2006, does the same hold true for the lowest achievers? Moreover, do the PISA science scores of Northern Ireland’s lowest achievers compare favourably or unfavourably relative to the least skilled 15-year-olds in other countries? Table 2.4 provides evidence on this matter. It does so by comparing the 10^{th} percentile of the science proficiency distribution in Northern Ireland to other countries.

22. The value of the 10^{th} percentile of the science proficiency distribution in Northern Ireland is 379. There are eight countries where the 10^{th} percentile is more than 20 points above the value for Northern Ireland, and one other country where the 10^{th} percentile is between 10 and 20 points higher. Of these nine countries, six are East Asian, with just two from within Europe (Finland and Estonia). In other words, there are few European countries where the lowest achieving pupils have stronger science skills than the lowest achieving pupils in Northern Ireland.

Table 2.4 The 10th percentile of PISA 2015 science scores

(a) Countries more than 20 points ahead of Northern Ireland

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 Northern Ireland

Country	10th percentile
Taiwan	**395***

(c) Countries within 10 points of Northern Ireland

Country	10th percentile	Country	10th percentile
South Korea	388	China	377
Republic of 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		

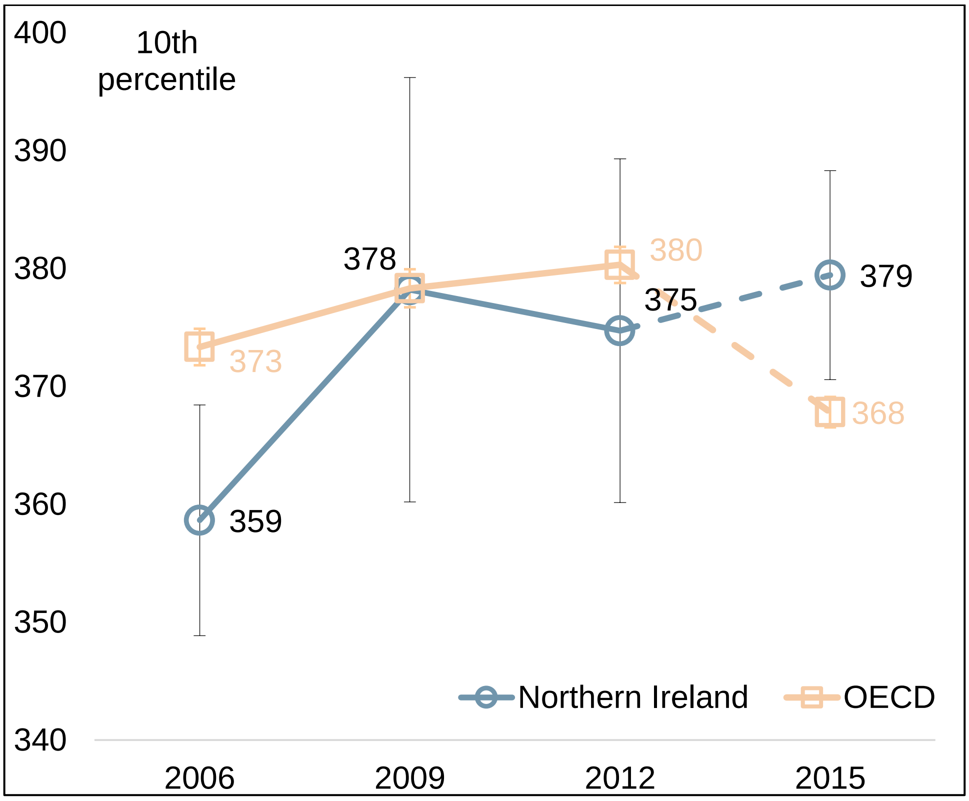
(d) Countries between 10 and 20 points behind Northern Ireland

Country	10th percentile	Country	10th percentile
Wales	368	Austria	365
United States	368	Belgium	364
Czech Republic	367	Croatia	360

Source: PISA 2015 database.

Note: Bold font with * indicates significantly different from Northern Ireland at the five per cent level. Table does not include countries where the 10th percentile of the science proficiency distribution is more than 20 points below the value in Northern Ireland.

Figure 2.5 The 10th percentile of PISA science scores for Northern Ireland 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 black 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.

23. Figure 2.5 proceeds by considering how the 10th percentile of PISA science scores in Northern Ireland has changed since 2006. The point estimate of the 10th percentile in 2015 (379) is very similar to the value in 2012 (375) and 2009 (378). However, the 10th percentile in 2006 was somewhat lower (359) and is significantly different to the value of the 10th percentile in 2015 at the five per cent level. Nevertheless, there is little evidence of a sustained trend over time, with the science skills of the lowest achieving pupils in Northern Ireland remaining broadly stable since at least 2009.

Key point

The skills of the lowest achieving Northern Ireland pupils in science have remained broadly unchanged between 2009 and 2015.

2.6 How big is the gap between the pupils with the strongest and weakest science skills? How does Northern Ireland compare to other countries in this respect?

24. Does Northern Ireland have an education system, society and culture that leads to large disparities in 15-year-olds science achievement? Or is this a country where there is a comparatively narrow gap between the highest and lowest performing pupils? The answer to this question matters because inequalities in education help to produce later lifetime disparities in a range of dimensions, including heath, well-being, occupational status and income[24]. This chapter therefore concludes by investigating whether the distance between the highest and lowest achieving pupils in Northern Ireland is greater than in other parts of the world.

25. To measure the gap between the highest and lowest performing pupils, we take the difference between the 10^{th} and 90^{th} percentiles of the PISA science achievement distribution within each country. This type of metric is commonly used to measure inequality in educational outcomes[25]. The magnitude of this gap is presented in Table 2.5. For brevity, the sample is restricted to only those countries with a mean PISA science score above 450 points. The 10 countries with the highest mean PISA science scores have been highlighted.

26. The 90^{th} percentile of the PISA science test score distribution in Northern Ireland is 618, while the 10^{th} percentile stands at 379. Table 2.5 demonstrates that the gap is therefore 239 test score points, equivalent to around eight years of schooling. Although this is a sizeable difference, it is smaller than in several other countries (the average across members of the OECD is 247). Indeed, in only five of the countries included in Table 2.5 is the difference between the 90^{th} and 10^{th} percentile significantly smaller than in Northern Ireland (three East Asian economies along with Russia and Latvia). Conversely, there are 18 countries where inequality in science achievement is significantly greater at the five per cent level. Consequently, by this metric, Northern Ireland has less inequality in 15-year-olds' science achievement than in many other countries.

[24] Micklewright and Schnepf (2006).
[25] Bruckauf and Chzhen (2016).

Table 2.5 Difference in PISA test points between the highest and lowest achievers in science

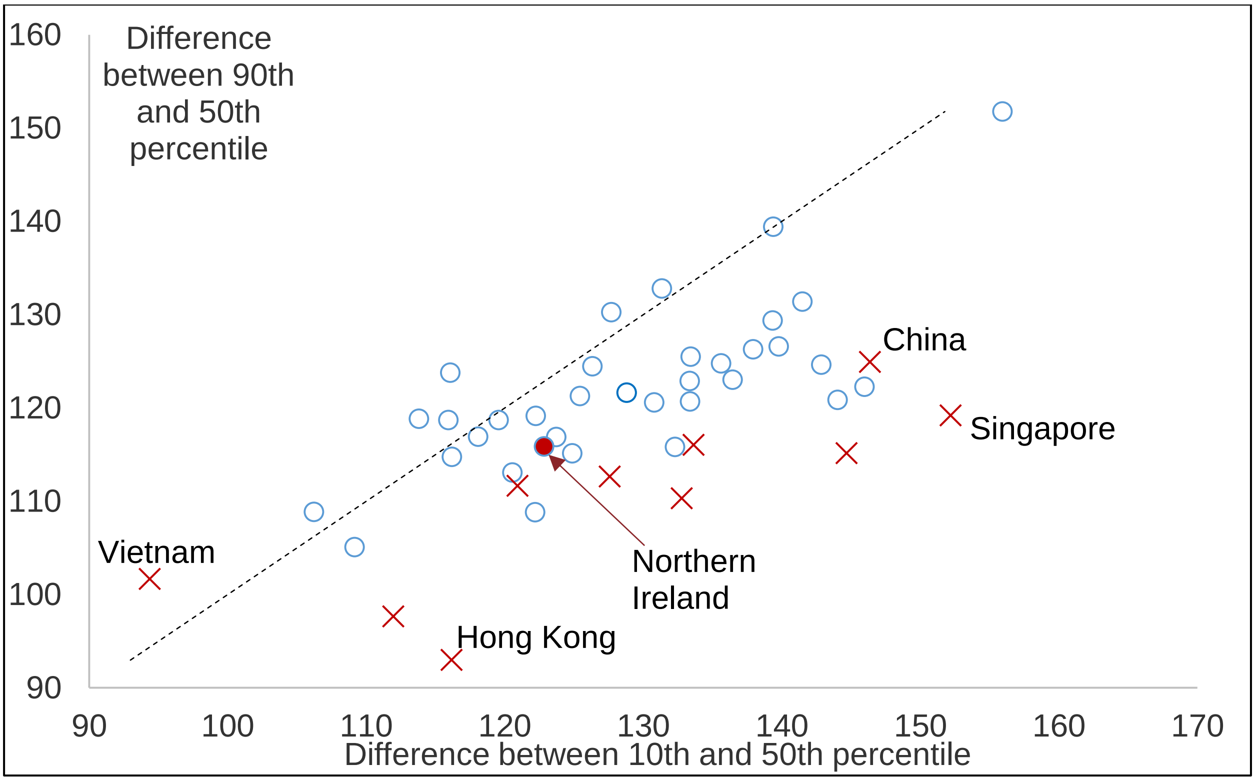
Country	Difference between the 90th and 10th percentile	Difference in years of schooling
Malta	**308***	**10.3 years**
Israel	**279***	**9.3 years**
New Zealand	**273***	**9.1 years**
Singapore	**271***	**9.0 years**
China	**271***	**9.0 years**
Sweden	**269***	**9.0 years**
France	**268***	**8.9 years**
Australia	**267***	**8.9 years**
Netherlands	**266***	**8.9 years**
Belgium	**265***	**8.8 years**
England	**264***	**8.8 years**
Luxembourg	**264***	**8.8 years**
Germany	**260***	**8.7 years**
Taiwan	**260***	**8.7 years**
Switzerland	**259***	**8.6 years**
Slovakia	**259***	**8.6 years**
United States	**258***	**8.6 years**
Austria	**256***	**8.5 years**
Hungary	254	8.5 years
Norway	251	8.4 years
Czech Republic	251	8.4 years
Slovenia	250	8.3 years
Finland	250	8.3 years
South Korea	248	8.3 years
Scotland	247	8.2 years
Japan	243	8.1 years
Greece	241	8.0 years
Portugal	241	8.0 years
Canada	240	8.0 years
Italy	240	8.0 years
Lithuania	240	8.0 years
Northern Ireland	239	8.0 years
Iceland	238	7.9 years
Poland	235	7.8 years
Wales	235	7.8 years
Denmark	234	7.8 years
Croatia	233	7.8 years
Estonia	233	7.8 years
Spain	231	7.7 years
Republic of Ireland	231	7.7 years
Russia	**215***	**7.2 years**
Latvia	**214***	**7.1 years**
Macao	**210***	**7.0 years**
Hong Kong	**209***	**7.0 years**
Vietnam	**196***	**6.5 years**

Source: PISA 2015 database.

Note: Bold font with * indicates statistically significant differences compared to Northern Ireland at the five per cent significance level. Table only includes countries where the mean PISA science score is above 450.

27. Figure 2.6 further explores the source of this educational inequality. The horizontal axis plots the difference between the median and the 10th percentile of the science test score distribution; the gap between the lowest achieving 10 per cent of pupils in each country and the average pupil. On the other hand, the vertical axis illustrates the difference between the median and the 90th percentile; the gap between the average pupil and the highest achieving 10 per cent within each country. This comparison therefore demonstrates whether inequality in pupils' skills is more pronounced in the bottom half of the science achievement distribution or the top half. Results are again presented for only those countries with a mean science score above 450 points. The red crosses refer to the 10 countries with the highest mean PISA science score ('H10').

Figure 2.6 A comparison of the P90-P50 and P50-P10 science achievement gap 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 and economies where the mean PISA science score is above 450. Red crosses refer to the 10 countries with the highest average PISA science score.

28. There are two important features of Figure 2.6. First, the majority of countries (including Northern Ireland) sit below the 45 degree line. This illustrates that, in most countries, the gap between the lowest achieving pupils and the average pupil is

bigger than the gap between the average pupil and the highest achievers (including Northern Ireland). Second, it is notable how patterns of educational inequality differ markedly between the 10 countries with the highest average PISA science scores. For instance, countries like Vietnam and Hong Kong sit in the bottom-left hand corner of Figure 2.6, with smaller differences between low, average and high achieving pupils than in Northern Ireland. Conversely, there are countries like Singapore and China where inequality in achievement (particularly between low-achieving and average pupils) is much greater than in Northern Ireland. This illustrates how countries with the highest average PISA science scores differ markedly in terms of the distribution of performance.

Key point

The gap in science skills between the highest and lowest achieving pupils in Northern Ireland is roughly equivalent to eight years of schooling. Although sizeable, this difference is smaller in Northern Ireland than in many other countries.

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 Northern Ireland achieve equally as well across the ‘living’, ‘physical’ and ‘earth and space’ science systems in 2015. 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 Northern Ireland 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 Northern Ireland 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 the PISA science domain. 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. For instance, do pupils in Northern Ireland have a particularly good understanding of one aspect of science (e.g. physics) but comparatively poor understanding of another (e.g. biology)? 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 two exemplar science questions. This includes one of the new interactive test items that have been introduced into PISA as part of the move to computer-based assessment. We also provide some descriptive evidence on how pupils in Northern Ireland performed on these two 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 Northern Ireland demonstrate the same proficiency across the PISA 'physical', 'living' and 'earth and space' science systems? How does Northern Ireland compare to other countries in this respect?*
- *How do average PISA scores vary in Northern Ireland 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?*
- *What types of questions were pupils asked as part of the PISA science test? What proportion of pupils in Northern Ireland answered these exemplar items correctly?*

4. When interpreting the results presented in this chapter, readers should note that the eight PISA 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; average scores can be compared across physical and living science systems, or between content knowledge and procedural/epistemic knowledge, for example. However, comparisons should not be made 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 in Northern Ireland demonstrate the same proficiency across the PISA physical, living and earth and space science systems?

5. Science is a broad term used to encapsulate many different topics. For instance, in the Northern Ireland 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[26].

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)

[26] See OECD (2016).

Table 3.2 Average scores across the PISA 'scientific systems' 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***
Republic of 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***

Source: PISA 2015 database.

Notes: Table only includes countries with an average score above 450 points 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 for the 'living' system. Information on sub-domain scores is not available for Malta and Vietnam. Bold font with * indicates significant difference from Northern Ireland.

6. As science is the focus of PISA 2015, it is possible to compare 15-year-olds' skills across these three areas. The results are presented in Table 3.2, with the living system chosen as the reference domain (i.e. we interpret results for the physical and the earth and space science systems relative to the results for the living system). Cells have been highlighted in green/red in the physical and earth and space science columns where the mean score is at least five points higher/lower than the mean score for the living system. Light shading indicates a difference of five points or more, with dark shading indicating a difference of 10 points or more. Countries have been ordered by their average overall science score, with results presented for only those countries where the average is above 450 test points.

7. In all three scientific systems, pupils in Northern Ireland perform reasonably well internationally. There are, however, around 15 countries with statistically significant higher scores in each of the three domains. This includes Singapore, Japan, Estonia, Taiwan, Finland, Macao, Canada and Hong Kong, with further details provided in Table 3.2. The mean score for the living system (498) in Northern Ireland is also very similar to the mean score for either the physical (501) or earth and space science (498) systems.

8. Northern Ireland's similar score across the living, physical and earth and space science system is similar to the situation in 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. 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.

9. Several other industrialised countries exhibit the same pattern of achievement as Northern Ireland 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. Likewise, pupils in the Republic of Ireland achieve higher average scores in physical sciences (507) than in living sciences (500). More generally, there are relatively few red shaded cells in Table 3.2. This indicates that in most countries the living science system is not a particular strength of pupils, in common with Northern Ireland.

Key point

Pupils in Northern Ireland achieve similar scores across the three PISA scientific systems.

3.2 How do average scores vary in Northern Ireland across the three core scientific 'competencies' measured by PISA?

10. For pupils to be able to understand and engage in critical discussions about science, they need to be able to demonstrate proficiency in three separate areas. First, they need to be able to explain and understand key scientific phenomena; for example, how a microwave oven works or why it is possible to compress gasses but not liquids. Second, pupils must understand the key principles of scientific investigation, such as what things should be measured, or what variables should be controlled, so that accurate and precise data can be collected. Finally, pupils need to be able to interpret data and evidence scientifically, in order to reach appropriate conclusions. For instance, they should recognise that an article within a peer-reviewed academic journal is a more trustworthy source of scientific information than a newspaper report.

11. The PISA 2015 test examined pupils' skills in these three core scientific competencies. They 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 core competencies encapsulates can be found in Table 3.3.

Table 3.3 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)

12. A comparison of pupils' proficiency across these core scientific competencies is presented in Table 3.4. Evaluating and designing scientific enquiry is taken as the reference competency, with green/red shading used to illustrate where average scores are at least five points higher/lower than in the 'explaining phenomena scientifically' and 'interpreting data and evidence scientifically' domains. Light shading refers to a difference of at least five points and dark shading a difference of at least 10 points.

Table 3.4 Average scores for the scientific 'competencies' tested in PISA

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. 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. Bold font with * indicates significant difference from Northern Ireland.

13. Pupils in Northern Ireland are equally adept at interpreting data and evidence scientifically (501), explaining phenomena scientifically (500) and evaluating and designing scientific enquiry (497). This is not unique to Northern Ireland; in most countries there is relatively little difference across these three domains. This includes several of the high-performers, such as Japan, Estonia and Hong Kong. Table 3.4 illustrates there are only a few exceptions to this pattern amongst the high-performers, such as Singapore (where pupils have a particular strength in evaluating and designing scientific enquiry), Taiwan and Macao (where pupils are weaker at evaluating and designing scientific enquiry). Within the UK, pupils in Wales are slightly stronger at explaining phenomena scientifically than in the other two competencies, while 15-year-olds in Scotland are weakest at interpreting data and evidence scientifically. Nevertheless, the overall message of Table 3.4 is that, in most countries, differences across the three scientific competencies are relatively modest.

Key point

Pupils in Northern Ireland 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 Northern Ireland, and occurs in several other countries, including some of the very top performers.

3.3 How does pupils' knowledge of scientific content compare to their knowledge of scientific processes and procedures?

14. 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 (as listed in Table 3.1), but also of the rigorous processes and procedures that must be applied in order to generate high quality evidence. It also encompasses how knowledge in science is built.

15. 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 3.5 provides further details on the definition of procedural and epistemic knowledge within the PISA science framework.

16. Pupils in Northern Ireland are equally able in content knowledge (499) and procedural and epistemic knowledge (501). 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 Table 3.6. In Singapore, South Korea, France and the United States the opposite holds true, with pupils having stronger skills in procedural and epistemic knowledge.

Table 3.5 Average scores across the PISA 'scientific knowledge' sub-domains

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. 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. Bold font with * indicates significant difference from Northern Ireland.

Table 3.6 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)

Key point

In Northern Ireland, pupils' knowledge of science content is approximately equal to their knowledge of scientific practices and procedures. Northern Ireland 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 Example question 1. Slope face investigation.

17. To further illustrate the content of the PISA science test, we conclude this chapter by providing an analysis of two of the released PISA test questions. The first is the slope face investigation task[27]. To begin, pupils were shown an introductory information screen, as depicted in the top half of Figure 3.1. This includes a visual stimulus of two hills in a valley, one with plentiful green vegetation and one without. The screen 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.

[27] Although this question is formed of several independently scored parts, our description and analysis focuses upon the first task.

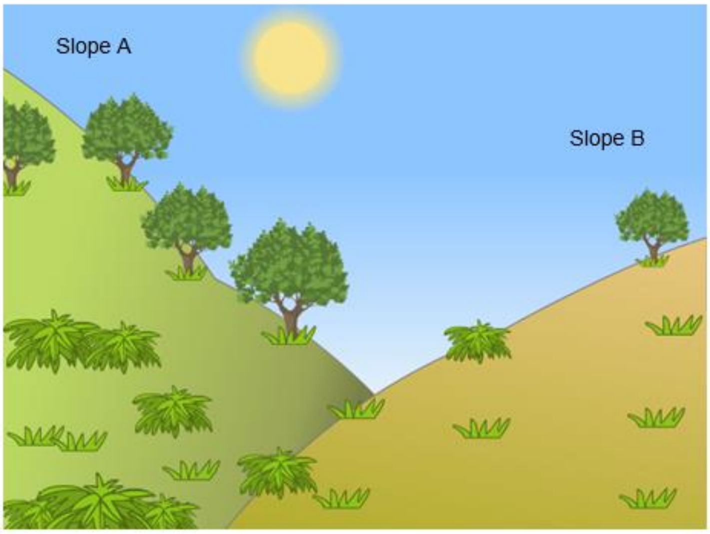
Figure 3.1 The 'slope face investigation' question

SLOPE FACE INVESTIGATION

A group of students notices a dramatic difference in the vegetation on the two slopes of a valley: the vegetation is much greener and more abundant on slope A than on slope B. This difference is shown in the illustration on the right.

The students investigate why the vegetation on the slopes is so different from one slope to the other. As part of this investigation, the students measure three environmental factors over a given period of time:

- **Solar radiation:** how much sunlight falls on a given location
- **Soil moisture:** how wet the soil is in a given location
- **Rainfall:** how much rain falls on a given location



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/m²)

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.

18. 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 3.1. 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.

Table 3.7 Properties of the exemplar PISA science questions

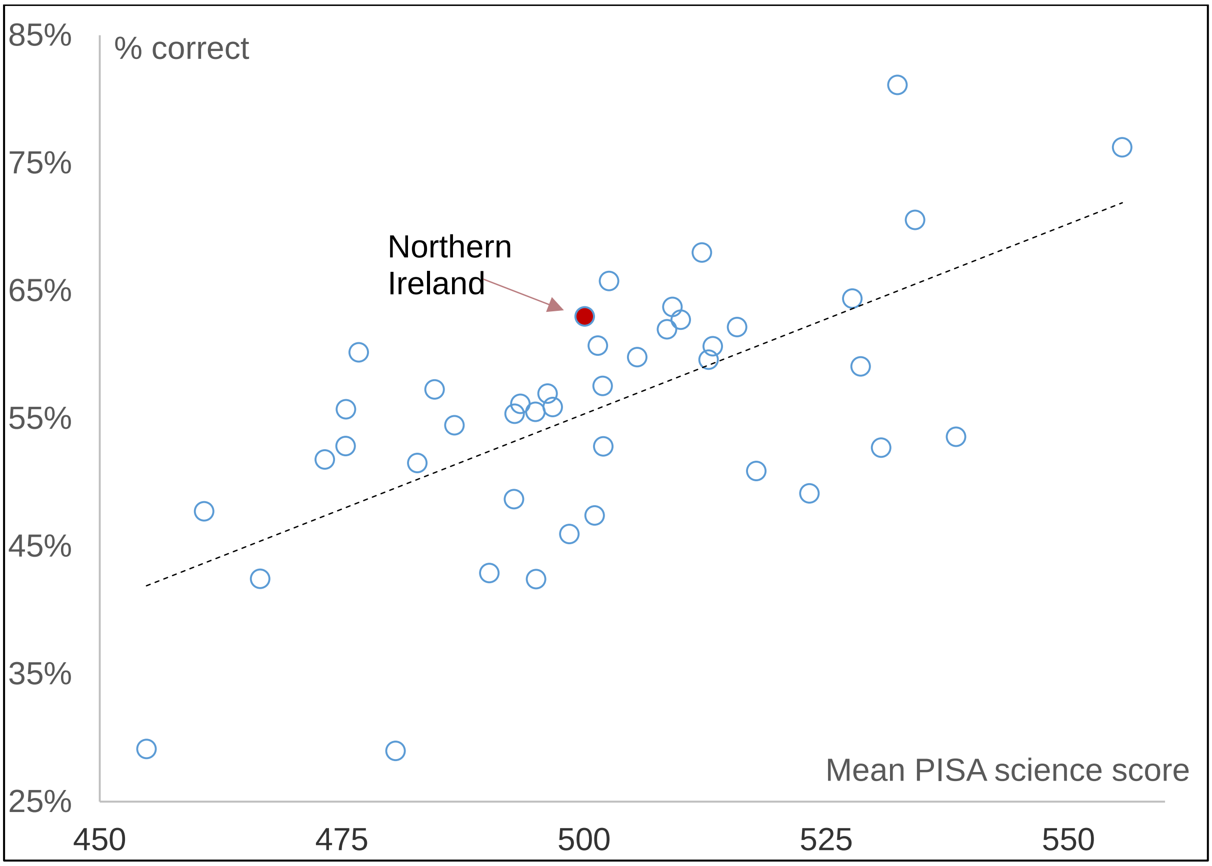
	Slope face investigation	Bird migration
Item code	CS637Q01	CS656Q01
Science content system	Earth and space	Living
Scientific competency	Evaluate and design scientific enquiry	Explain phenomena scientifically
Knowledge category	Epistemic	Content
Difficulty	517 science points	501 science points
PISA level	Level 3	Level 3
% correct Northern Ireland	63%	54%
% correct girls in Northern Ireland	62%	53%
% correct boys in Northern Ireland	64%	56%
Median response time (girls correct)	64 seconds	64 seconds
Median response time (boys correct)	59 seconds	63 seconds
Median response time (girls incorrect)	53 seconds	70 seconds
Median response time (boys incorrect)	57 seconds	59 seconds

Source: PISA 2015 database and OECD (2016).

19. Table 3.7 describes the key properties of this question. It is testing 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). The difficulty of the question is around 517 points on the PISA science scale; pupils achieving at PISA Level 3 have around a 50/50 chance of answering this question correctly. In Northern Ireland, almost two-thirds (63 per cent) of pupils who took this question provided the correct response, with little difference between girls and boys. Finally, as the PISA 2015 test was taken on computer, we know the median response time of pupils in Northern Ireland who answered this question

correctly was around 60 seconds. This compares to approximately 55 seconds for individuals who provided an incorrect response.

Figure 3.2 The percentage of pupils who answer the slope face investigation question correctly across countries



Source: PISA 2015 database

20. Figure 3.2 places Northern Ireland pupils' performance on this question into an international context. Average PISA science scores are plotted along the horizontal axis, with the percentage of pupils providing the correct response on the vertical axis. Northern Ireland sits well above the dashed regression line; this is a question where Northern Ireland pupils perform better than one would anticipate, given Northern Ireland's average PISA science score. Specifically, 63 per cent of pupils in Northern Ireland answered this question correctly, compared to the 55 per cent one would expect based upon the fitted regression line. Indeed, there are relatively few countries where the proportion of pupils who provided the correct response is higher.

3.5 Example question 2. Bird migration.

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

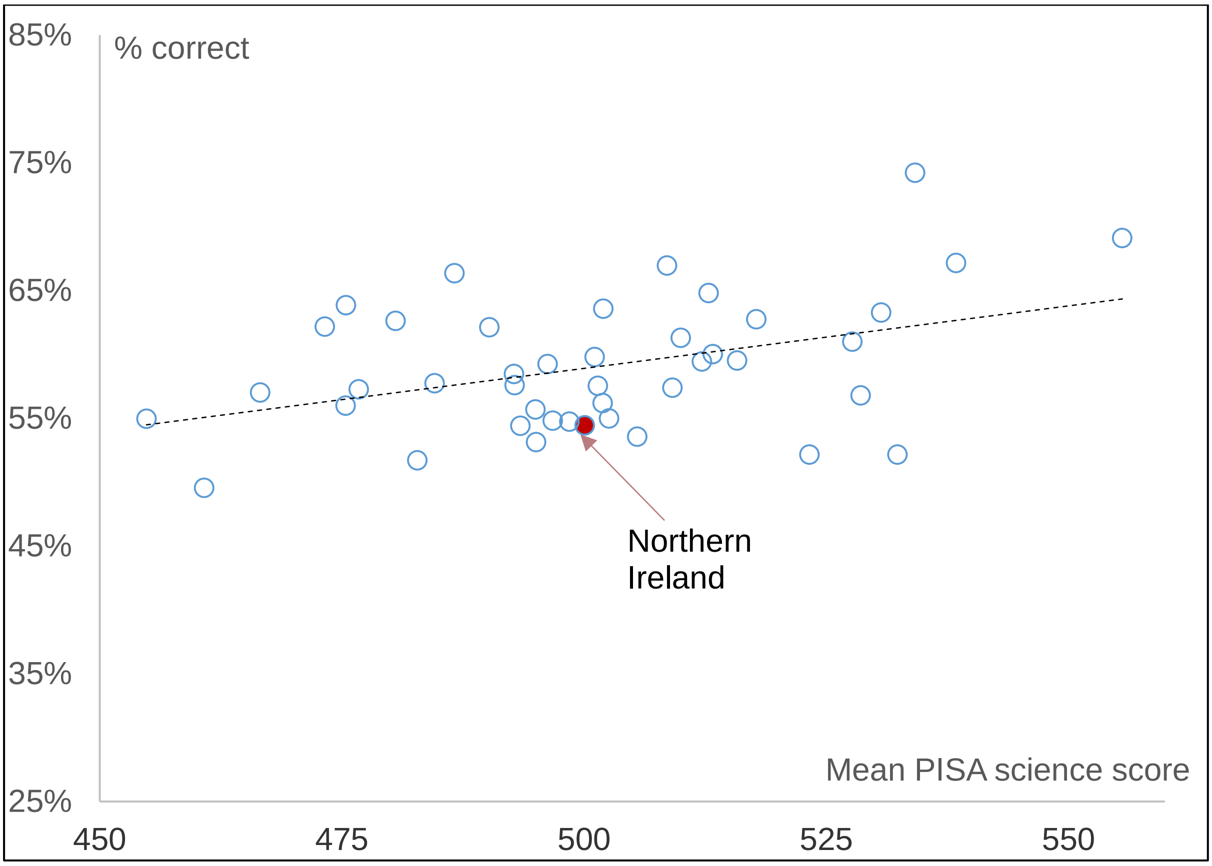
> *'Bird migration is a seasonal large-scale movement of birds to and from their breeding grounds. Every year volunteers count migrating birds at specific locations. Scientists capture some of the birds and tag their legs with a combination of coloured rings and flags. The scientists use sightings of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

22. Returning to Table 3.7, this question examined 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. The difficulty of the question is around 501 points on the PISA science scale; pupils achieving at PISA Level 3 have around a 50/50 chance of answering this question correctly. In Northern Ireland, 54 per cent of pupils who took this question provided the correct response, with little difference between girls and boys. Finally the median response time of pupils in Northern Ireland who answered correctly was just over 60 seconds. This is similar to the amount of time that was spent by pupils who answered incorrectly (median time of 59 seconds for boys and 70 seconds for girls).

Figure 3.3 Proportion of pupils answering the 'bird migration' question correctly versus average PISA science scores



Source: PISA 2015 database

23. How does Northern Ireland's pupils' performance on this question compare to pupils in other countries? The answer is provided in Figure 3.3. Northern Ireland is somewhat below the dashed regression line; 15-year-olds in Northern Ireland found this question slightly harder to answer than one would anticipate, given the mean science score of 500 test points. However, a diverse range of countries have a similar proportion of 15-year-olds answering this question correctly as in Northern Ireland. This includes countries with both lower (e.g. Greece, Croatia) and higher (e.g. Hong Kong, Taiwan) average PISA science scores.

Chapter 4. Achievement in mathematics

The average PISA 2015 mathematics score in Northern Ireland is 493. This is not significantly different to the average score in 2006 (494).

There are 10 countries where the mean mathematics score is at least 20 points higher than in Northern Ireland. These include seven East Asian economies, two European countries and one North American member of the OECD.

There are a further eight European countries where the average PISA score is between 10 and 20 points higher than in Northern Ireland. These include Finland, Poland, Germany and the Republic of Ireland.

Northern Ireland has a smaller proportion of high achieving pupils in mathematics (seven per cent) than the average across members of the OECD (11 per cent).

Around one-in-five (19 per cent) 15-year-olds in Northern Ireland lacks basic mathematics skills. This is lower than the average across members of the OECD (23 per cent).

The highest achieving pupils in Northern Ireland obtain lower PISA mathematics scores than the highest achieving pupils in many other countries.

There is some evidence that the mathematics skills of the highest achieving pupils in Northern Ireland have declined over the last decade.

The difference in mathematics skills between the highest and lowest achieving pupils in Northern Ireland is 204 test points (approximately seven years of schooling). This is a significantly smaller difference than in most other industrialised countries.

4.1 What is the average PISA mathematics score in Northern Ireland, and how does this compare to other countries?

1. An understanding of mathematics is central to a young person's preparedness for life in modern society. A growing proportion of problems and situations encountered in daily life, including in professional contexts, require some level of understanding of mathematics, mathematical reasoning and mathematical tools, before they can be fully understood and addressed. Mathematics is a critical tool for young people as they confront issues and challenges in personal, occupational, societal, and scientific aspects of their lives. 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 solving meaningful problems. The results from PISA 2015 provide such insight, helping us understand whether 15-year-olds in Northern Ireland are able to use their knowledge and skills in mathematics to solve real world problems. Table 4.1 therefore presents the average PISA mathematics score for Northern Ireland, and how this compares in a comparative context.

2. The mean PISA mathematics score in Northern Ireland is 493. Panel (a) refers to those countries where the average PISA mathematics score is at least 20 points higher. A total of 10 countries belong to this group; the top seven being from East Asia (Singapore, Hong Kong, Macao, Taiwan, Japan, China and South Korea). The other three countries include two within Europe (Switzerland and Estonia) and one from North America (Canada).

3. Panel (b) of Table 4.1 turns to countries where the average PISA mathematics score is between 10 and 20 test points higher than in Northern Ireland. There are eight countries within this group, all from Europe. This includes Finland (511), Poland (504), Germany (506) and the Republic of Ireland (504). For each of these countries, the average PISA mathematics score ranges between 504 and 512 test points.

4. Panel (c) includes all countries within 10 points of Northern Ireland's mean mathematics score. Differences of this magnitude are equivalent to less than a quarter of an additional year of schooling, and are generally not outside the range one would expect given sampling error. A total of 16 countries are within this group (excluding Northern Ireland). Most are European nations, including England (493), Sweden (494), France (493) and Italy (490). Other notable countries with a similar average PISA mathematics score to Northern Ireland include Australia (494), New Zealand (495) and Vietnam (495).

Table 4.1 Mean PISA 2015 mathematics scores

(a) Countries more than 20 points ahead of Northern Ireland

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 Northern Ireland

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

(c) Countries within 10 points of Northern Ireland

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 Northern Ireland

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

Source: PISA 2015 database.

Note: Bold font with * indicates mean score significantly different from Northern Ireland at the five per cent level. Table does not include countries with average mathematics scores more than 20 points lower than in Northern Ireland.

5. The final panel of Table 4.1 (panel d) contains countries where the average PISA mathematics score is between 10 and 20 points below Northern Ireland. A total of six countries belong to this group, with four of these from Eastern Europe (Latvia, Lithuania, Hungary and Slovakia). Wales (478) is another notable inclusion.

6. It is important to note that Table 4.1 does not include any country with a mean PISA mathematics score more than 20 points below the score for Northern Ireland. Results have therefore not been presented for 30 countries, including some members of the OECD, such as Greece (454) and the United States (470). A full set of average PISA mathematics scores, including all participating countries, is provided in the online data tables.

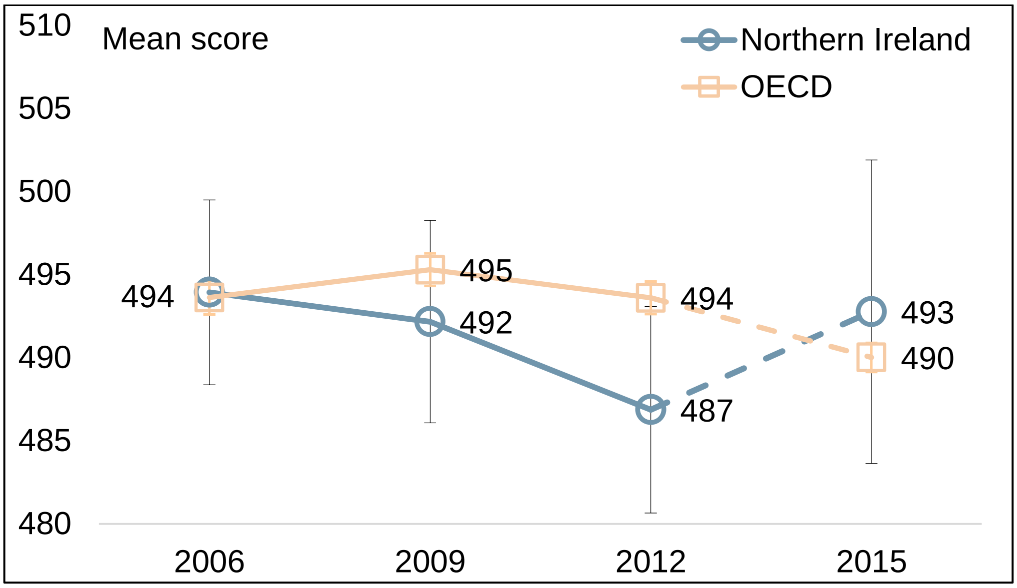
Key point

The average PISA mathematics score in Northern Ireland is 493. There are 18 countries where the average is at least 10 test points higher than in Northern Ireland, and 35 countries where the average is at least 10 test points lower.

4.2 How have average PISA mathematics scores in Northern Ireland changed over time? How does this compare to other countries?

7. Figure 4.1 illustrates that the mean PISA mathematics score for Northern Ireland has remained stable over time. Specifically, the average PISA mathematics score in Northern Ireland in 2015 is 493 test points. This is not significantly different from the mean score in 2012 (487), 2009 (492) or 2006 (494). There is hence no evidence of any significant increase or decrease in average PISA mathematics scores in Northern Ireland over the last decade.

Figure 4.1 Mean PISA 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 black 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

8. Table 4.2 compares the change for Northern Ireland to the five 'fastest improving' (red cells) and the five 'fastest declining' (blue cells) countries. In order to facilitate relevant comparisons, any country where the average PISA 2015 mathematics score is below 450 points has been excluded from this table. Results are presented for both the change between 2006 and 2015 (panel a), and between 2012 and 2015 (panel b).

9. Starting with panel (a), Italy has experienced the greatest improvement in mean mathematics scores between 2006 to 2015, gaining approximately 28 PISA test points (moving from 462 to 490 on the PISA mathematics scale). Other countries with a more than 20 test point (half a year of schooling) increase include Israel and Portugal. 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 The five fastest improving and declining countries in mathematics

(a) PISA 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 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 PISA mathematics score. Table restricted to only those countries with a mean score above 450 in the PISA 2015 mathematics test. Bold font with * indicates statistically significant change. The difference between the 'from' and 'to' column may not equal 'change' due to rounding.

10. Panel (b) of Table 4.2 provides the analogous comparison between PISA 2012 and PISA 2015. The sub-set of countries included is now rather different. 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. On the other hand, a 30 point decline has occurred in South Korea, though it is too early to

tell whether this is a once-off fall or part of a sustained trend[28]. 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).

Key point

There has been no statistically significant change in Northern Ireland's average PISA mathematics score since 2006.

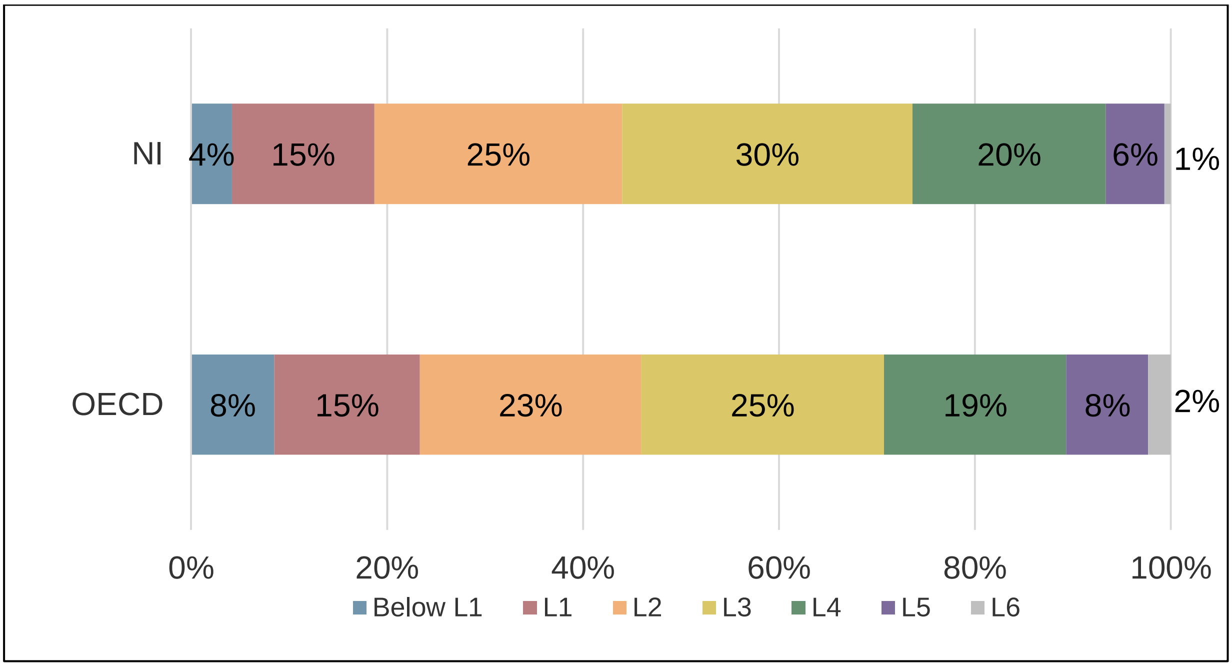
4.3 What proportion of pupils in Northern Ireland reach each mathematics proficiency level?

11. Figure 4.2 illustrates the percentage of pupils in Northern Ireland reaching each PISA mathematics level, and compares this to the average across members of the OECD. In Northern Ireland, 15 per cent of 15-year-olds reach PISA mathematics Level 1 while four per cent are working below Level 1. Analogous figures for the average across OECD members are 15 per cent at Level 1 and eight per cent below Level 1. Therefore, the proportion of 'low-achievers' in Northern Ireland (19 per cent) is somewhat below the average across OECD members (23 per cent).

12. However, Northern Ireland also seems to have fewer pupils reaching the top two PISA mathematics levels than the average member of the OECD. Specifically, around seven per cent of pupils in Northern Ireland obtain a PISA mathematics score at PISA Level 5 or Level 6, compared to an average across OECD members of around 11 per cent.

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

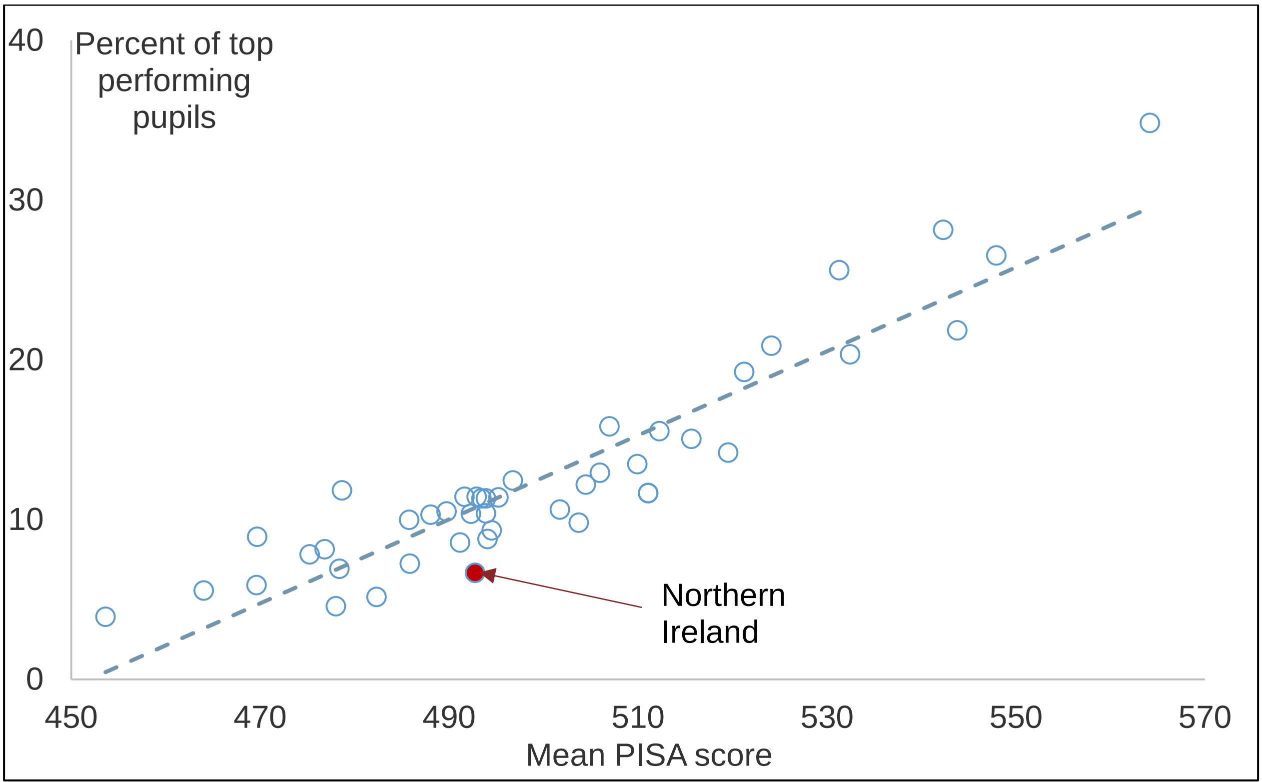
Figure 4.2 The percentage of pupils in Northern Ireland reaching each PISA mathematics level



Source: PISA 2015 database.

13. Figure 4.3 provides further insight into how Northern Ireland compares to other countries in terms of the proportion of high-performing pupils in mathematics. The horizontal axis plots the average PISA mathematics score, while the vertical axis presents the proportion of pupils in each country achieving PISA Level 5 or Level 6. The dashed regression line then illustrates the cross-country relationship between these variables. In this figure, the sample of countries has been restricted to those with a mean mathematics score above 450 points. Northern Ireland sits below the dashed regression line; the share of high achieving pupils in mathematics is lower than one would anticipate for a country with its mean score. Specifically, the regression line suggests that a typical country with an average score of 493 has around 12 per cent of its pupils achieving PISA Level 5 or Level 6. Yet only seven per cent of pupils in Northern Ireland reach this benchmark. This further illustrates Northern Ireland's comparatively low proportion of pupils with high level mathematics skills.

Figure 4.3 The percent of top-performing pupils in mathematics compared to mean PISA 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 points.

Key point

Around one-in-five 15-year-olds in Northern Ireland lack basic mathematics skills. This is lower than the average across members of the OECD.

4.4 How do the PISA mathematics scores of the *highest* achieving pupils in Northern Ireland compare to other countries?

14. The previous sub-section highlighted how Northern Ireland has a lower proportion of high-performing pupils in mathematics than the average across members of the OECD. We now provide further insight into the proficiency of the highest achieving pupils by comparing the 90th percentile of the mathematics distribution for Northern Ireland to the 90th percentile in other countries. We then consider whether the PISA mathematics scores of the highest achievers in Northern Ireland have changed over the last decade.

15. Table 4.3 compares the 90th percentile of the PISA mathematics distribution for Northern Ireland to a range of other countries. In 2015, the 90th percentile of the mathematics proficiency distribution in Northern Ireland was 592. This means that the top-performing 10 per cent of 15-year-olds in this country achieved a score of 592 test points or more. There are 24 countries where the 90th percentile is more than 20 points above the value for Northern Ireland, including a number of European and English-speaking countries. The 90th percentile is between 10 and 20 points higher in a further eight (mainly European) countries, including the Republic of Ireland. Conversely, there are relatively few industrialised nations where the value of the 90th percentile is significantly lower than in Northern Ireland. (Latvia, Greece, Wales, Turkey, Mexico and Chile are the only members of the OECD where the 90th percentile is more than 10 test points below the value in Northern Ireland – see the online data tables for further details). Overall, Table 5.3 illustrates how the mathematics skills of the highest achieving pupils in Northern Ireland is significantly below the level of the highest achieving pupils in several other countries.

Table 4.3 The 90th percentile of PISA 2015 mathematics scores

(a) Countries more than 20 points ahead of Northern Ireland

Country	90th percentile	Country	90th percentile
Singapore	**682***	**Slovenia**	**622***
Taiwan	**670***	**Germany**	**620***
China	**664***	**Austria**	**618***
Hong Kong	**659***	**Poland**	**617***
South Korea	**649***	**Malta**	**616***
Macao	**643***	**Finland**	**614***
Japan	**643***	**Denmark**	**614***
Switzerland	**641***	**Portugal**	**614***
Belgium	**630***	**Australia**	**613***
Canada	**627***	**England**	**613***
Netherlands	**627***	**New Zealand**	**613***
Estonia	**623***	**France**	**613***

(b) Countries between 10 and 20 points ahead of Northern Ireland

Country	90th percentile	Country	90th percentile
Norway	**610***	**Iceland**	**608***
Italy	**610***	**Luxembourg**	**607***
Sweden	**609***	**Republic of Ireland**	**606***
Czech Republic	**608***	Vietnam	604

(c) Countries within 10 points of Northern Ireland

Country	90th percentile	Country	90th percentile
Russia	601	Spain	593
Israel	601	Northern Ireland	592
Scotland	601	Lithuania	590
Hungary	598	United States	585
Slovakia	596		

(d) Countries between 10 and 20 points behind Northern Ireland

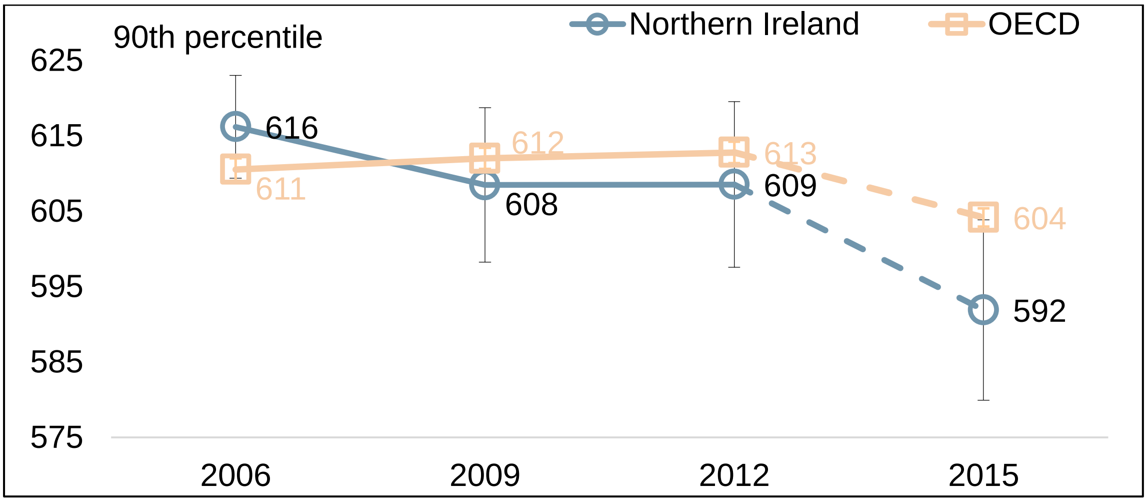
Country	90th percentile	Country	90th percentile
Latvia	**582***	**Wales**	**578***
Croatia	**580***		

Source: PISA 2015 database.

Note: Bold font with * indicates significantly different from Northern Ireland at the five per cent level. Table does not include countries where the 90th percentile of the mathematics proficiency distribution is more than 20 points below Northern Ireland.

16. How has the performance of Northern Ireland's highest achieving pupils in mathematics changed over time? Figure 4.4 provides the answer by plotting the 90th percentile of the PISA mathematics distribution from 2006 to 2015, accompanied by the estimated 95 per cent confidence interval. There is some evidence of a decline over this period, although this is to some extent being driven by a decline between 2012 and 2015. In particular, the 90th percentile stood at 616 in 2006, 608 in 2009 and 609 in 2012, followed by a somewhat more pronounced fall to 592 in the latest PISA cycle. There is nevertheless a 24 point difference in the 90th percentile between 2006 and 2015, which is statistically significant at the five per cent level.

Figure 4.4 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 black 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

There is some evidence of a decline in the mathematics skills of the highest achieving pupils in Northern Ireland since 2006.

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

17. Although there may have been some change in the mathematics skills of the highest achieving pupils in Northern Ireland over the last decade, does the same also hold true for the lowest achievers? Moreover, how do the PISA 2015 mathematics scores of the lowest achieving pupils in Northern Ireland compare to the lowest achieving 15-year-olds in other countries? Table 4.4 provides evidence on this matter by comparing the 10th percentile of the PISA mathematics distribution across countries.

18. The value of the 10th percentile of the mathematics proficiency distribution in Northern Ireland is 388. There are four East Asian economies and one European country where the 10th percentile is more than 20 points above the value for Northern Ireland (Macao, Singapore, Hong Kong, Japan and Estonia). In a further five countries, the 10th percentile is between 10 and 20 points above Northern Ireland (Denmark, Finland, Taiwan, Canada and the Republic of Ireland). Yet there is also a number of countries where the 10th percentile is either around the same level or lower than in Northern Ireland. For instance, low-achieving pupils in Northern Ireland achieve similar mathematics scores to low-achieving pupils in countries such as Germany, the Netherlands, China and South Korea. Moreover, in Australia, Sweden and England, the 10th percentile of the PISA mathematics distribution is more than 10 test points (a quarter of a year of schooling) lower than in Northern Ireland. The comparative position of Northern Ireland in Table 4.4 (results for the 10th percentile) is therefore somewhat more favourable than the comparative position of Northern Ireland in Table 4.3 (results for the 90th percentile).

19. Figure 4.5 proceeds by considering how the 10th percentile of PISA mathematics scores in Northern Ireland has changed since 2006. The point estimate of the 10th percentile has fluctuated over this period, standing at 373 in 2006, 378 in 2009, 365 in 2012 and 388 in 2015. However, there is little evidence of a consistent upwards or downwards trend, with the difference between the 2006 and 2015 values not reaching statistical significance at conventional thresholds.

Table 4.4 The 10th percentile of PISA 2015 mathematics scores

(a) Countries more than 20 points ahead of Northern Ireland

Country	10th percentile	Country	10th percentile
Macao	**439***	**Japan**	**416***
Singapore	**436***	**Estonia**	**415***
Hong Kong	**426***		

(b) Countries between 10 and 20 points ahead of Northern Ireland

Country	10th percentile	Country	10th percentile
Denmark	**405***	Canada	400
Finland	**404***	Republic of Ireland	400
Taiwan	**404***		

(c) Countries within 10 points of Northern Ireland

Country	10th percentile	Country	10th percentile
Switzerland	394	Vietnam	388
Slovenia	394	China	388
Poland	391	Northern Ireland	388
South Korea	391	Russia	387
Norway	391	Scotland	382
Netherlands	390	Latvia	382
Germany	389		

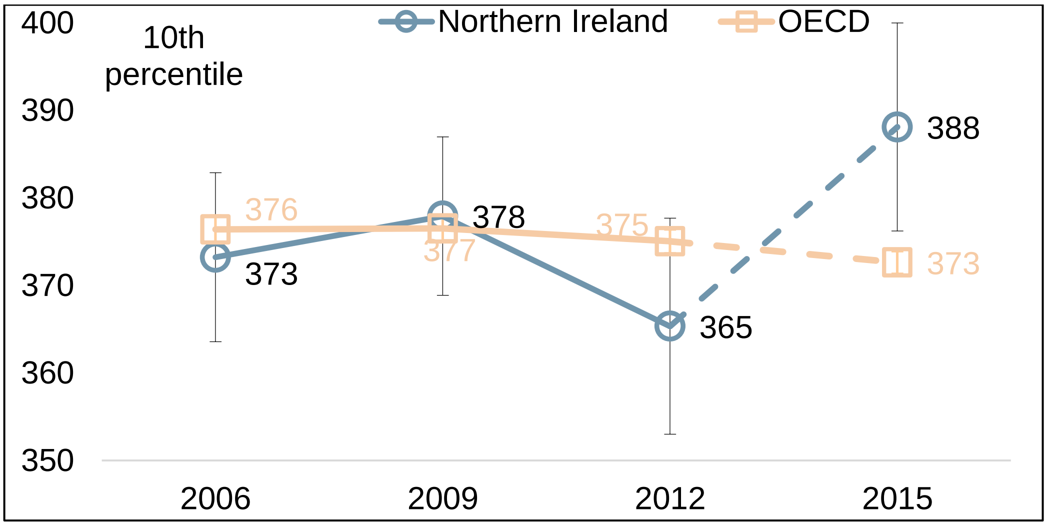
(d) Countries between 10 and 20 points behind Northern Ireland

Country	10th percentile	Country	10th percentile
Wales	377	**Czech Republic**	**373***
Sweden	376	**Australia**	**371***
New Zealand	375	**Austria**	**370***
Belgium	374	**England**	**369***
Spain	**374***	**Italy**	**368***

Source: PISA 2015 database.

Note: Bold font with * indicates significantly different from Northern Ireland at the five per cent level. Table does not include countries where the 10th percentile of the mathematics distribution is more than 20 points below Northern Ireland.

Figure 4.5 The 10th percentile of PISA mathematics scores for Northern Ireland 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 black 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

International comparisons of Northern Ireland's lowest achieving pupils in mathematics are more favourable than international comparisons of Northern Ireland's highest achieving pupils in mathematics.

4.6 How big is the gap between the pupils with the strongest and weakest mathematics skills? How does Northern Ireland compare to other countries in this respect?

20. To conclude this chapter, we consider inequality in 15-year-olds' mathematics skills, as measured by the difference between the 90th percentile and the 10th percentile. The magnitude of this gap is presented in Table 4.5. For brevity, the sample is restricted to only those countries and economies with a mean PISA mathematics score above 450 points. The 10 countries with the highest mean PISA mathematics scores have been highlighted in red.

21. The 90th percentile of the PISA mathematics distribution in Northern Ireland is 592, while the 10th percentile stands at 388. Table 4.5 demonstrates that the gap is therefore 204 test points, equivalent to around seven years of schooling. This is smaller than in most other countries (OECD average = 232). Indeed, no other country included in Table 4.5 has a significantly smaller gap than in Northern Ireland. Conversely, there are 33 countries where there is significantly more inequality in 15-year-olds mathematics achievement. In other words, by this metric, Northern Ireland has one of the most equal distributions of mathematics performance anywhere in the industrialised world.

Key point

The gap between the highest and lowest achieving pupils in mathematics is smaller in Northern Ireland than in most other industrialised countries.

Table 4.5 Difference between the highest and lowest achievers in mathematics

Country	Difference between the 90th and 10th percentile	Difference in years of schooling
Malta	**285***	**9.5 years**
China	**276***	**9.2 years**
Israel	**269***	**9.0 years**
Taiwan	**266***	**8.9 years**
South Korea	**258***	**8.6 years**
Belgium	**255***	**8.5 years**
France	**249***	**8.3 years**
Portugal	**249***	**8.3 years**
Switzerland	**247***	**8.2 years**
Slovakia	**247***	**8.2 years**
Austria	**247***	**8.2 years**
Singapore	**247***	**8.2 years**
Hungary	**246***	**8.2 years**
England	**245***	**8.2 years**
Luxembourg	**244***	**8.1 years**
Australia	**242***	**8.1 years**
Iceland	**241***	**8.0 years**
Italy	**241***	**8.0 years**
New Zealand	**238***	**7.9 years**
Netherlands	**237***	**7.9 years**
Czech Republic	**235***	**7.8 years**
Greece	**234***	**7.8 years**
Sweden	**233***	**7.8 years**
Hong Kong	**232***	**7.7 years**
Germany	**230***	**7.7 years**
United States	**230***	**7.7 years**
Croatia	**229***	**7.6 years**
Slovenia	**228***	**7.6 years**
Canada	**227***	**7.6 years**
Japan	**227***	**7.6 years**
Poland	**226***	**7.5 years**
Lithuania	**225***	**7.5 years**
Spain	220	7.3 years
Scotland	219	7.3 years
Norway	**219***	**7.3 years**
Vietnam	215	7.2 years
Russia	214	7.1 years
Finland	210	7.0 years
Denmark	209	7.0 years
Estonia	209	7.0 years
Republic of Ireland	206	6.9 years
Macao	204	6.8 years
Northern Ireland	204	6.8 years
Wales	201	6.7 years
Latvia	200	6.7 years

Source: PISA 2015 database.

Note: Bold font with * indicates significant difference compared to Northern Ireland at the five per cent level. Table only includes countries where the mean PISA mathematics score is above 450.

Chapter 5. Achievement in reading

The average PISA reading score in Northern Ireland is 497. This is not significantly different to the average score in 2006 (495).

There are seven countries where the average reading score is more than 20 points higher than in Northern Ireland. There are a further five countries where the average PISA reading score is between 10 and 20 points higher.

Around one-in-six (15 per cent) 15-year-olds in Northern Ireland lack basic reading skills. This is fewer than the average across members of the OECD (20 per cent). On the other hand, Northern Ireland has fewer high achieving pupils in reading (six per cent) than the average member of the OECD (eight per cent).

There has been a steady decline in the reading skills of the highest achieving pupils in Northern Ireland over the last decade; the 90th percentile has fallen from 627 to 605 test points.

The reading skills of the lowest achieving pupils in Northern Ireland have improved since 2006; the 10th percentile of PISA reading scores has risen from 352 to 385 test points.

The difference in reading skills between the highest and lowest achieving pupils in Northern Ireland is 220 test points (approximately seven years of schooling). This is a significantly smaller difference than in most other countries, suggesting that there is less inequality in 15-year-olds' reading skills in Northern Ireland than in most other parts of the industrialised world.

5.1 What is the average PISA reading score in Northern Ireland, and how does this compare to 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[29], the impact of reading literacy upon personal well-being and social cohesion is likely to be just as important[30]. This foundational nature of reading literacy has been summed up by the European Commission[31], which noted such skills to be '*key to all areas of education and beyond, facilitating participation in the wider context of lifelong learning and contributing to individuals' social integration and personal development.*' Throughout this chapter we therefore consider the reading proficiency of 15-year-olds in Northern Ireland, and how this compares to the reading skills of young people living in other countries. This particular sub-section focuses upon average PISA reading scores.

2. The mean PISA reading score in Northern Ireland is 497. Panel (a) of Table 5.1 lists the countries where the average PISA reading score is at least 20 points higher than in Northern Ireland. A total of seven countries belong to this group; three from East Asia (Singapore, Hong Kong and South Korea), three from Europe (Finland, the Republic of Ireland and Estonia) and one from North America (Canada). In all these countries, the average PISA reading score is at least 517 test points.

3. Panel (b) of Table 5.1 turns to countries where the average PISA reading score is between 10 and 20 test points higher than in Northern Ireland. There are a further five countries within this group: Japan (516), Norway (513), New Zealand (509), Germany (509) and Macao (509).

29 Machin and McNally (2008).
30 Friedman (2005) and OECD (2001).
31 European Commission (2001).

Table 5.1 Mean PISA 2015 reading scores

(a) Countries more than 20 points ahead of Northern Ireland

Country	Mean score	Country	Mean score
Singapore	**535***	**Republic of Ireland**	**521***
Hong Kong	**527***	**Estonia**	**519***
Canada	**527***	**South Korea**	**517***
Finland	**526***		

(b) Countries between 10 and 20 points ahead of Northern Ireland

Country	Mean score	Country	Mean score
Japan	**516***	**Germany**	**509***
Norway	**513***	**Macao**	**509***
New Zealand	**509***		

(c) Countries within 10 points of Northern Ireland

Country	Mean score	Country	Mean score
Poland	506	Taiwan	497
Slovenia	505	Northern Ireland	497
Netherlands	503	United States	497
Australia	503	Spain	496
Sweden	500	Russia	495
Denmark	500	China	494
England	500	Scotland	493
France	499	Switzerland	492
Belgium	499	Latvia	488
Portugal	498	Czech Republic	487

(d) Countries between 10 and 20 points behind Northern Ireland

Country	Mean score	Country	Mean score
Croatia	487	**Iceland**	**482***
Vietnam	487	**Luxembourg**	**481***
Austria	**485***	**Israel**	**479***
Italy	**485***	**Wales**	**477***

Source: PISA 2015 database.

Note: Bold font with * indicates mean score significantly different from Northern Ireland at the five per cent level. Table does not include countries with average reading scores more than 20 points lower than Northern Ireland.

4. Panel (c) includes all countries within 10 points of the mean reading score in Northern Ireland. Differences of this magnitude are equivalent to less than a quarter of an additional year of schooling, and generally not outside the range one would expect given sampling error. A total of 19 countries are within this group (excluding Northern Ireland). These are mostly European nations, including Poland (506), England (500) and Scotland (493). Other non-European countries with a similar average PISA reading score to Northern Ireland include Australia (503), China (494), Russia (495) and the United States (497).

5. The final panel of Table 5.1 (panel d) contains countries where the average PISA reading score is between 10 and 20 points lower than in Northern Ireland. Eight countries fall within this group; six from Europe (Croatia, Austria, Italy, Iceland, Luxembourg and Wales) along with Israel and Vietnam. However, it is important to note that Table 5.1 does not include any country with a mean PISA reading score more than 20 points below the score for Northern Ireland. Results have therefore not been presented for 31 countries, including some members of the OECD, such as Greece (467). A full set of average PISA reading scores, including all participating countries, is provided in the online data tables.

Key point

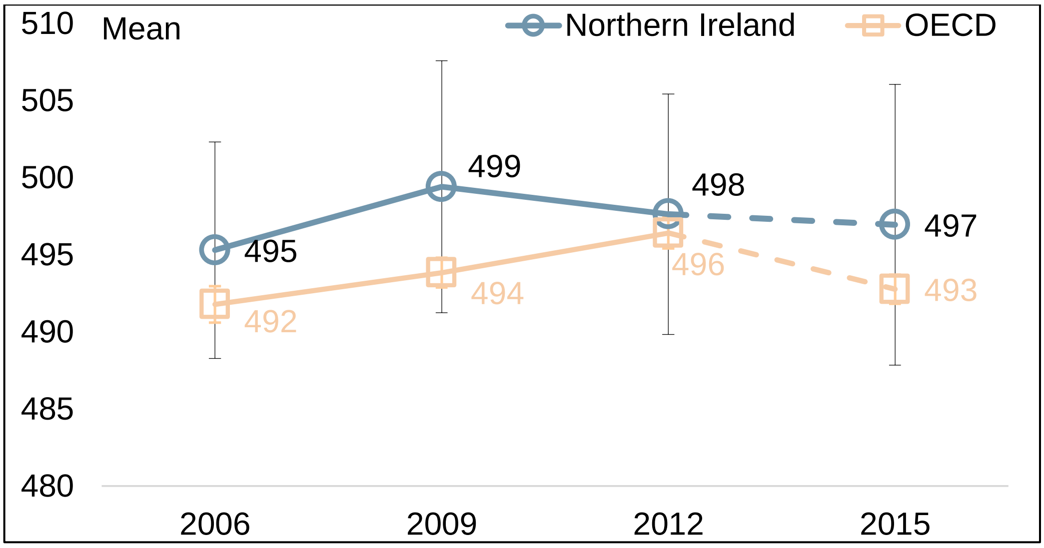
The average PISA reading score in Northern Ireland is 497. There are 12 countries where the average is at least 10 test points higher than in Northern Ireland, and 39 countries where the average is at least 10 test points lower.

5.2 How have average PISA reading scores in Northern Ireland changed over time? How does this compare to other countries?

6. Figure 5.1 illustrates that the mean PISA reading score for Northern Ireland has remained stable over time. Specifically, the average PISA reading score in 2015 for Northern Ireland (497) is not significantly different from the mean score in 2012 (498), 2009 (499) or 2006 (495). There is hence no evidence of any significant increase or decrease in average PISA reading scores in Northern Ireland over the last decade.

7. Table 5.2 compares the change for Northern Ireland to the five ‘fastest improving’ (red cells) and the five ‘fastest declining’ (blue cells) countries. In order to facilitate relevant comparisons, any country where the average PISA 2015 reading score is below 450 points has been excluded from this table. Results are presented for both the change between 2006 and 2015 (panel a), and between 2012 and 2015 (panel b).

Figure 5.1 Mean reading scores for Northern Ireland 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 black 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

8. Starting with panel (a), Russia has experienced the greatest improvement in mean reading scores during the 2006 to 2015 period, gaining approximately 55 test points (moving from 440 to 495 on the PISA reading scale). Other countries with a greater than 20 test point (half a year of schooling) increase include Israel (+40, from 439 to 479), 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 the most pronounced declines.

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 PISA reading score. Table restricted to only those countries with a mean score above 450 in the PISA 2015 reading test. Bold font with * indicates statistically significant change. The difference between the 'from' and 'to' column may not equal 'change' due to rounding.

9. Panel (b) of Table 5.2 provides the analogous comparison between PISA 2012 and PISA 2015. Perhaps the most notable feature of this table is that four of the five countries with the biggest decline since 2012 are East Asian. 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 PISA reading scores since PISA 2012.

Key point

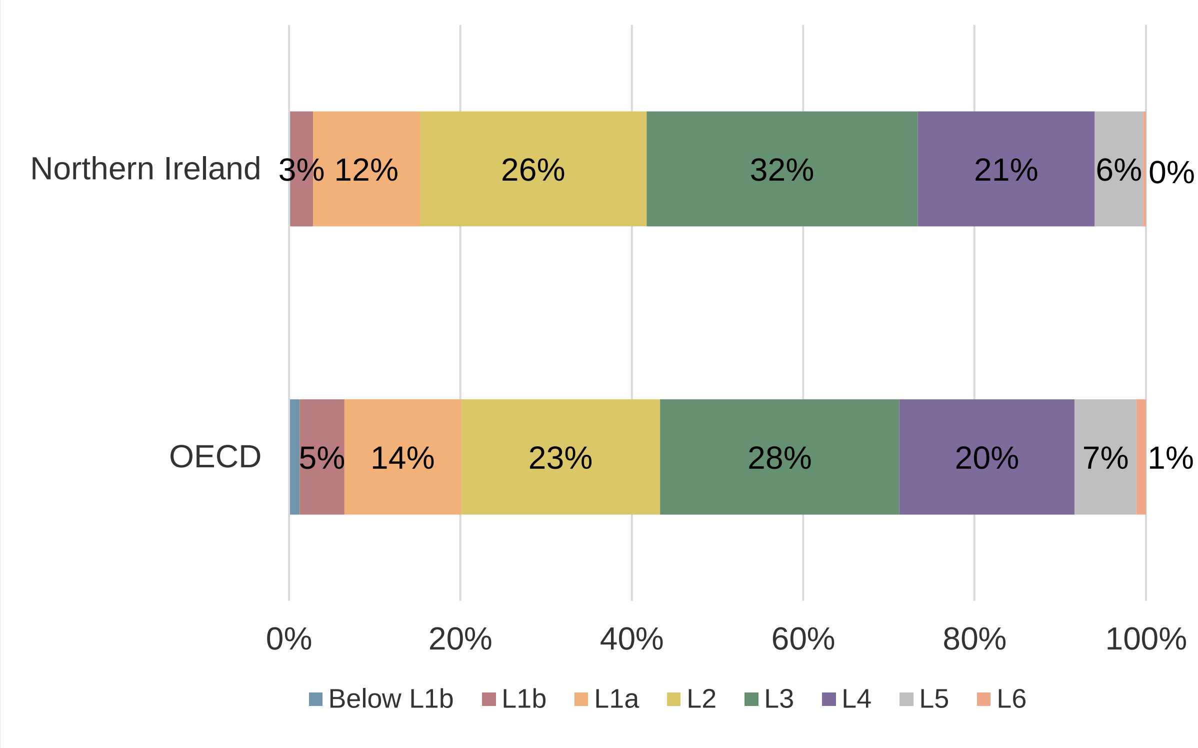
There has been no statistically significant change in the average PISA reading score for Northern Ireland since 2006.

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

10. Figure 5.2 illustrates the percentage of pupils in Northern Ireland reaching each PISA reading level, and compares this to the average across members of the OECD. In Northern Ireland, 12 per cent of 15-year-olds reach PISA reading Level 1a, three per cent reach Level 1b, while less than one per cent of pupils are working below Level 1b. Analogous figures for the average across OECD members are 14 per cent at Level 1a, five per cent at Level 1b and one per cent below Level 1b. Northern Ireland therefore has a smaller proportion of pupils with low-level reading skills (15 per cent) than the average across members of the OECD (20 per cent).

11. On the other hand, the proportion of high achieving pupils in reading in Northern Ireland is slightly below the OECD average. Specifically, six per cent of pupils in Northern Ireland reach one of the top two PISA achievement levels in reading, compared to an average across members of the OECD of eight per cent.

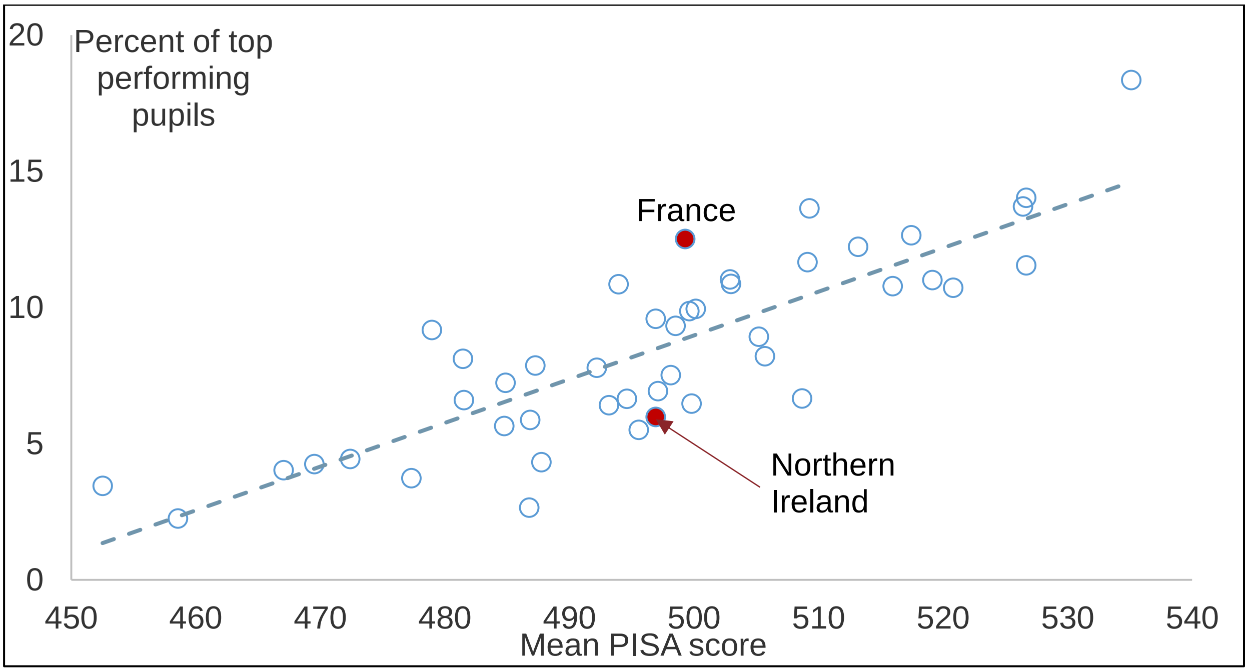
Figure 5.2 The percentage of pupils in Northern Ireland reaching each PISA reading level



Source: PISA 2015 database.

12. Figure 5.3 provides further insight into how Northern Ireland compares to other countries in terms of the proportion of high-performing pupils in reading. The horizontal axis plots the average PISA reading score, while the vertical axis presents the proportion of pupils in each country achieving PISA Level 5 or Level 6. The dashed regression line then illustrates the cross-country relationship between these variables. In this figure, the sample of countries has been restricted to those with a mean reading score above 450 points. Northern Ireland sits below the dashed regression line; this means that Northern Ireland has fewer high achieving pupils than one would anticipate given its mean reading score. Specifically, the fitted regression line suggests that around nine per cent of pupils will reach PISA Level 5 or 6 in the typical country with a mean PISA reading score of 497; yet only six per cent of 15-year-olds reach this benchmark in Northern Ireland. Indeed, there are countries such as France which have double the proportion of pupils with high level reading skills (13 per cent) despite a similar average score (499). This illustrates how Northern Ireland has a smaller proportion of 15-year-olds with high level reading skills than in several other countries with similar mean PISA reading scores.

Figure 5. 3 The percentage of top-performing pupils in reading compared to mean PISA 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

Around 15 per cent of 15-year-olds in Northern Ireland lack basic reading skills. This is below the average across members of the OECD.

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

13. The previous sub-section highlighted how Northern Ireland has a smaller proportion of its pupils reaching the top two PISA achievement levels in reading than the average member of the OECD. We now provide further insight into the proficiency of the highest achieving pupils by comparing the 90th percentile of the reading distribution for Northern Ireland to the 90th percentile in other countries. We then consider whether the PISA reading scores of the highest achievers in Northern Ireland have changed over the last decade.

14. Table 5.3 compares the 90th percentile of the PISA reading distribution for Northern Ireland to a range of other countries. In 2015, the 90th percentile of the reading proficiency distribution in Northern Ireland was 605. This means that the top-performing 10 per cent of 15-year-olds in this country achieved a score of 605

reading test points or more. There are 17 countries where the value of the 90th percentile is more than 20 points above the value for Northern Ireland, with a further four countries where the 90th percentile is between 10 and 20 points higher. Conversely, there are relatively few industrialised nations where the value of the 90th percentile is more than 10 points lower than in Northern Ireland. (There are only seven members of the OECD where the 90th percentile is more than 10 test points lower – see the online data tables for further details). Overall, Table 5.3 further illustrates how the reading skills of the highest achieving pupils in Northern Ireland are significantly below the skills of the highest achieving pupils in a number of other countries.

15. How has the performance of Northern Ireland's highest achieving pupils in reading changed over time? Figure 5.4 provides the answer by plotting the 90th percentile of the PISA reading distribution from 2006 to 2015, accompanied by the estimated 95 per cent confidence interval. There is evidence of a trend, with a steady decline in the 90th percentile over the last decade. In particular, the 90th percentile stood at 627 in 2006, 622 in 2009, 618 in 2012 and 605 in 2015. The point estimate has hence fallen in each of the last four consecutive PISA rounds. Moreover, the difference between 2006 and 2015 is statistically significant at the five per cent level. Hence, there has been a decline of around half a year of schooling in the reading skills of Northern Ireland's highest achieving pupils since 2006.

Table 5.3 The 90th percentile of PISA 2015 reading scores

(a) Countries more than 20 points ahead of Northern Ireland

Country	90th percentile	Country	90th percentile
Singapore	**657***	**Australia**	**631***
New Zealand	**643***	**Estonia**	**630***
Canada	**642***	**China**	**630***
Finland	**640***	**Netherlands**	**630***
South Korea	**637***	**Japan**	**629***
France	**637***	**Republic of Ireland**	**629***
Norway	**636***	**Sweden**	**625***
Germany	**634***	**England**	**625***
Hong Kong	**632***		

(b) Countries between 10 and 20 points ahead of Northern Ireland

Country	90th percentile	Country	90th percentile
United States	**624***	**Slovenia**	**621***
Belgium	**623***	Poland	617
Israel	**621***	Luxembourg	616

(c) Countries within 10 points of Northern Ireland

Country	90th percentile	Country	90th percentile
Czech Republic	614	Russia	608
Switzerland	614	Iceland	607
Portugal	614	Northern Ireland	605
Austria	611	Croatia	603
Taiwan	611	Spain	603
Macao	610	Italy	602
Denmark	608	Malta	595
Scotland	608		

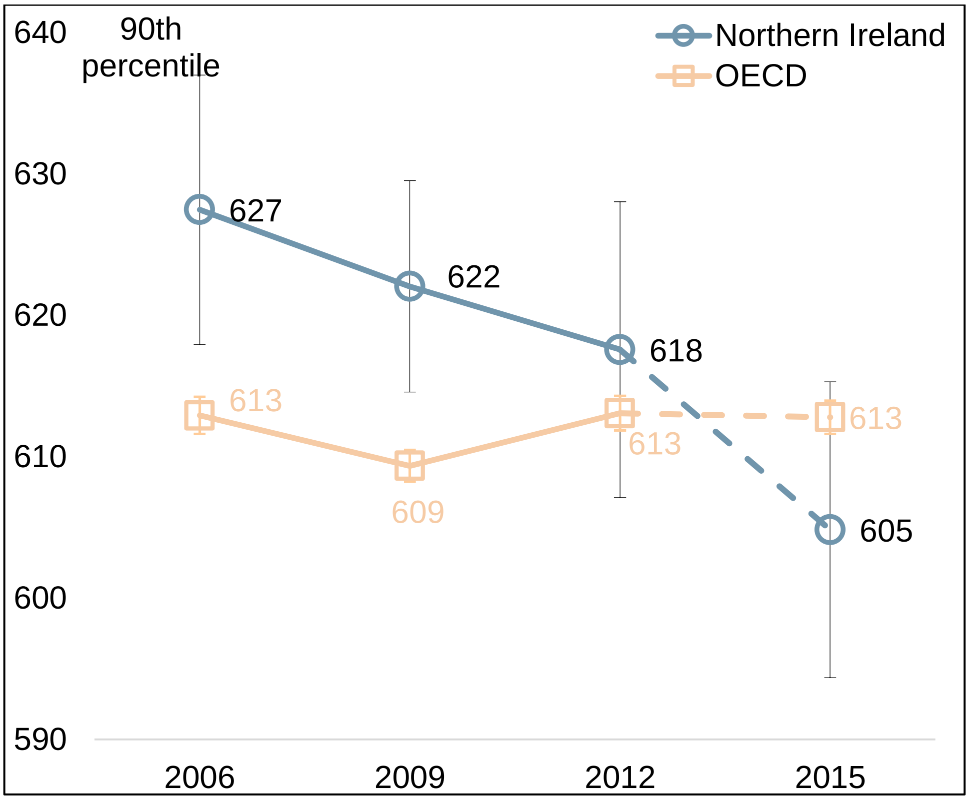
(d) Countries between 10 and 20 points behind Northern Ireland

Country	90th percentile	Country	90th percentile
Latvia	595	**Greece**	**590***
Lithuania	593	**Wales**	**588***
Hungary	**593***		

Source: PISA 2015 database.

Note: Bold font with * indicates significantly different from Northern Ireland at the five per cent level. Table does not include countries where the 90th percentile of the reading proficiency distribution is more than 20 points below Northern Ireland.

Figure 5.4 The 90th percentile of PISA reading scores for Northern Ireland 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 black 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.4.4b. See Appendix F for further information on trends in performance over time

Key point

The reading skills of the highest achieving pupils in Northern Ireland have declined over the past decade.

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

16. Although the reading skills of the highest achieving pupils in Northern Ireland may be lower than the top performing pupils in several other countries, does the same hold true for the lowest achievers? Table 5.4 provides evidence on this matter by comparing the 10th percentile of the PISA reading distribution across countries.

Table 5.4 The 10th percentile of PISA 2015 reading scores

(a) Countries more than 20 points ahead of Northern Ireland

Country	10th percentile	Country	10th percentile
Hong Kong	**412***	**Republic of Ireland**	**406***

(b) Countries between 10 and 20 points ahead of Northern Ireland

Country	10th percentile	Country	10th percentile
Estonia	**404***	**Singapore**	**400***
Canada	**404***	**Macao**	**399***
Finland	**401***		

(c) Countries within 10 points of Northern Ireland

Country	10th percentile	Country	10th percentile
Vietnam	393	Slovenia	382
Japan	391	Norway	381
South Korea	386	Russia	381
Poland	386	Spain	379
Northern Ireland	385	Germany	375
Denmark	383		

(d) Countries between 10 and 20 points behind Northern Ireland

Country	10th percentile	Country	10th percentile
Portugal	374	**New Zealand**	**368***
Latvia	374	**Wales**	**368***
Scotland	373	**Netherlands**	**368***
England	371	**Croatia**	**367***
Taiwan	371	**Australia**	**365***

Source: PISA 2015 database.

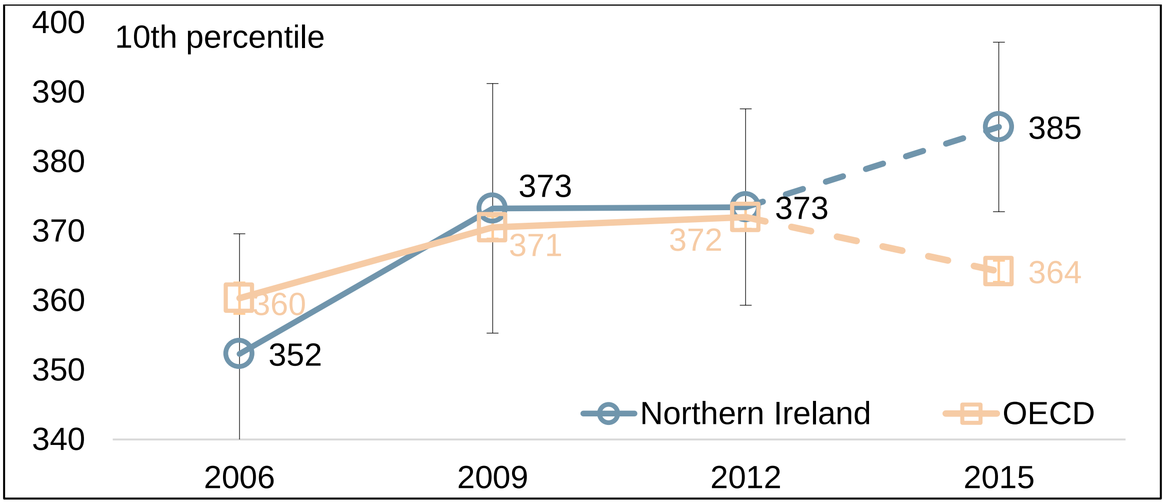
Note: Bold font with * indicates significantly different from Northern Ireland at the five per cent level. Table does not include countries where the 10th percentile of the reading distribution is more than 20 points below Northern Ireland.

17. The value of the 10th percentile of the reading proficiency distribution in Northern Ireland is 385. There are only two countries where the 10th percentile is more than 20 points above the value for Northern Ireland; Hong Kong (412) and the Republic of Ireland (406). In a further five countries, the 10th percentile is between 10

and 20 points above Northern Ireland, including Canada (404), Finland (401) and Singapore (400). However, Table 5.4 also indicates that the reading scores of low-achieving pupils in Northern Ireland are also significantly higher than in a number of other countries, including several members of the OECD (e.g. New Zealand, the Netherlands, Australia) and the rest of the UK. Overall, the position of Northern Ireland in this international comparison of the lowest achievers in reading is somewhat more favourable than the results presented previously for the highest achievers in Table 5.3.

18. Figure 5.5 proceeds by considering how the 10th percentile of the PISA reading distribution in Northern Ireland has changed since 2006. There is some evidence of a trend, with a steady increase in the 10th percentile since 2006. In particular, the 10th percentile stood at 352 in 2006, 373 in 2009, 373 in 2012 and 385 in 2015. The point estimate has therefore increased by around 30 test points (one year of schooling) over this nine year period. Moreover, the difference between 2006 and 2015 is statistically significant at the five per cent level. When considered in conjunction with Figure 5.4, this result implies that there has been a marked decline in educational inequality (in terms of 15-year-olds reading skills) in Northern Ireland over the past decade.

Figure 5.5 The 10th percentile of PISA reading scores for Northern Ireland 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 black 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.4.4b. See Appendix F for further information on trends in performance over time

Key point

There has been an increase in the PISA reading scores of the lowest achieving pupils over the past decade. The gap between the highest and lowest achieving pupils in reading has also fallen since PISA 2006.

5.6 How big is the gap between the pupils with the strongest and weakest reading skills? How does Northern Ireland compare to other countries in this respect?

19. To conclude this chapter, we consider inequality in 15-year-olds' reading skills, as measured by the difference between the 90th percentile and the 10th percentile. The magnitude of this gap is presented in Table 5.5. For brevity, the sample is restricted to only those countries with a mean PISA reading score above 450 points. The 10 countries with the highest mean PISA reading scores have been highlighted in red.

20. The 90th percentile of the PISA reading distribution in Northern Ireland is 605, while the 10th percentile stands at 385. Table 5.5 demonstrates that the gap is therefore 220 test points, equivalent to around seven and a third years of schooling. This is smaller than in most other countries included in the comparison (OECD average = 249). Indeed, there is only one country included in Table 5.5 where the difference between the 90th and 10th percentile is significantly smaller than in Northern Ireland (this is Vietnam). Conversely, there are 31 countries where inequality in reading achievement is significantly greater. Consequently, by this metric, Northern Ireland seems to be one of the most equal countries in the world in terms of 15-year-olds' reading skills.

Key point

The difference in reading skills between the highest and lowest achieving pupils is smaller in Northern Ireland than in most other countries.

Table 5.5 Difference between the highest and lowest achievers in reading

Country	Difference between the 90th and 10th percentile	Difference in years of schooling
Israel	**295***	**9.8 years**
France	**293***	**9.8 years**
China	**283***	**9.4 years**
Luxembourg	**279***	**9.3 years**
New Zealand	**274***	**9.1 years**
Slovakia	**271***	**9.0 years**
Australia	**265***	**8.8 years**
Austria	**265***	**8.8 years**
Belgium	**263***	**8.8 years**
Czech Republic	**262***	**8.7 years**
Netherlands	**262***	**8.7 years**
Sweden	**262***	**8.7 years**
United States	**259***	**8.6 years**
Germany	**258***	**8.6 years**
Singapore	**257***	**8.6 years**
Iceland	**256***	**8.5 years**
Greece	**256***	**8.5 years**
Norway	**255***	**8.5 years**
Hungary	**255***	**8.5 years**
Switzerland	**254***	**8.5 years**
England	**254***	**8.5 years**
South Korea	**251***	**8.4 years**
Lithuania	**246***	**8.2 years**
Italy	**244***	**8.1 years**
Taiwan	**240***	**8.0 years**
Portugal	**240***	**8.0 years**
Finland	**239***	**8.0 years**
Slovenia	**239***	**8.0 years**
Canada	**238***	**7.9 years**
Japan	**238***	**7.9 years**
Croatia	**237***	**7.9 years**
Scotland	235	7.8 years
Poland	231	7.7 years
Chile	229	7.6 years
Russia	227	7.6 years
Estonia	226	7.5 years
Denmark	225	7.5 years
Spain	224	7.5 years
Republic of Ireland	222	7.4 years
Latvia	221	7.4 years
Hong Kong	220	7.3 years
Northern Ireland	220	7.3 years
Wales	219	7.3 years
Macao	212	7.1 years
Vietnam	**187***	**6.2 years**

Source: PISA 2015 database.

Note: Bold font with * indicates statistically significant differences compared to Northern Ireland at the five per cent significance level. Table only includes countries and economies where the mean PISA reading score is above 450.

Chapter 6. Variation in PISA scores by pupil characteristics

There is no statistically significant gender difference in Northern Ireland for either the PISA science or mathematics test.

The gender gap in 15-year-olds' reading skills is smaller in Northern Ireland than in most other countries, and is also smaller than in previous PISA cycles.

Family background has a similar impact upon pupils' achievement in Northern Ireland as in many other countries. This includes some of the countries with the highest average scores, such as Finland and Canada.

Around one-in-three pupils in Northern Ireland overcomes a disadvantaged socio-economic background to achieve a top score on the PISA science test.

There is no significant difference between the average PISA scores of pupils from Catholic and Protestant backgrounds, regardless of socio-economic disadvantage experienced by the pupil.

1. This chapter explores differences in pupils' PISA test scores according to selected demographic characteristics – gender, socioeconomic status and religion. Variation in achievement by these characteristics is a key policy concern in Northern Ireland, where there is an emphasis on reducing educational inequalities. Although we already know much about achievement differentials by these characteristics from national GCSE examination data, PISA provides an opportunity to consider the magnitude of these gaps in a comparative context. For instance, although there are socio-economic disparities in educational achievement in Northern Ireland, are these disparities bigger in this country than elsewhere? PISA also allows us to re-examine differences between demographic groups using a rather different measure to GCSEs, one with a greater emphasis upon young people's 'functional skills' (see Box 1.1 for further details).

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

- *How do boys and girls in Northern Ireland perform on the PISA science, mathematics and reading test? Is the gender difference in achievement bigger or smaller than in other countries?*
- *What is the 'strength' and 'impact' of socio-economic status upon pupils' PISA test scores? How does Northern Ireland compare to other countries in this respect?*
- *What proportion of young people in Northern Ireland are classified as 'resilient' – overcoming the odds to achieve highly in science, despite a disadvantaged socio-economic background?*
- *Do PISA scores differ between pupils of Protestant and Catholic community backgrounds?*

3. Due to limited sample sizes for certain groups, caution will be needed when interpreting some results.

6.1 How big is the gender gap in PISA test scores?

4. In Northern Ireland's GCSE examinations, girls tend to achieve higher grades than boys in most subject areas. For instance, in the 2014/15 academic year, 92 per cent of girls received an A*-C grade in GCSE science double award, compared to 88 per cent of boys[32]. The difference between genders is bigger for GCSE English (85 per cent A*-C for girls versus 74 per cent for boys), though non-existent for GCSE mathematics (68 per cent A*-C for both boys and girls). Yet the PISA assessment differs from Northern Ireland's GCSE examinations in a number of ways, including the precise type of knowledge and skill each is attempting to measure (see Box 1.1 for further details). This raises the question, how does the gender gap in PISA test scores in Northern Ireland compare to the gender gap in GCSE grades? Moreover, how does the gender gap in Northern Ireland, as measured by PISA, compare to other countries?

5. Evidence on this matter is presented in Table 6.1. This documents the gender gap in average PISA test scores, with positive figures indicating a higher mean for boys than girls. Estimates are presented for countries with a mean PISA science score above 450 points.

6. In Northern Ireland, there is no statistically significant difference in average PISA science scores by gender (mean = 501 for boys and 499 for girls). This is reasonably similar to the pattern observed for science GCSEs, where girls achieve only slightly higher grades than boys[33]. It is also consistent with the results from the PISA 2006, 2009 and 2012 assessments.

7. Table 6.1 suggests that Northern Ireland is not particularly unusual 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 typically reach statistical significance at the five per cent level. There is also little evidence of a consistent pattern emerging across the countries with the highest average PISA 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 for boys are at least 10 points higher for boys than for girls). Yet in others

[32] For single award science, the percentage A*-C grades are 69 per cent for boys and 74 per cent for girls.
[33] For example, in the 2014/15 academic year, 92 per cent of boys earned A*-C on biology compared to 91 per cent of girls, 94 per cent of boys earned A*-C in physics compared to 98 per cent of girls and 92 per cent of boys earned A*-C on chemistry compared to 96 per cent of girls.

(e.g. Canada and Estonia) the situation is similar to Northern Ireland, with almost no difference in science achievement by gender.

Table 6.1 Difference in mean PISA test scores between boys and girls

Science		Maths		Reading	
Country	**Gap**	**Country**	**Gap**	**Country**	**Gap**
Austria	**19***	Austria	**27***	Wales	**-11***
Italy	**17***	Italy	**20***	Chile	**-12***
Japan	**14***	Germany	**17***	Republic of Ireland	**-12***
Belgium	**12***	Republic of Ireland	**16***	Japan	**-13***
Republic of Ireland	**11***	Spain	**16***	Northern Ireland	**-14***
Germany	**10***	Belgium	**14***	Belgium	**-16***
Portugal	**10***	Japan	**14***	Italy	**-16***
China	**9***	Croatia	**13***	China	**-16***
Czech Republic	**9***	England	**12***	Portugal	**-17***
Luxembourg	**8***	Switzerland	**12***	United States	**-20***
United States	**7***	Poland	**11***	Austria	**-20***
Spain	**7***	Luxembourg	**11***	Singapore	**-20***
Singapore	**6***	Portugal	**10***	Spain	**-20***
Poland	**6***	Wales	**10***	Germany	**-21***
Switzerland	6	Denmark	**9***	Scotland	**-21***
Denmark	6	Canada	**9***	Luxembourg	**-21***
Croatia	6	New Zealand	**9***	Denmark	**-22***
Wales	5	United States	**9***	Israel	**-23***
New Zealand	5	Israel	8	England	**-23***
Taiwan	4	Hungary	8	Netherlands	**-24***
Russia	4	Czech Republic	7	Hungary	**-25***
Israel	4	Scotland	7	Vietnam	**-25***
Netherlands	4	Northern Ireland	7	Taiwan	**-25***
Estonia	3	France	6	Switzerland	**-25***
Hungary	3	Russia	6	Czech Republic	**-26***
Norway	3	China	6	Russia	**-26***
Northern Ireland	3	Australia	6	Canada	**-26***
Australia	2	Slovakia	6	Croatia	**-26***
France	2	Taiwan	6	Estonia	**-28***
Scotland	1	Estonia	5	Hong Kong	**-28***
Canada	1	Slovenia	4	France	**-29***
England	0	Netherlands	2	Poland	**-29***
Slovakia	-1	Hong Kong	2	Macao	**-32***
Hong Kong	-1	Greece	0	Australia	**-32***
Vietnam	-3	Singapore	0	New Zealand	**-32***
Iceland	-3	Iceland	-1	Slovakia	**-36***
Sweden	-5	Lithuania	-1	Greece	**-37***
Slovenia	**-6***	Latvia	-2	Lithuania	**-39***
Lithuania	**-7***	Sweden	-2	Sweden	**-39***
Macao	**-8***	Norway	-2	Norway	**-40***
Greece	**-9***	Vietnam	-3	South Korea	**-41***
South Korea	**-10**	Malta	-4	Iceland	**-42***
Latvia	**-11***	South Korea	-7	Latvia	**-42***
Malta	**-11***	Finland	**-8***	Slovenia	**-43***
Finland	**-19***	Macao	**-8***	Finland	**-47***

Source: PISA 2015 database.

Notes: Table restricted to those countries and economies with a mean science score greater than 450 test points. Positive figures refer to higher average score for boys than girls. Bold font with * indicates gender gap statistically significant at the five per cent level.

8. Although there may be no gender difference in PISA science scores overall in Northern Ireland, there could be marked differences within some of the PISA science sub-domains. For instance, might boys achieve higher average scores in one area of science (e.g. understanding physical systems) while girls are more proficient in another (e.g. knowledge of living systems)? Table 6.2 provides insight into this matter by presenting average PISA scores by gender for each of the eight separate science skills that the PISA test examines.

9. There is little evidence of gender differences across the three science systems; boys and girls in Northern Ireland appear to have approximately the same skills in the physical, living and earth and space science systems[34]. In terms of science competencies, the mean for boys in 'explaining phenomena scientifically' is around nine points higher than the mean for girls, but six points lower in 'evaluating and designing scientific enquiry'. However, these differences do not quite reach statistical significance at the five per cent level[35]. Similarly, boys in Northern Ireland seem to have a slight advantage in terms of content knowledge (mean score of 503 for boys versus 494 for girls) with this difference again on the boundary of statistical significance at the five per cent level (t=1.92; p=0.06). Consequently, in Northern Ireland there is only limited evidence of gender differences within any of the eight PISA science sub-domains.

Table 6.2 Gender differences in PISA science scores by sub-domain in Northern Ireland

		Girls mean	Boys Mean	Gender gap
System	Physical	498	504	+6
	Living	499	497	-2
	Earth and space science	496	500	+4
Competency	Explain phenomena scientifically	495	504	+9
	Evaluate and design	500	494	-6
	Interpret data and evidence	502	500	-2
Knowledge	Content knowledge	494	503	+9
	Procedural and epistemic	502	500	-3

Source: PISA 2015 database.

[34] The online data tables provide further details by illustrating how Northern Ireland compares to other countries in terms of gender differences across these three science systems.
[35] The p-value for the gender gap in explaining phenomena scientifically sub-domain is 0.06, thus sitting on the boundary of statistical significance at the five per cent level.

10. Returning to Table 6.1, the middle columns turns to gender differences within the PISA mathematics domain. In Northern Ireland, there is a seven test point (approximately three months of schooling) difference; boys achieve a mean score of 496 compared to 489 for girls. This difference is not statistically significant at the five per cent level. Moreover, Northern Ireland sits around the middle of the central column of Table 6.1, with the magnitude of the gender gap similar to many of the other countries included in this cross-national comparison. Indeed, the gender gap in mathematics is, on average, also approximately six test points across the countries included in Table 6.1. These results are broadly consistent with the patterns observed for GCSE mathematics in Northern Ireland, where the proportion who achieve an A* to C grade is very similar for boys (68 per cent) and girls (68 per cent).

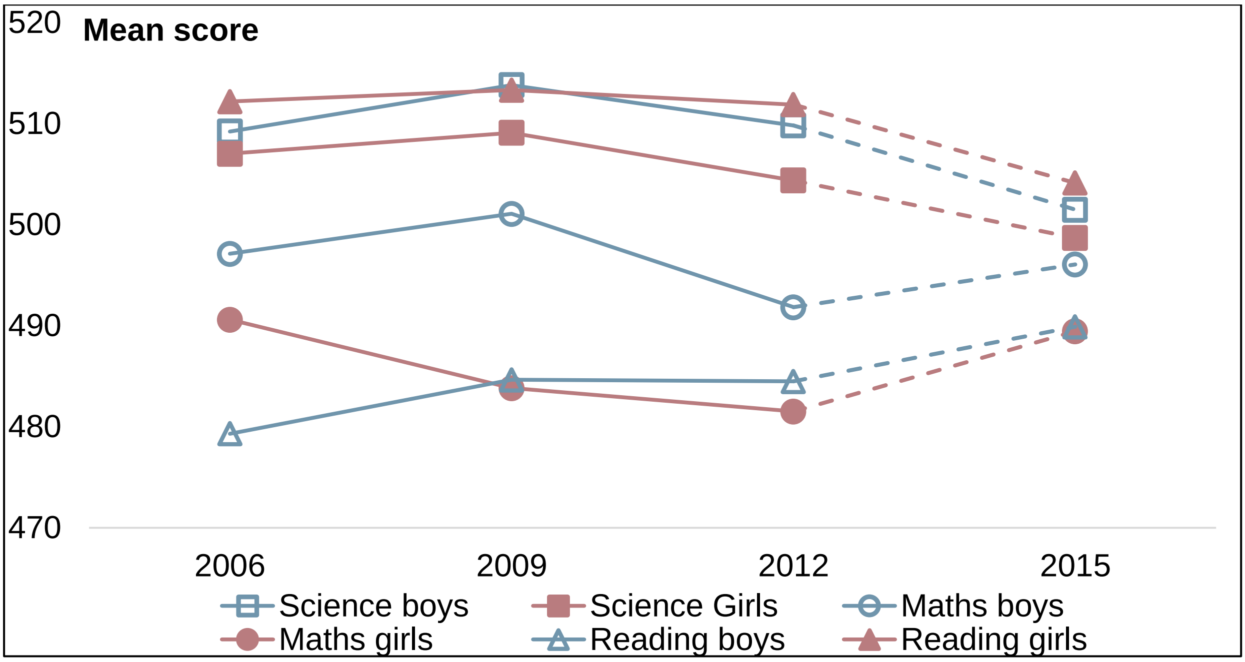
11. The final two columns of Table 6.1 provide analogous results for gender differences in pupils' reading skills. In every country, the average PISA reading score for girls is higher than the average score for boys. The magnitude of this difference across members of the OECD is approximately 27 test points. This pattern is also observed in Northern Ireland, with the mean PISA reading score for boys (490 points) significantly below the score for girls (504 points). It is also consistent with GCSE results, where 85 per cent of girls obtain an A*-C grade in English compared to only 74 per cent of boys. However, it is also notable how the gender gap in pupils' reading skills is substantially lower in Northern Ireland than in most other countries. Indeed, no other country included in this comparison has a significantly smaller difference than Northern Ireland. For instance, much more extreme genders differences in 15-year-olds reading skills (in the region of 40 PISA test points) can be observed in countries like Finland, Sweden, Norway and South Korea.

12. To conclude this sub-section, Table 6.3 and Figure 6.1 illustrate how average PISA science, mathematics and reading test scores for boys and girls have changed since 2006. Solid markers provide the results for girls and hollow markers the results for boys. The first interesting feature to highlight is how the collection of data points in Figure 6.1 are much more spread out for the 2006-2012 PISA cycles than they are for 2015 (where the data points are now much closer together due to smaller differences in average scores across subjects). Notably, there has been a decline in the gender gap in specific subject areas – most pronounced in reading. For instance, in 2006, 2009 and 2012, the average PISA reading score of Northern Ireland girls was around 30 points above the average score for boys. Yet this difference has approximately fallen in half in 2015 to 14 test points. Figure 6.1 illustrates how this is due to the combined effect of a five point increase in the point estimate of the mean

for boys (484 in 2012 to 490 in 2015) and an eight point decrease for girls (from 512 to 504).

13. This change in the gender gap for reading skills should be carefully interpreted. A number of possible explanations exist, including sampling error, the move to computer-based assessment, changes to the scoring procedures, in addition to a genuine substantive change in boys and girls reading skills (recall the discussion in chapter one for further details). As discussed in the Introduction, the change to computer-based assessment has advantages and disadvantages. Evidence from the 2012 PISA cycle shows that pupils in several countries performed worse on the same mathematics test when they took it as a computer-based assessment instead of as a paper-based assessment, but that girls were more disadvantaged by the computer-based assessment [36] .This change in assessment mode partially explain the change in the gender gap. The OECD is releasing a report focusing on the mode of assessment in their annex to the international report, which more fully addresses this issue.

Figure 6.1 Average PISA scores for boys and girls since 2006



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[36] The United Kingdom was not one of the 32 countries, which used both versions of the mathematics assessment in 2012, so there is no data comparing these two modes in Northern Ireland; however, pupils in the Republic of Ireland perform eight points worse on the CBA as compared to the PBA (Jerrim 2016). The gender difference on the CBA is statistically significant and in favour of boys for 20 of the 32 countries. See Appendix F for further information on trends in performance over time

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

Table 6.3 Average PISA scores for boys and girls since 2006

	Science		Mathematics		Reading	
	Boys	**Girls**	**Boys**	**Girls**	**Boys**	**Girls**
2006	509	507	497	491	479	512
2009	514	509	501	484	485	513
2012	510	504	492	481	484	512
2015	501	499	496	489	490	504

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

Note: None of the differences between 2015 and any comparison year are statistically significant at the five per cent level for either boys or girls.

Key point

There is no statistically significant gender difference in Northern Ireland for either the PISA science or mathematics test. The gender gap in 15-year-olds' reading skills is smaller in Northern Ireland than in most other countries, and is also smaller than in previous PISA cycles.

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

14. The relationship between family background and young people's academic achievement has long been recognised as a challenge facing the Northern Ireland education system. A wealth of previous research has documented the achievement gap between young people from socio-economically advantaged and disadvantaged backgrounds, with a widespread belief that this is hindering the prospects of greater social mobility[37]. This sub-section therefore provides evidence on the relationship between socio-economic status and the PISA test scores of 15-year-olds in Northern Ireland, and how this compares to other countries. It will therefore illustrate the challenge Northern Ireland faces in narrowing educational inequalities by family background.

[37] Goodman and Gregg (2010).

15. 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. It encompasses the following information:

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

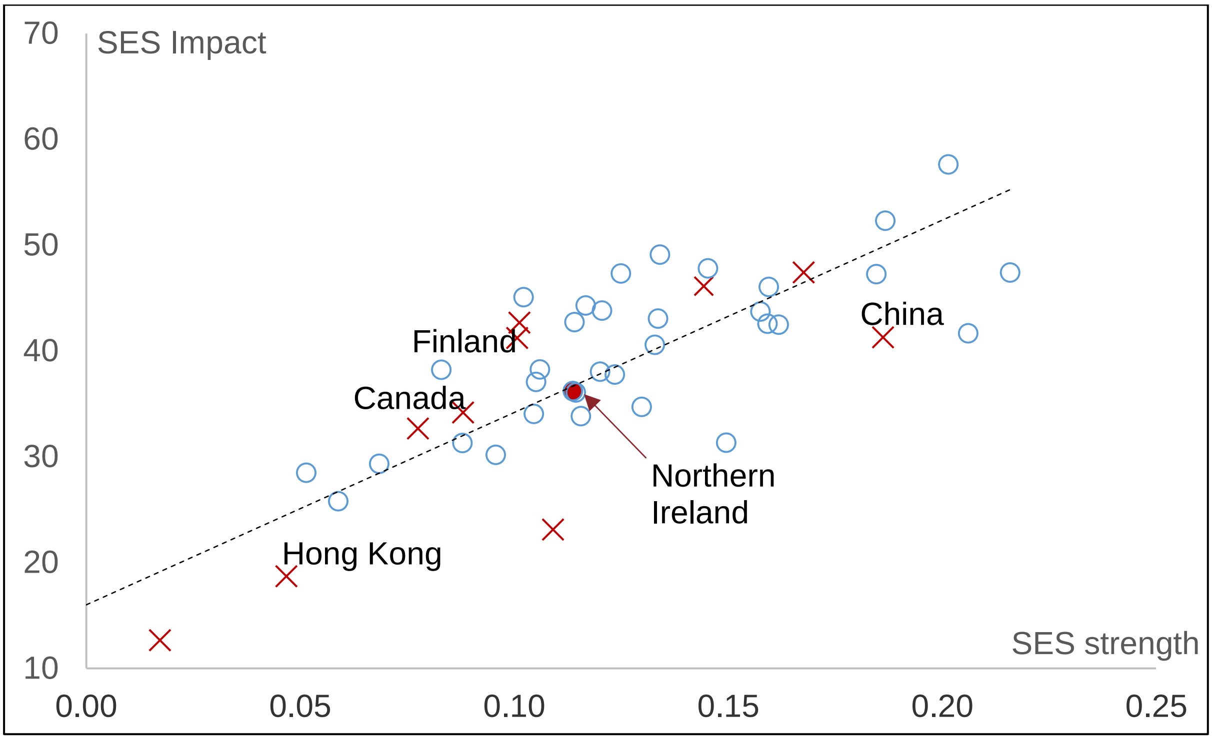
The OECD use this measure to estimate the *impact* socio-economic status has upon achievement and the *strength* of this relationship.

16. The OECD measure the *impact* of the relationship between pupil's socio-economic backgrounds (ESCS score) and their attainment in terms of the steepness of the socio-economic gradient for each participating country. Specifically, these figures refer to the change in PISA science scores when comparing the median pupil to a pupil at approximately the 85th ESCS percentile[38]. Low values indicate that socio-economic background has less impact upon pupil attainment; high values indicate socio-economic background has more impact upon pupil attainment. In Northern Ireland, the impact of socio-economic status upon pupils' science scores is estimated to be around 36 test points.

17. The OECD measure the *strength* of the relationship between pupil's socio-economic backgrounds and their attainment 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 PISA 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 Northern Ireland, approximately 11 per cent of the variation in pupils' science achievement can be explained by the ESCS index.

[38] In other words, these figures refer to the change in PISA 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 test scores.

Figure 6.2 The 'impact' and 'strength' of the relationship between socio-economic status and PISA science scores



Source: PISA 2015 database.

Notes: 'Impact' refers to the bivariate relationship between the ESCS index and PISA science scores, estimated using OLS regression. 'Strength' refers to the percentage of variance in PISA science scores that is explained by the ESCS index. Sample of countries restricted to those with a mean science score above 450 points. Red crosses refer to the 10 countries with the highest average PISA science score.

18. These two measures of socio-economic inequality in pupils' science achievement are plotted against one another in Figure 6.2. Countries towards the top right of Figure 6.2 indicate where family background matters a lot for pupils' science achievement, while family background has less of an influence in those countries towards the bottom left. Northern Ireland is very much in the centre of Figure 6.2, indicating that socio-economic inequalities do not stand out as particularly large or small in this country compared to elsewhere. Similar findings emerge regarding the link between family background and pupils' achievement in reading and mathematics (see the online data tables for further details).

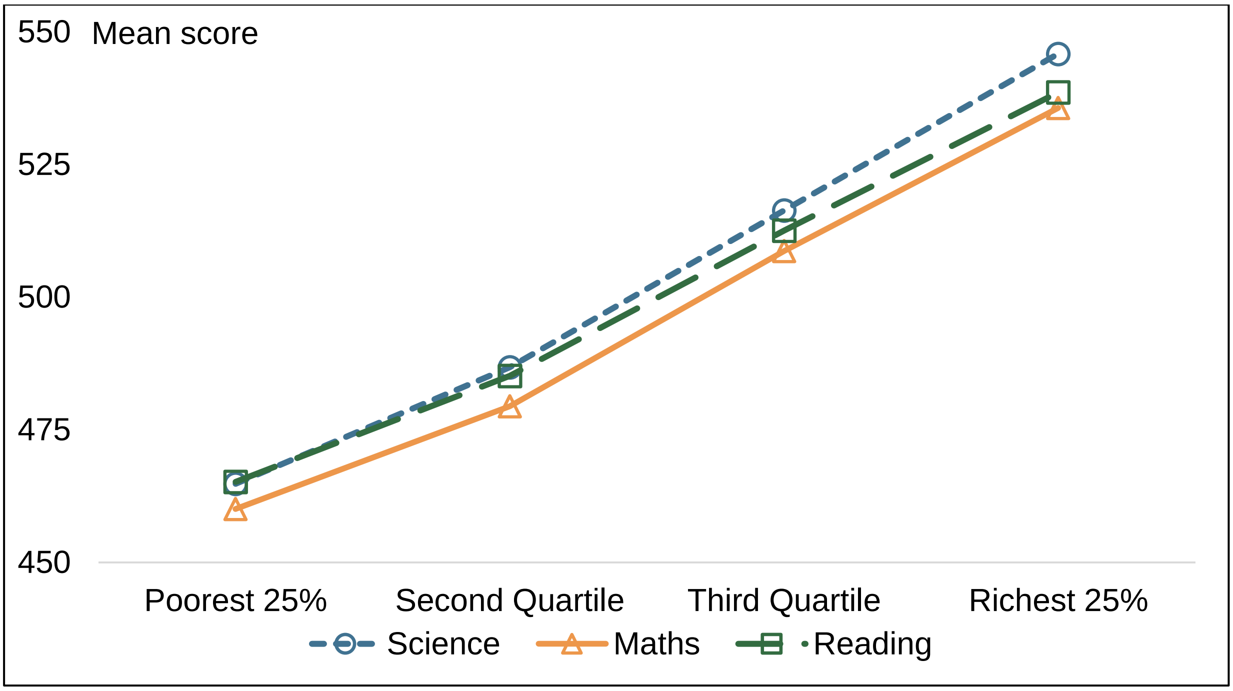
19. It is also interesting to note the variation that occurs across the high-performing countries in this respect. In some the strength of the relationship between socio-economic status and achievement is much stronger than in Northern Ireland; 19 per cent of the variation in pupils' science scores is explained by the ESCS index in China, compared to 11 per cent in Northern Ireland, for example. Yet in others,

such as Hong Kong, both the impact (19 points versus 36 points) and strength (five per cent versus 11 per cent) is weaker. For both measures, Northern Ireland is also quite similar to some of the high-performing Western nations, such as Canada and Finland. The overall conclusion that we therefore reach is that family background has a similar impact upon pupils' achievement in Northern Ireland as in many other countries, including some of those with the highest overall PISA test scores.

20. Figure 6.3 provides a different insight into the relationship between socio-economic status and PISA test scores. Pupils have been divided into four equal groups (quartiles) within each country according to their ESCS index score. These groups, from the least advantaged (bottom quartile) up to the most advantaged (top quartile), run along the horizontal axis. Mean PISA reading, mathematics and science scores are then plotted along the vertical axis.

21. The most disadvantaged 25 per cent of 15-year-olds in Northern Ireland score, on average, around 464 on the PISA science test. This is around 20 points behind the second most disadvantaged quartile. Meanwhile, young people from the most advantaged 25 per cent of families score significantly higher than all other groups, with a mean score of 544 in science. Note that this is approximately 80 points (two and two thirds years of schooling) higher than pupils from the most disadvantaged backgrounds. Similar results also hold for reading and mathematics.

Figure 6.3 Average PISA test scores by national quartiles of the ESCS index



Source: PISA 2015 database.

22. An alternative measure of socio-economic disadvantage that is often used in Northern Ireland is eligibility for Free School Meals (FSM). Table 6.4 illustrates how the FSM measure of socio-economic disadvantage compares to quartiles of the ESCS index, while Table 6.5 considers how average PISA test scores vary by FSM eligibility. Unsurprisingly, there are statistically significant differences between FSM-eligible and FSM-ineligible pupils within each domain. In science, FSM pupils (460 points) score, on average, 53 PISA test points below their non-FSM peers (513 points). According to the OECD (2010:110) this difference is equivalent to around 18 months of additional schooling. A similarly sized gap between FSM eligible and ineligible pupils exists for reading (46 points) and mathematics (48 points).

Table 6.4 A comparison of FSM eligibility to national quartiles of the PISA ESCS index

	FSM eligible	
	No	**Yes**
Least advantaged ESCS quartile	19%	48%
Second quartile	25%	31%
Third quartile	28%	13%
Most advantaged ESCS quartile	28%	8%
Number of observations	**1,714**	**537**

Source: PISA 2015 – school census matched database.

Note: Sample of pupils has been restricted to those with data available on both FSM eligibility and the ESCS index.

Table 6.5 The relationship between FSM eligibility and PISA test scores

	Not eligible for FSM	Eligible for FSM
Science	513	**460***
Mathematics	504	**457***
Reading	508	**462***
Observations	**1,767**	**581**

Source: PISA 2015 – school census matched database.

Note: Bold font with * indicates difference statistically significant at the five per cent level.

Key point

Family background has a similar impact upon pupils' achievement in Northern Ireland as in many other countries. This includes some of countries with the highest average scores, such as Finland and Canada.

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

23. A number of studies have highlighted the challenges socio-economically disadvantaged young people face when trying to access professional jobs[39]. Many believe that improving the educational achievement of young people from low-income backgrounds is key to breaking this glass ceiling[40] – 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 / non-selective or selective 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 Northern Ireland who 'succeed' in PISA against the odds (see Box 6.1), and compares this to the situation in other countries - particularly those with more selective education systems.

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, after accounting for 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.

24. In Table 6.6, we document the proportion of resilient pupils in countries where the mean science score is above 450 points. In Northern Ireland, just under a third of pupils (30 per cent) from low socio-economic backgrounds are classified as 'resilient'. This is similar to countries like Germany (34 per cent), Australia (33 per cent) and the United States (32 per cent). However, it is lower than in several East Asian nations, which tend to dominate the top of Table 6.6. Indeed, eight of the top 10 countries with the greatest proportion of resilient pupils are within East Asia (Finland and Estonia are the exceptions). Moreover, the fact that the majority of disadvantaged pupils in Vietnam (76 per cent), Macao (65 per cent) and Hong Kong (62 per cent) are classified as resilient is particularly striking. Likewise, it is notable how all of the 10 countries with the highest average PISA science scores have a

[39] See Macmillan et al. (2015).
[40] Economic and Social Research Council (2012).

comparatively large proportion of resilient pupils (these are the countries highlighted).

25. In debates about the pros and cons of grammar schools, it is often suggested that they may help disadvantaged young people to excel academically and overcome their low socio-economic background. Evidence from PISA can help to guide this debate by illustrating how the proportion of resilient pupils varies across countries. Specifically, do countries with more selective post-primary education systems have more resilient pupils? This is the focus of Figure 6.4. The vertical axis plots the proportion of 15-year-olds in each country who have been classified as 'resilient' by the OECD (following the definition in Box 6.1). The horizontal axis provides an index of the selectivity of schooling-systems across the world[41]. Higher values on this index indicate greater segregation of 15-year-olds into different types of school based upon their prior academic achievements[42]. Note that Figure 6.4 has been restricted to the 34 countries included in the study by Bol et al. (2014), and that the United Kingdom has been treated here as a single entity (rather than as separate data points for England, Scotland, Northern Ireland and Wales)[43]. If data were available, the four countries within the UK may well vary in terms of the amount of selection used within the post-primary education system[44].

Table 6.6 The percentage of 'resilient' pupils across countries

Country	Percentage of resilient pupils	Country	Percentage 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%

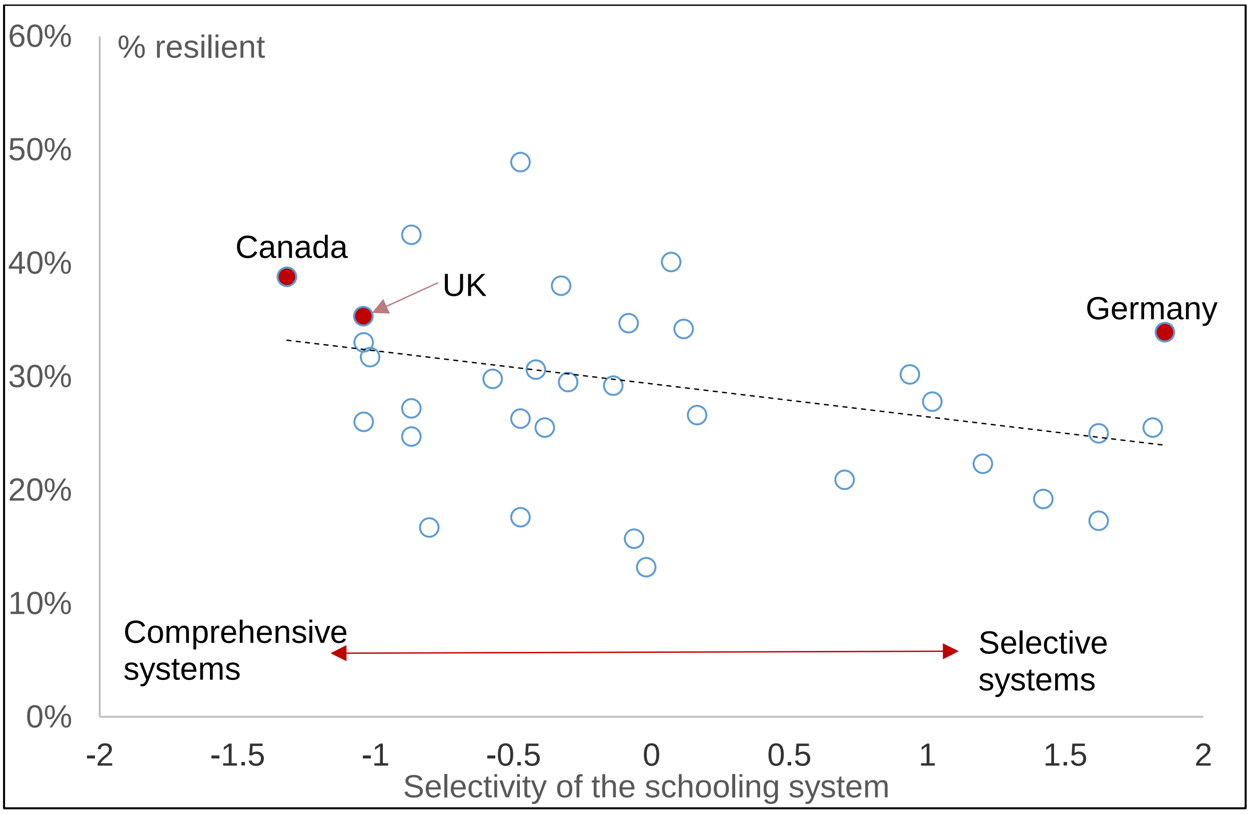
41 This information has been drawn from Bol et al. (2014).
42 Countries with a comprehensive schooling system, such as Finland and Norway, are therefore towards the left-hand side of this graph. In contrast, countries like Germany, where early academic selection is common, are towards the right.
43 This has been done as the information on school-system selectivity in Bol et al. (2014) is only provided for the United Kingdom as a whole, and not separately for England, Northern Ireland, Scotland and Wales.
44 In England, around five per cent of pupils are taught in grammar schools, compared to around a third of pupils in Northern Ireland. However, whereas grammar schools in England are fully selective, those in Northern Ireland are a mixture of fully selective, partially selective and non-selective.

England	36%	Croatia	24%
Slovenia	35%	Lithuania	23%
Poland	35%	Malta	22%
Country	**Percentage of resilient pupils**	**Country**	**Percentage of resilient pupils**
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 data required at the time of writing.

Figure 6.4 The proportion of 'resilient' pupils in a country compared to the academic selectivity of its post-primary schooling system



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

Notes: Sample restricted to the 34 countries included in Bol et al. (2014).

26. There is little evidence of an association between the selectivity of the post-primary education system and the chances of young people from disadvantaged backgrounds succeeding academically against the odds. Rather, if anything, the opposite may hold true, with the downward sloping regression line indicating a weak, negative relationship (i.e. countries with more academic selection into post-primary schools have 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 post-primary education system is highly selective). Consequently, evidence from PISA 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 post-primary school education system.

Key point

Around one-in-three pupils in Northern Ireland overcomes a disadvantaged socio-economic background to achieve a top score on the PISA science test. There is no evidence that countries with academically selective schooling systems have a greater proportion of resilient pupils.

6.4 How do PISA scores differ between pupils of Catholic and Protestant community background?

27. Education in Northern Ireland remains highly segregated by religion; the majority of pupils in Northern Ireland are educated with their peers from the same community / religious background. However, in recent years there has been some movement towards more integrated education, bringing together young people, parents and teachers from both Catholic and Protestant traditions. This sub-section concludes chapter 6 by considering differences in achievement between Catholic and Protestant pupils.

28. A total of 749 Protestant and 1,414 Catholic 15-year-olds took the PISA 2015 test in Northern Ireland. Table 6.7 provides further information on the demographic characteristics of these two groups. Overall, there are relatively few differences in the distribution of gender, books in the home and parental occupational status. Likewise, although Catholic pupils are slightly more likely than Protestant pupils to report that at least one of their parents holds a university degree (40 per cent versus 34 per cent), differences in the distribution of parental education are also relatively modest. Table 6.7 therefore illustrates how Catholic and Protestant pupils in Northern Ireland share similar background characteristics.

Table 6.7 The characteristics of Catholic and Protestant pupils who completed the PISA 2015 test

	Protestant	Catholic
Gender		
Female	46%	51%
Male	54%	49%
Highest parental education		
No education	2%	3%
GCSEs	18%	16%
A/AS-Levels	17%	16%
Higher education below degree	21%	19%
University degree	34%	40%
No data	7%	7%
Books in the home		
0-10 books	19%	18%
11-25 books	17%	16%
26-100 books	27%	28%
101-200 books	15%	17%
201-500 books	13%	12%
More than 500 books	6%	6%
No data	3%	4%
Parental occupation		
Least advantaged	22%	27%
Second quartile	28%	18%
Third quartile	18%	23%
Most advantaged	18%	19%
No data	13%	14%
Observations	**749**	**1,414**

Source: PISA 2015 matched database.

29. Table 6.8 compares average PISA test scores across these two groups. Although Catholic pupils tend to achieve slightly lower average scores than Protestant pupils, on no occasion is the difference statistically significant at the five per cent level. For instance, Table 6.8 illustrates how there is less than a 10 point difference between Protestant and Catholic pupils in science (504 versus 495), mathematics (495 versus 489) and reading (499 versus 493). Similar findings also hold across each of the science sub-domains (see online data tables for further details). Moreover, in additional analysis, we illustrate how this finding continues to hold after controlling for gender, parental education, parental occupation and number of books at home (see online data tables for further details). Consequently, we find no evidence that average PISA test scores differ between pupils of Protestant and Catholic community backgrounds.

Table 6.8 Average PISA test scores of Catholic and Protestant pupils

	Protestant	Catholic
Science	504	495
Mathematics	495	489
Reading	499	493
Observations	**749**	**1,414**

Source: PISA 2015 matched database.

30. A topic of particular concern in Northern Ireland is the potential underachievement of Protestant pupils from working class backgrounds – particularly amongst boys. For instance, in a recent report, the Equality Commission for Northern Ireland noted how '*there is persistent underachievement and lack of progression of working class Protestants, particularly males*[45]'. Table 6.9 therefore explores this issue using the PISA 2015 data. Specifically, it illustrates how PISA science scores differ between Catholic and Protestant pupils, according to their socio-economic status. Panel (a) refers to where socio-economic status is measured by ESCS quartile, while panel (b) uses eligibility for FSM[46].

31. Although PISA scores differ substantially by socio-economic status, there is little evidence that the strength of this relationship varies between Catholic and Protestant pupils. Indeed, within each socio-economic status quartile, average PISA science scores do not differ significantly depending upon pupils' community background. For instance, focusing upon panel (a), the difference in mean scores between socio-economically disadvantaged Catholic and Protestant pupils (six points) is similar to the difference between socio-economically advantaged Catholic and Protestant pupils (12 points). The online data tables illustrate that similar results hold for reading and mathematics. Consequently, PISA suggests that working class pupils in general have lower levels of achievement than their peers from more affluent backgrounds, though with little discernible difference between Catholic and Protestant groups. This is somewhat different to the pattern observed in GCSE grades, where around 45 per cent of FSM eligible Catholic school leavers achieve five or more GCSEs at A*-C including English and mathematics, compared to around 33 per cent of Protestant FSM school leavers.

[45] Equalities Commission for Northern Ireland (2015).
[46] Pupils have been divided into four approximately equal groups (quartiles) according to the PISA Economic, Social and Cultural Status (ESCS) index. Those in the bottom quartile are defined as low socio-economic status pupils, with those in the top quartile high socio-economic status pupils.

Table 6.9 Differences in PISA test scores between Catholic and Protestant pupils from different socio-economic backgrounds

(a) Estimates using ESCS index

Socio-economic quartile	Protestant	Catholic	Difference
Most disadvantaged 25%	466	461	-6
Q2	494	481	-13
Q3	521	511	-11
Most advantaged 25%	552	540	-12

(b) Estimates using FSM eligibility

FSM eligible	Protestant	Catholic	Difference
Science			
No	516	510	-6
Yes	456	457	+1
Mathematics			
No	506	502	-3
Yes	452	455	+4
Reading			
No	509	506	-2
Yes	462	458	-4

Source: PISA 2015 matched database.

Notes: Difference refers to mean score for Catholic pupils minus mean score for Protestant pupils. None of the figures in the difference column are statistically significant at the five per cent level. All estimates based upon the subset of observations with data available on the ESCS index (panel a) or FSM eligibility (panel b). The difference between the Protestant and Catholic column may not be equal to the difference column due to rounding.

Key point

There is little evidence that average PISA scores differ between pupils from Catholic and Protestant backgrounds.

Chapter 7. Differences in achievement between schools

In Northern Ireland, around two-thirds of the variation in PISA scores occurs amongst pupils who attend the same school. This is somewhat more than several other countries with an academically selective post-primary school system, such as Germany, the Netherlands and Austria.

Pupils who attend a grammar school scored, on average, 553 in PISA science, 539 in mathematics and 544 in reading. This is around 100 test points (more than three years of schooling) above non-grammar school pupils in each subject area.

The average PISA science score of 15-year-olds in schools with a high proportion of FSM pupils is 446. This compares to a mean score of 560 for 15-year-olds in schools with the lowest proportion of FSM pupils.

In schools with a high proportion of FSM pupils, 35 per cent of 15-year-olds lack basic skills in science. This compares to less than two per cent of 15-year-olds in schools with a low proportion of FSM pupils.

Just one per cent of pupils in high-FSM schools reach the top two PISA levels. This compares to one-in-six (15 per cent) pupils in low-FSM schools.

1. This chapter examines differences in young people's science, mathematics and reading competencies by school characteristics. It begins by decomposing the variation in PISA test scores into two components: the proportion that occurs *within* schools versus the proportion that occurs *between* schools. The distribution of PISA test scores is then reported by school admissions policy (e.g. grammar, non-grammar) and by the proportion of pupils within each school who are eligible for Free School Meals[47].

2. All estimates presented within this chapter need to be carefully interpreted. For instance, Table 7.1 illustrates the small sample sizes for some of the groups considered in this chapter, particularly once grammar / non-grammar schools are divided into different management groups. For instance there are only 192 pupils in the seven controlled grammar schools that participated in the PISA 2015 study, and 218 pupils from the nine schools within the 'other' non-grammar school group. Estimates for these groups will therefore be accompanied by reasonably wide confidence intervals. More generally, all figures reported in this chapter refer to descriptive associations only, and do not reveal cause and effect.

Table 7.1 Sample sizes for grammar/non-grammar school pupils by school management type

	Non-grammar	Grammar
Controlled	356 (15)	192 (7)
Catholic maintained	738 (29)	0 (0)
Voluntary	0 (0)	872 (32)
Other	218 (9)	0 (0)

Source: PISA 2015 matched database.

Notes: Figures in brackets refers to the number of schools within each group.

[47] Throughout this and the following chapter, schools in Northern Ireland have been divided into four groups (quartiles) based upon the proportion of pupils within the school who are eligible for Free School Meals (FSM). When referring to schools with a 'high' proportion of FSM pupils, we are referring to the most disadvantaged quartile. Similarly, a 'low' proportion of FSM pupils refers to schools with the least disadvantaged intake.

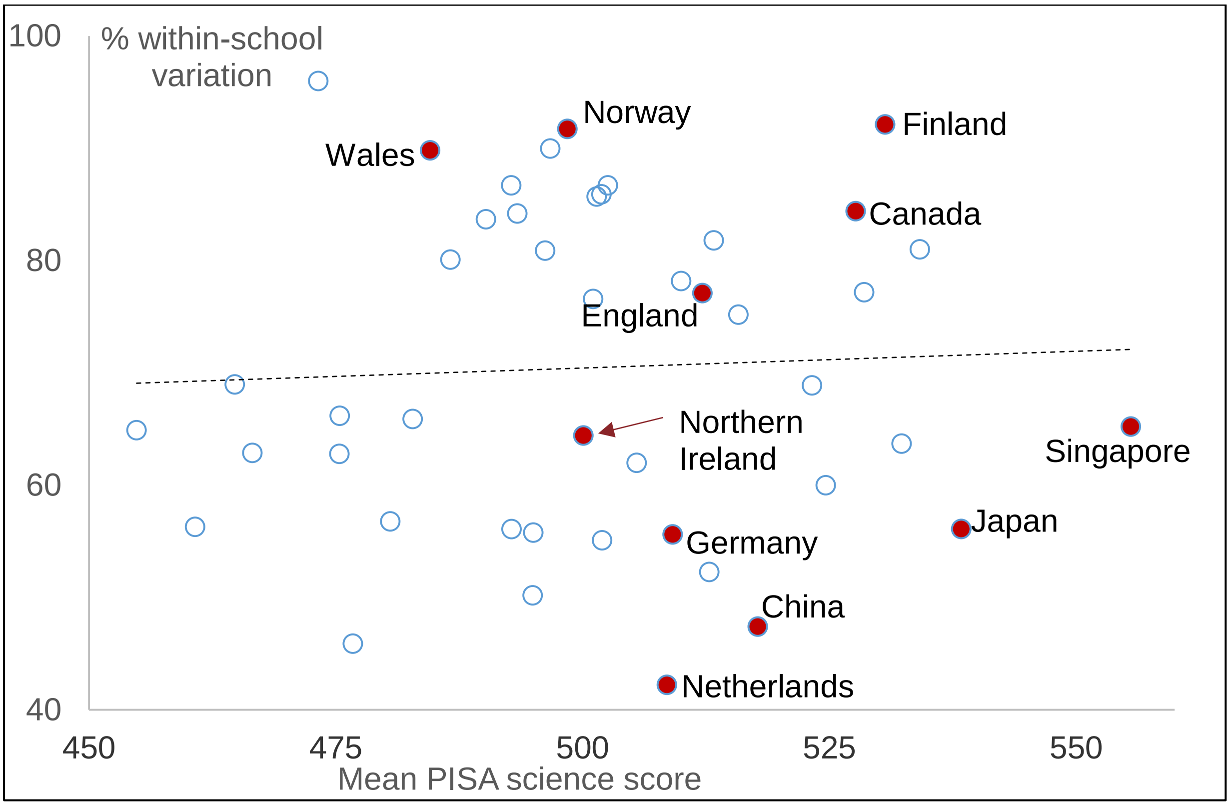
7.1 To what extent does variation in science achievement occur within schools versus between schools in Northern Ireland? How does this compare to other countries?

3. This sub-section decomposes the variation in 15-year-olds' PISA science scores into the portion that occurs within schools versus the portion that occurs between schools. Between-school variation refers to the extent to which differences in achievement can be 'explained' (in a statistical sense) by the sorting of pupils into different schools. In contrast, within-school variation refers to the extent that PISA test scores differ, even amongst 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, where the between school variation is higher, the impact of schools is more important). Rather, the proportion of the variance explained between schools is partially determined by 'selection effects', reflecting the fact that young people 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*[48]'. It is therefore important to understand the extent of within-school achievement variation that occurs in Northern Ireland and how this compares to other countries.

4. Figure 7.1 plots average PISA science scores (horizontal axis) against the proportion of the variation in pupils' science achievement that occurs within schools (vertical axis). Note that the sample of countries has been restricted in this analysis to those with a mean science score above 450 test points. In Northern Ireland, around two-thirds of the variation in 15-year-olds' science achievement occurs within schools (64 per cent), and around a third between schools (36 per cent). This suggests that there are substantial differences in 15-year-olds' science achievement in Northern Ireland, even amongst pupils who attend the same school. Indeed, within-school variation is the larger of the two components in most countries. Thus, despite significant differences in the structure of post-primary schooling systems across countries, within-school variation in pupils' achievement always has an important role.

[48] Reynolds (2007).

Figure 7.1 The proportion of the variation in pupils' PISA 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.

5. Northern Ireland sits around the middle of Figure 7.1; the proportion of within-school variation in Northern Ireland does not stand out as either particularly large or small relative to other countries. It is notable that other countries with a strong tradition of academic selection into post-primary schools sit towards the bottom of Figure 7.1, with a comparatively small proportion of the variance in pupils' science scores occurring within schools. Prominent examples include Germany, Austria and the Netherlands. Indeed, compared to these other countries where academic selection into different schools is prominent, the proportion of variance in pupils' achievement that occurs within schools in Northern Ireland is comparatively high. In contrast, countries with a mainly comprehensive schooling system, where the use of academic selection into post-primary schools is rare, are generally towards the top of Figure 7.1. This includes other parts of the UK (e.g. Wales), and several Nordic countries (e.g. Finland, Norway and Sweden), where up to 90 per cent of the variation in PISA science scores occurs within schools. This indicates that most of

the inequality in 15-year-olds' science achievement in Northern Ireland occurs amongst pupils who attend the same post-primary school (and not between pupils who attend different schools).

6. Figure 7.1 also shows that there is essentially no association between the proportion of achievement variation that occurs within-schools and average PISA science scores at the country level (correlation = 0.05). For instance, whereas the proportion of within-school variation is comparatively low in some of the top-performing PISA countries (e.g. Singapore, Japan) it is relatively high in others (e.g. Finland, Canada). There is hence little evidence to suggest that a low (or a high) proportion of within-school variation is a common trait amongst the leading PISA countries.

Key point

PISA scores vary more amongst pupils within the same school in Northern Ireland than they do between schools. The proportion of variance occurring amongst pupils who attend different schools is smaller in Northern Ireland than in many other countries with an academically selective post-primary school system.

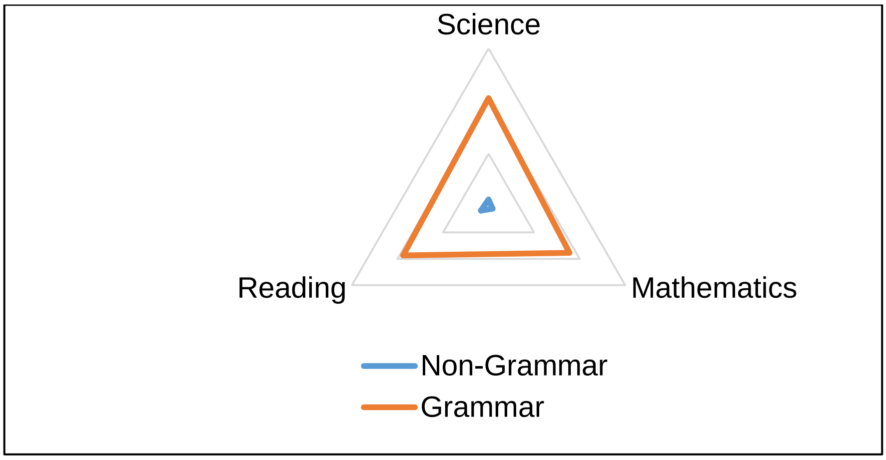
7.2 How do PISA test scores vary between grammar and non-grammar schools?

7. Whereas less than five per cent of 15-year-olds in the rest of the UK are educated in grammar schools, more than 40 per cent of post-primary pupils in Northern Ireland attend a grammar school[49]. However, whereas grammar schools in the rest of the UK are academically selective, there is much more variation within the grammar school sector in Northern Ireland, with a mixture of fully-selective, partially selective and non-selective schools. Moreover, in recent years, there has been a change in the composition of Northern Ireland's grammar school sector. Specifically, whereas there has been a decline in non-grammar school sector pupil numbers, pupil numbers in grammar schools have remained stable – yet their intake have become more mixed in terms of prior attainment and socio-economic characteristics. Given these changes, it is interesting to consider how PISA scores differ between pupils who attend grammar and non-grammar schools, and by different school management types within these sectors. This chapter therefore provides evidence on this issue.

[49] Department of Education (2015b).

8. As indicated in Table 7.1, a total of 1,064 pupils from 39 grammar schools participated in PISA 2015. Figure 7.2 illustrates how average PISA scores for pupils within this group compare to 15-year-olds who attended a post-primary (non-grammar) school. The average PISA test score achieved by grammar school pupils is 553 in science, 539 in mathematics and 544 in reading. This is around 100 test points (equivalent to approximately three and a third years of schooling) ahead of non-grammar school pupils within each of the science (457), mathematics (455) and reading (458) domains. All differences between grammar and non-grammar schools reported in Figure 7.2 are statistically significant at the five per cent level.

Figure 7.2 Mean PISA scores by school admissions policy in Northern Ireland



	Science	Maths	Reading
Non-grammar	**457***	**455***	**458***
Grammar	553	539	544

Source: PISA 2015 matched database.

Note: Bold font and * indicates difference compared to grammar schools is statistically significant at the five per cent level.

9. We have also considered how these results change after accounting for a selection of socio-economic and demographic characteristics of the pupils who attend grammar versus non-grammar schools (gender, parental education, parental occupation and books in the home). The central finding of this additional analysis is that the gap in PISA scores between grammar and non-grammar school pupils is reduced for each subject area, though with a sizeable and statistically significant difference still remaining. Specifically the difference between grammar and non-grammar school pupils falls from 96 PISA test points to 69 test points in science, from 84 to 60 test points in mathematics and from 85 to 60 in reading. Hence

grammar school pupils continue to outperform their non-grammar peers on the PISA test, even after differences in a selection of their pupils' background characteristics have been taken into account. However, some caution is required when interpreting these results. In particular, as no control has been included for pupils' prior achievement before they entered post-primary school, these results cannot be interpreted as providing evidence of differential pupil progress or of school effectiveness.

10. Table 7.2 concludes this section by comparing PISA science scores for grammar and non-grammar school pupils according to the management type of the school that they attend. This provides the estimate of the mean score, accompanied by the 95 per cent confidence interval. For grammar schools, the difference between the voluntary and controlled groups is less than 10 points and not statistically significant at the five per cent level. There is also little difference in average PISA science scores within non-grammar schools across the controlled, Catholic maintained and other sectors. Similar results hold within mathematics and reading (see the online data tables).

Table 7.2 Average PISA science scores between non-grammar and grammar school pupils according to school management type

	Non-grammar	Grammar
Controlled	456 (443 to 469)	546 (525 to 567)
Catholic maintained	455 (446 to 463)	-
Voluntary	-	555 (546 to 564)
Other	463 (445 to 481)	-

Source: PISA 2015 matched database.

Notes: Figures in brackets refer to the estimated 95 per cent confidence interval.

Key point

Grammar school pupils in Northern Ireland achieve PISA test scores that are similar, on average, to the mean in the top-performing PISA countries. The gap in average PISA test scores between grammar and non-grammar school pupils is over 100 test points (equivalent to more than three years of schooling) in science, reading and mathematics.

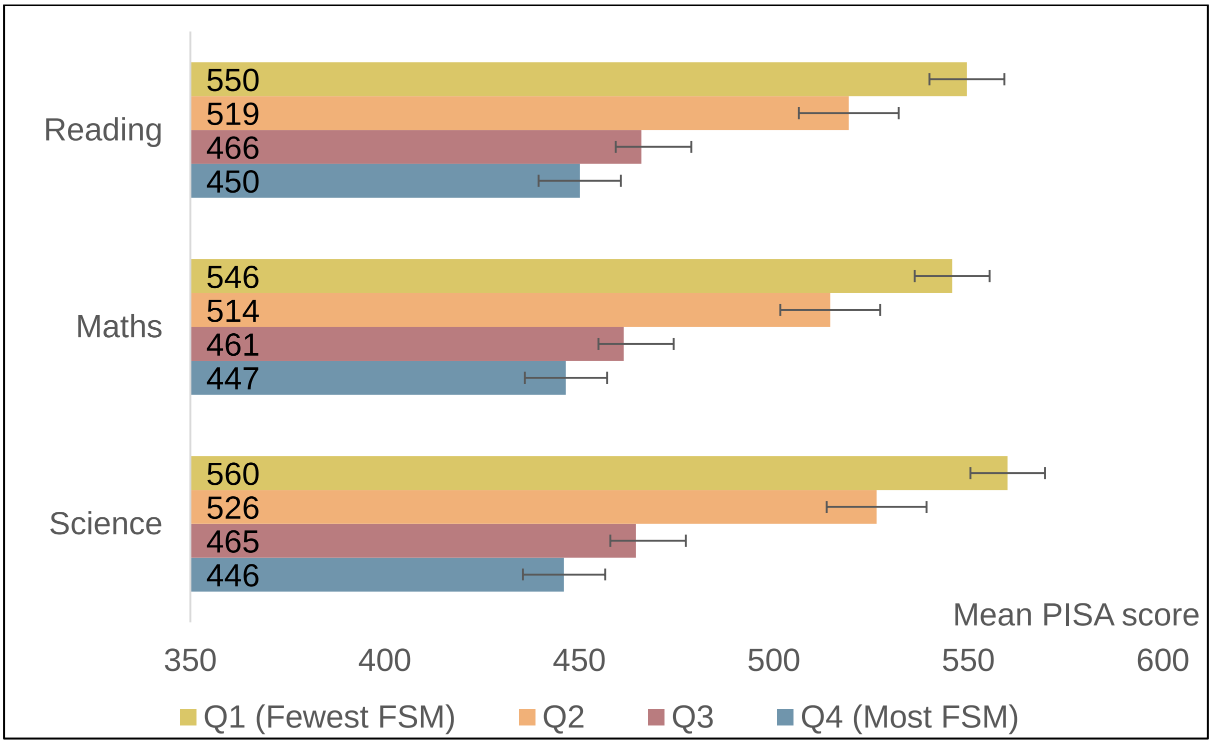
7.3 How do PISA test scores vary by the proportion of pupils within a school who are eligible for Free School Meals (FSM)?

11. There is significant policy interest in Northern Ireland in educational inequality and equality of opportunity. For instance, closing the performance gap and increasing access and equity is one of the Department of Education's overarching goals. The 'shared education' policy highlights a particular interest in the prospects of young people from economically deprived backgrounds. This includes their tendency to be segregated into different types of schools from their more economically advantaged peers, and the impact this in turn has upon their academic achievement[50]. As page four of this policy document notes: '*the education system also experiences significant divisions in other respects as well. The most notable of these is in relation to socio-economic background where a clear tendency exists at post-primary level for young people from more affluent backgrounds to attend grammar schools and those from more economically deprived backgrounds to attend non-selective schools. These divisions are, in turn, associated with significant achievement gaps*'.

12. The final sub-section of this chapter therefore explores differences in achievement between schools, according to what proportion of their intake stems from a socio-economically disadvantaged background. Specifically, we have divided schools in Northern Ireland into four groups (quartiles) based upon the proportion of pupils within each school who are eligible for Free School Meals (FSM). Schools in the top quartile are henceforth referred to 'high FSM schools', while those in the bottom quartile are referred to as 'low FSM schools'. The question we now address is how big is the achievement gap amongst pupils who attend high and low FSM schools.

[50] Department of Education (2015a).

Figure 7.3 Mean PISA scores by school FSM quartile in Northern Ireland



Source: PISA 2015 matched database.

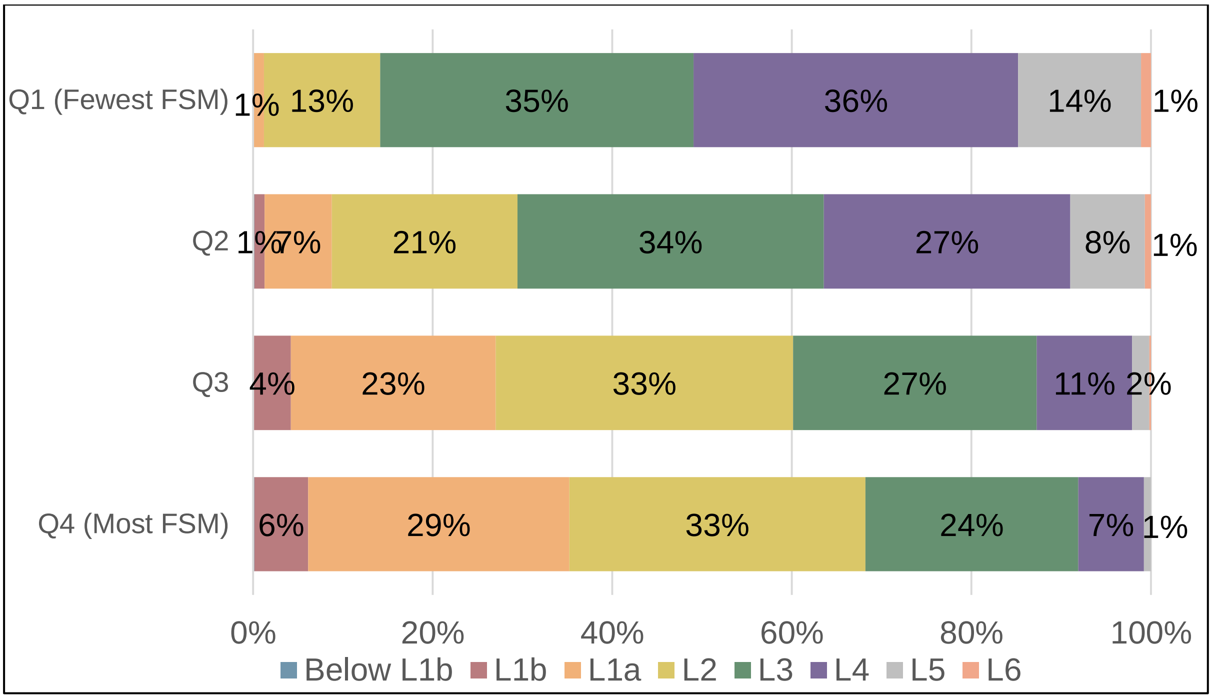
Note: 95 per cent confidence interval represented by thin black lines running through the centre of each bar. Results reported for schools and pupils where data available.

13. Figure 7.3 illustrates how average PISA reading, mathematics and science test scores vary by school FSM quartile. Schools with the fewest disadvantaged pupils schools score, on average, 560 on the PISA science test, 546 in mathematics and 550 in reading. This is significantly higher than pupils within high FSM schools, where average PISA scores stand at 446 (science), 447 (mathematics) and 450 (reading) respectively. Differences between the top and bottom FSM quartile are therefore more than 100 PISA test points (equivalent to more than three years of schooling) and statistically significant at the five per cent level. There is also a clear trend, where schools with a greater proportion of FSM pupils tend to have lower levels of average achievement.

14. Figure 7.4 provides further detail on how academic achievement varies by FSM quartile of the school by comparing the distribution of pupils across the PISA science proficiency levels. (Additional results for reading and mathematics are provided in the online data tables). Around a third of pupils in high-FSM schools lack basic skills in science. This compares to approximately one per cent of young people within low-FSM schools. At the other end of the spectrum, 15 per cent of 15-year-olds in low-FSM post-primary schools are classified as 'high-achievers' (reaching

PISA Level 5 or 6). In comparison, only one per cent of 15-year-olds reach at least Level 5 in schools with a high percentage of FSM pupils.

Figure 7.4 The distribution of PISA science proficiency levels by school FSM quartile in Northern Ireland



Source: PISA 2015 matched database.

15. Does there continue to be a relationship between the proportion of pupils eligible for FSM in a school and PISA scores, even after pupils' own family background (and other demographic characteristics) have been taken into account? Such a relationship could continue to exist for a number of reasons, including peer effects, school quality or school selection. To provide some descriptive evidence on this matter, we have investigated whether pupils in high FSM schools continue to achieve lower scores on the PISA test than pupils in low FSM schools, after controlling for gender, parental education, parental occupation and number of books in the home. As expected, in all three domains, differences in achievement between pupils attending high and low FSM schools are reduced; yet the relationship is not completely eradicated. For instance, the gap in PISA scores between pupils attending high versus low FSM schools has declined from 114 points to 78 points in the science domain. This suggests that the relationship between school-level FSM and pupils' achievement in the PISA test is capturing more than the effect of pupils own socio-economic background alone.

Key point

Average PISA scores achieved by pupils in low-FSM schools are close to the mean achieved by 15-year-olds in the top-performing countries (e.g. 560 points in PISA science versus 556 points in Singapore). Pupils in high-FSM schools achieve average PISA scores of 446 test points in science, which is comparable to the mean score in countries like Bulgaria and Chile.

Chapter 8. School management and resources

Principals in Northern Ireland are much more likely to regularly use pupil performance data to develop their school's goals than principals in other countries.

Within Northern Ireland, principals who lead schools with a greater proportion of disadvantaged pupils are more likely to pay regular attention to disruptive classroom behaviour.

A lack of good quality school infrastructure stands out as a particular concern amongst principals in Northern Ireland.

There is little evidence that principals are more likely to report a lack of educational resources as a barrier to learning if they lead a school with a high proportion of disadvantaged pupils.

Principals in Northern Ireland are generally positive about the resources available to support science learning within their school. However, science is a lower priority for additional funding in schools with a greater share of pupils from disadvantaged social backgrounds.

Principals in Northern Ireland are more likely to report staff absenteeism as a barrier to pupils learning than principals in the average OECD or high-performing country. This is a particular concern of principals who lead post-primary schools with a high proportion of disadvantaged pupils.

Extensive quality assurance processes are already in place within the Northern Ireland education system. Principals in Northern Ireland report that external inspections lead to a lasting impetus for change, particularly within schools with a high proportion of socio-economically disadvantaged pupils.

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. The aim of this chapter is to provide new evidence on such matters for Northern Ireland by drawing upon the PISA principal questionnaire.

2. As part of the PISA study, principals 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 76 principals completed this questionnaire in Northern Ireland, reflecting an unweighted response rate of 80 per cent amongst the participating schools.

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

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

4. Each sub-section within this chapter will follow a similar structure. Responses of Northern Ireland's principals are first compared to the responses of principals in other countries. This will focus upon comparisons to the average across OECD members and the average across the 10 countries with the highest mean PISA science scores ('H10'). We then turn to variation within Northern Ireland, focusing upon differences between schools according to the proportion of pupils who are eligible for Free School Meals (FSM).

5. As with the preceding chapter, the results presented need to be carefully interpreted. First, school level sample sizes remain small. All estimates are therefore subject to a high degree of sampling error. Second, it should be remembered that the analysis presented in this chapter is based upon information reported by principals. These data may therefore be subject to recall bias and measurement

error. The subjective nature of some questions should also be considered when interpreting the results.

8.1 How do principals in Northern Ireland manage their staff and schools?

6. Effective leadership is an essential ingredient for school effectiveness, with research suggesting pupils make more academic progress in schools with better leadership[51]. There has consequently been much academic and policy interest in the development of effective leaders for schools. In this sub-section we provide new insight into school leadership styles in Northern Ireland using data from PISA 2015.

7. Principals across all participating countries were asked the following question as part of the school 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 principals were asked to respond to, along with the percentage who reported undertaking each activity at least once a month during the last academic year[52]. Based upon the evidence provided in Table 8.1, there are two points of particular note.

8. First, there is a small selection of questions where Northern Ireland differs markedly from the average across H10 and OECD countries. For instance, principals in Northern Ireland are much more likely to regularly use pupils' performance data to develop their school's educational goals (46 per cent in Northern Ireland versus an OECD average of 23 per cent and an H10 average of 18 per cent). Indeed, a greater proportion of principals in Northern Ireland regularly use pupil performance data in setting their school's objectives than in any of the 10 highest performing countries. This highlights the central role that performance metrics play in the management of Northern Ireland's schools. Other differences include principals in Northern Ireland being more likely to regularly praise staff when they see pupils actively engaged in learning (83 per cent versus an OECD average of 63 per cent), and being more likely to ensure that teachers work according to the schools educational goals (76 per cent in Northern Ireland versus a 53 per cent average across OECD members). It is also

[51] Day et al. (2009).

[52] Principals 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 percentage of teachers who ticked one of the top three categories ('*once a month'*, *'once a week' or 'more than once a week'*).

interesting to note that school leaders in Northern Ireland are somewhat more likely to encourage teachers to develop pupils' social capacities than school leaders across the 10 highest performing PISA countries.

Table 8.1 Principals' management of teachers and schools

	Northern Ireland	OECD	H10
I use pupil performance results to develop the school's educational goals	46%	**23%***	**18%***
I make sure that the professional development activities of teachers are in accordance with the teaching goals of the school	43%	33%	33%
I ensure that teachers work according to the school's educational goals	76%	**53%***	**48%***
I promote teaching practices based on recent educational research	50%	41%	**34%***
I praise teachers whose pupils are actively participating in learning	83%	**63%***	**55%***
When a teacher has problems in his/her classroom, I take the initiative to discuss matters	69%	68%	64%
I draw teachers' attention to the importance of pupils' development of critical and social capacities	62%	56%	51%
I pay attention to disruptive behaviour in classrooms	78%	82%	79%
I provide staff with opportunities to participate in school decision-making	65%	72%	65%
I engage teachers to help build a school culture of continuous improvement	76%	73%	66%
I ask teachers to participate in reviewing school management practices	45%	34%	36%
When a teacher brings up a classroom problem, we solve the problem together	72%	78%	76%
I discuss the school's academic goals with teachers at faculty meetings	60%	51%	**49%***

Source: PISA 2015 database

Notes: Figures refer to the percentage of pupils in schools where the principal reported undertaking the activity at least once a month over the past academic year. Bold font with * indicates significant difference from Northern Ireland.

9. Finally, although insightful, the H10 and OECD average figures reported in Table 8.1 mask the substantial variation that occurs across these countries. For instance, whereas 72 per cent of Canadian principals encourage the development of pupils' social skills, only 55 per cent do so in Finland and 12 per cent in Japan. Similarly, the proportion of principals who ensure their staff work towards the school's educational goals is notably higher in Canada (67 per cent) and China (57

per cent) than in Finland (36 per cent), Hong Kong (32 per cent) and Japan (11 per cent). This illustrates how school leadership and management approaches vary greatly across countries, even when we focus upon only those with the highest average PISA scores.

10. Variation in principals' approaches to leadership and management can also be considered across different school types within Northern Ireland. The most notable difference that occurs between grammar and non-grammar schools is in principals' responses to the statement '*I pay attention to disruptive behaviour in classrooms.'* Almost all principals in non-grammar schools (94 per cent) report that this occurs on at least a monthly basis, compared to 59 per cent within grammar schools (a statistically significant difference at the five per cent level). This may, of course, be a reflection of differences in the demographic characteristics of pupils who attend such schools. There also appears to be some variation by school type in principals' responses to the statements '*when a teacher has problems in his/her classroom, I take the initiative to discuss matters*' (78 per cent non-grammar schools versus 59 per cent grammar; p=0.10) and '*when a teacher brings up a classroom problem, we solve the problem together*' (82 per cent non-grammar schools versus 62 per cent grammar; p=0.06). However, the small school sample size means these differences do not quite reach statistical significance at the five per cent level.

11. Similar findings hold for the relationship between principals' responses to the three statements highlighted in the paragraph above and the proportion of pupils in their school who are eligible for FSM. Specifically, the greater the proportion of young people who are eligible for FSM, the more likely principals are to respond that they take each of these actions at least once a month. For instance, whereas 65 per cent of principals leading schools with a low proportion of FSM pupils report that they pay attention to disruptive classroom behaviour, this increases up to almost 100 per cent for principals leading schools with a high proportion of FSM pupils. Further details are provided in the online data tables (see Table 8.1b).

Key point

Principals in Northern Ireland are much more likely to regularly use pupil performance data to develop their school's goals than principals in other countries. Within Northern Ireland, principals who lead schools with a greater proportion of disadvantaged pupils are more likely to pay regular attention to disruptive classroom behaviour.

8.2 Do principals in Northern Ireland believe they have access to sufficient resources to support pupils' learning?

12. 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 (e.g. textbooks, computers, equipment). Previous research has also suggested that the physical environment of a school may have an impact upon pupils' educational attainment[53]. For these reasons, it is important to consider whether principals in Northern Ireland feel that their schools are appropriately resourced, and how Northern Ireland compares to other countries in this respect.

13. Table 8.2 therefore details the extent to which principals report lacking, or only have access to poor quality, educational resources. Specifically, it provides the percentage of principals who report that the factor in question hinders the school's capacity to provide instruction either 'to some extent' or 'a lot'. Figures for Northern Ireland are compared to the average across OECD members, and the average across the 10 highest performing PISA countries in science (H10).

Table 8.2 Principals' reports of resources lacking within their school

	Northern Ireland	OECD	H10
A lack of teaching staff	27%	29%	31%
Inadequate or poorly qualified teachers	4%	**20%***	**26%***
A lack of assisting staff	21%	**36%***	**33%***
Inadequate or poorly qualified assisting staff	5%	**19%***	**20%***
A lack of educational material	26%	34%	32%
Inadequate or poor quality educational material	23%	30%	30%
A lack of physical infrastructure	45%	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 principal ticked either the 'to some extent' or 'a lot' categories. Bold font with * indicates significant difference from Northern Ireland.

14. Overall, the figures for Northern Ireland are broadly in-line with the average across members of the OECD and the average across the H10 countries. In other words, in terms of resources, there are few issues which stand out as a particular concern amongst principals in Northern Ireland (relative to principals in other countries). The only notable exception is with regards the physical infrastructure of

[53] Barrett et al. (2015). Neilson and Zimmerman (2011).

schools. Almost half of Northern Ireland pupils are taught in schools where the principal believes that poor quality infrastructure is hindering their learning (45 per cent). This is around 10 percentage points higher than the OECD and H10 averages (35 per cent). Moreover, principals in Northern Ireland are more likely to answer 'to some extent' or 'a lot' to this statement than any of the other statements presented in Table 8.2. Consequently, it seems that the physical infrastructure of schools is one of the most important resourcing issues facing Northern Ireland, at least in the view of principals.

15. It is also interesting to note that a lower proportion of principals in Northern Ireland reported staffing as an issue hindering instruction than in the average OECD/H10 country. For instance, four per cent of pupils in Northern Ireland are taught in schools where the principal believes inadequate or poorly qualified teachers is a factor hindering instruction, compared to an average of 20 per cent across members of the OECD. A similar finding holds true with respect to the quality of support staff (five per cent saw this as a factor hindering instruction in Northern Ireland versus an OECD average of 19 per cent). Hence principals in Northern Ireland appear generally more satisfied with their ability to hire suitably qualified staff than principals in the average industrialised country.

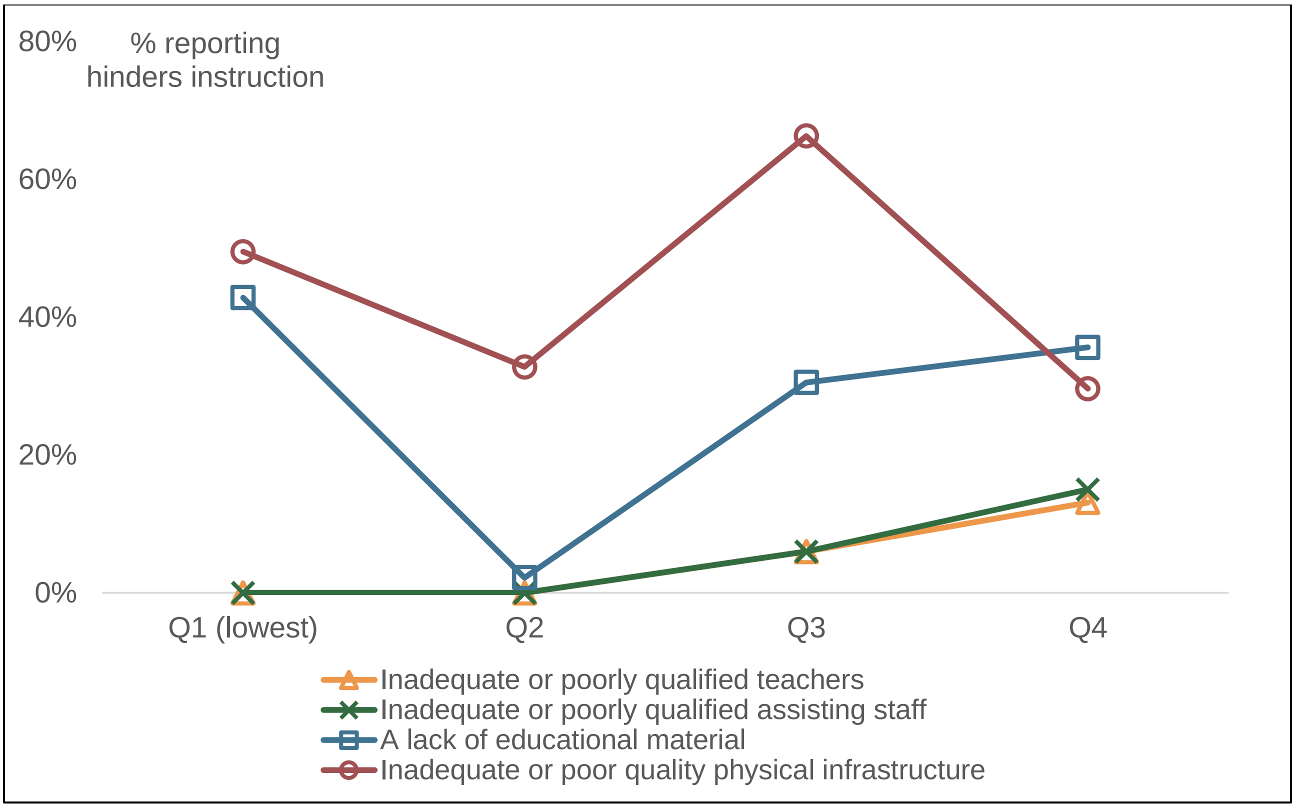
16. Of course, differential access to educational resources may also vary within countries, including between different school types within Northern Ireland. Figure 8.1 therefore explores how principals' views of educational resources varies by the proportion of pupils in the school who are eligible from FSM.

17. Overall, there is little evidence that principals leading schools with a greater proportion of socio-economically disadvantaged pupils are more likely to report issues regarding a lack of resources. For instance, the proportion of principals reporting a lack of educational material as hindering instruction (blue line with square markers) is similar for those leading schools in the top and bottom FSM quartile (43 per cent versus 36 per cent). Likewise, responses to the statement regarding '*inadequate or poor quality infrastructure'* do not show any clear relationship with the proportion of pupils in the school who are eligible for FSM (red line with circular markers), with any variation in the line likely due to sampling error. Finally, although 15 per cent of principals leading the most socio-economically deprived schools report a problem with inadequate support staff (green line with crossed markers), compared to no principal leading the least deprived schools, this difference does not reach statistical significance at the five per cent level (p=0.18). It therefore does not seem to be the case that principals who lead schools with a high proportion of

disadvantaged pupils are more likely to report issues with inadequate resources than those leading schools with a more socially advantaged intake.

18. Similar results hold for differences between grammar and non-grammar schools; principals' responses to most of the statements given in Table 8.2 do not vary substantially between these school types. Although principals leading non-grammar schools are more likely to report challenges with inadequate teaching staff (eight per cent) and assistant staff (nine per cent) than grammar schools (zero per cent), these differences are not statistically significant at the five per cent level (p=0.14 and p=0.16).

Figure 8.1 Principals' reports of lacking resources by school FSM quartile



Source: Matched PISA 2015 database

Key point

A lack of good quality school infrastructure stands out as a particular concern of principals in Northern Ireland. There is little evidence that principals are more likely to report a lack of educational resources as a barrier to learning if they lead a school with a high proportion of disadvantaged pupils.

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

19. Whereas the previous sub-section focused upon principals' views of school resources in general, this sub-section pays specific attention to the availability of resources for use in the instruction of science. For instance, do principals in Northern Ireland believe that they have adequate laboratory equipment and appropriately trained staff to support pupils' learning in this subject? Or is it the case that when schools receive additional funds, principals tend to prioritise other areas? Table 8.3 provides some insight into such matters. It details how principals respond to a series of eight questions, each referring to a different aspect of the science resources available within their school.

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

	Northern Ireland	OECD	H10
Compared to other departments, our schools science department is well equipped	96%	**74%***	**75%***
If we ever have some extra funding, a big share goes into improvement of our school science teaching	30%	39%	**47%***
School science teachers are among our best educated staff members	75%	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	96%	**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	88%	**34%***	**51%***
Our school spends extra money on up-to-date school science equipment	58%	48%	49%

Source: PISA 2015 database

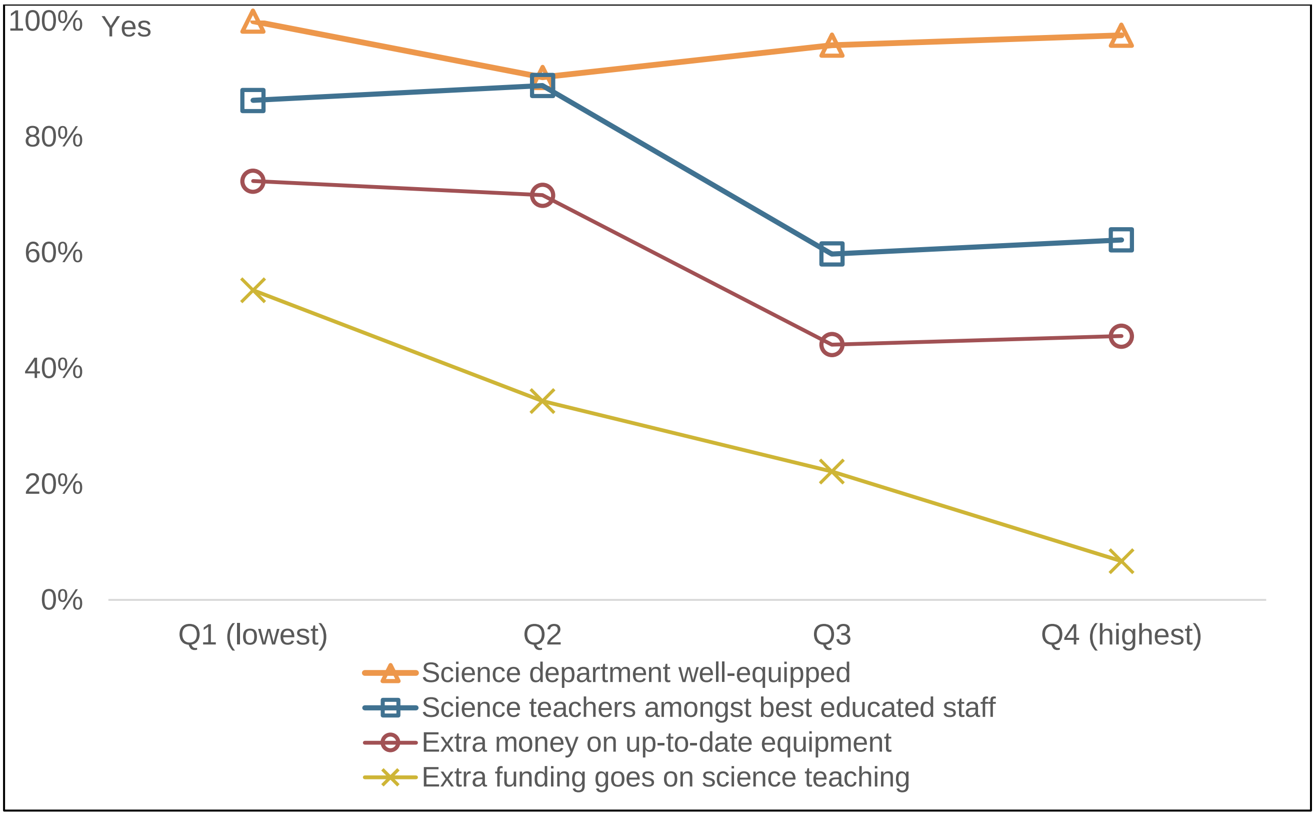
Notes: Figures refer to the percentage of pupils in schools where the principal ticks 'yes'. Bold font with * indicates significant difference from Northern Ireland.

20. Principals in Northern Ireland are generally positive about the science resources that are available within their school; more so than principals in the typical OECD or H10 country. This is particularly true for the availability of laboratory staff to support science teaching (88 per cent in Northern Ireland versus OECD / H10 averages of 34 per cent and 51 per cent respectively) and the availability of

laboratory material (92 per cent in Northern Ireland versus 66 per cent and 72 per cent for the OECD and H10 averages).

21. The question receiving the least positive response from principals in Northern Ireland was with regards the use of additional funding. Less than a third (30 per cent) of principals in Northern Ireland report that a big share of any extra funding goes towards improving science teaching. Of the eight statements included in Table 8.3, this is the only occasion where the percentage for Northern Ireland is lower than the average across members of the OECD (39 per cent) and the average across the H10 countries (47 per cent). This in turn suggests that principals have other priorities when additional funding is made available.

Figure 8.2 Principals' reports of school science resources by the proportion of pupils who are eligible for Free School Meals



Source: Matched PISA 2015 database

22. Figure 8.2 turns to variation within Northern Ireland, focusing upon differences in principals' responses according to the proportion of pupils in their school who are eligible for Free School Meals. One key issue stands out; funding for science appears to be a lower priority for principals who lead schools with a greater share of socio-economically disadvantaged pupils. For instance, principals who lead high FSM schools are significantly less likely to report that any additional funding is spent

upon science teaching (yellow line with cross markers) or that extra money is spent on up-to-date science equipment (red line with circular markers). Specifically, whereas 53 per cent of principals who lead schools with a low proportion of FSM pupils report that extra funding received is spent upon science teaching, this falls to around seven per cent for schools with the largest share of socio-economically disadvantaged pupils. Together, this suggests that areas other than science may take priority for funding in schools with a large share of young people from low socio-economic backgrounds.

23. A further interesting feature of Figure 8.2 is how principals respond to the statement '*school science teachers are among our best educated staff members*.' Around 85 per cent of principals leading schools with a low proportion of FSM pupils respond positively to this statement, compared to around 60 per cent of those principals in charge of schools with the greatest share of socio-economically disadvantaged pupils. This linear trend is statistically significant at the five per cent level.

Key point

Principals in Northern Ireland are generally positive about the resources available to support science learning within their school. However, science is a lower priority for additional funding in schools with a greater share of pupils from disadvantaged social backgrounds.

8.4 How do principals view the conduct of their staff?

24. 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 associated with lower levels of pupil attainment[54]. In this sub-section, we document the extent to which principals in Northern Ireland report negative behaviour of staff as hindering progress within their school.

25. Principals 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 percentage of principals reporting either 'to some extent' or 'a lot' in Northern Ireland to a series of five statements, and compares this to the average across OECD members and the 10 highest performing countries.

[54] Miller, Murnane and Willett (2008).

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

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

	Northern Ireland	OECD	H10
Teachers not meeting individual pupils' needs	11%	**23%***	**31%***
Teacher absenteeism	30%	**17%***	**14%***
Staff resisting change	21%	**30%***	**32%***
Teachers being too strict with pupils	4%	**13%***	**16%***
Teachers not being well prepared for classes	6%	**12%***	**19%***

Source: PISA 2015 database

Notes: Figures refer to the percentage of pupils in schools where the principal ticks either the 'to some extent' or 'a lot' categories. Bold font with * indicates significant difference from Northern Ireland.

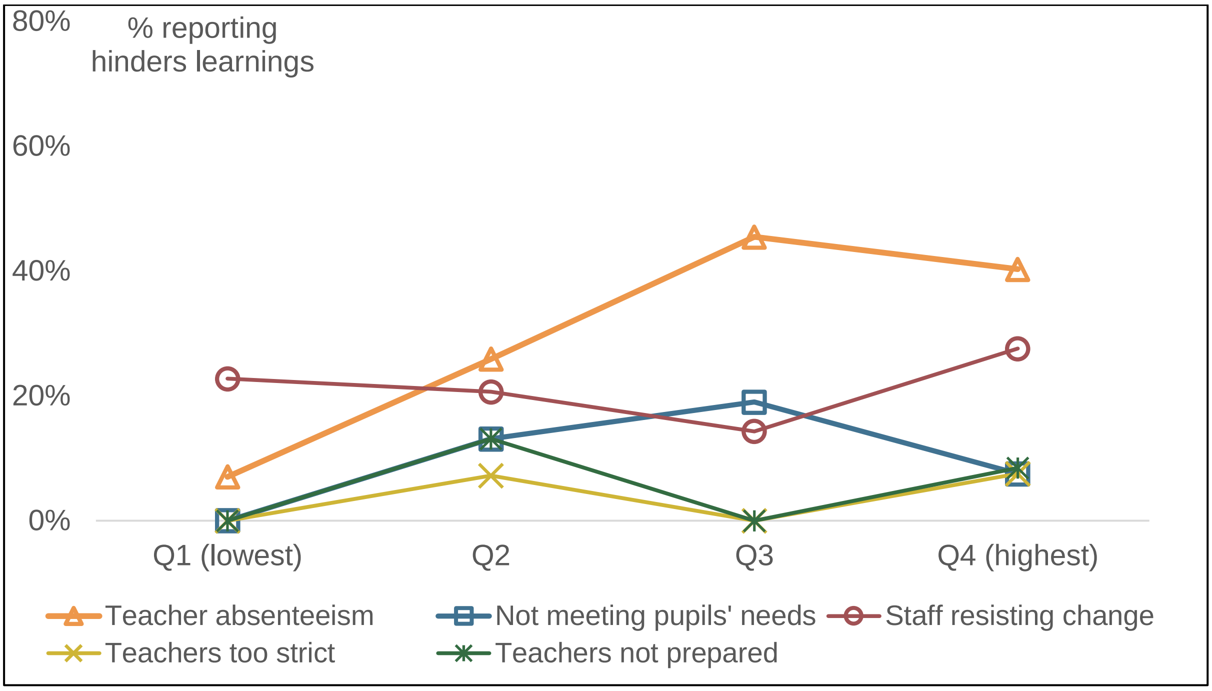
26. Around a third (30 per cent) of pupils in Northern Ireland are taught in schools where the principal believes that staff absenteeism acts as a barrier to learning. This is higher than the average across members of the OECD (17 per cent) and the average across the high-performing countries (14 per cent). However, these cross-national averages disguise substantial cross-national variation in principals' responses to this question. Specifically, whereas less than 10 per cent of principals report staff absenteeism to be a problem in some high-performing countries (e.g. Singapore, Japan, Canada), this is 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 principal views this as a barrier to instruction). Nevertheless, the negative views on staff absenteeism reported in Northern Ireland are rather different to the situation reported by principals in most of the countries with the highest average PISA science scores.

27. In contrast, principals in Northern Ireland are less likely to report that their staff are resistant to change (21 per cent in Northern Ireland versus an H10 average of 32 per cent). Likewise, comparatively few pupils in Northern Ireland are taught in schools where the principal believes that their staff are too strict (four per cent in Northern Ireland versus an average across OECD members of 13 per cent) or that staff are not meeting individual pupils' needs (11 per cent versus an average of 23 per cent across OECD members and a H10 average of 31 per cent). Therefore, out of all the factors considered in Table 8.4, staff absenteeism seems to be a particularly prominent concern amongst principals in Northern Ireland; more so than principals in the average industrialised country.

28. In terms of variation within Northern Ireland by school-level FSM, teacher absenteeism again stands out as the key issue (see Figure 8.3). A total of seven per cent of principals who lead a school with a low proportion of FSM-eligible pupils report teacher absenteeism as a problem. This compares to 40 per cent of principals who lead schools with a high proportion of disadvantaged pupils (top FSM quartile). Moreover, the linear trend between school FSM quartile and the percentage of principals reporting teacher absenteeism as an issue is statistically significant at the five per cent level. This therefore seems to be a particular concern of principals who lead schools with many pupils from disadvantaged socio-economic backgrounds.

29. There is little evidence that any of the other factors vary consistently by school FSM quartile. In other words, principals leading schools with a high proportion of disadvantaged pupils are no more likely to report that their staff are resistant to change, that teachers are ill prepared for classes or that teachers are not meeting individual pupils' needs.

Figure 8.3 Principals' reports of teachers' conduct by school FSM



Source: PISA 2015 database

30. There are also interesting points of difference between non-grammar schools and grammar schools. Teacher absenteeism again stands out as a key issue, with this reported to be a problem by almost half of non-grammar principals (47 per cent) compared to 11 per cent of those leading a grammar school. This is a difference of over 30 percentage points and is statistically significant at the five per cent level. However, there is also a significant difference in terms of teachers not meeting

individual pupils' needs (three per cent in grammar schools versus 18 per cent in non-grammar schools) and teachers not being well prepared for class (zero per cent in grammar schools versus 11 per cent in non-grammar schools). The overall message is therefore that principals who lead non-grammar schools have more points of concern regarding the conduct of their staff than principals who lead grammar schools.

> **Key point**
>
> Principals in Northern Ireland are more likely to report staff absenteeism as a barrier to pupils learning than principals in the average OECD or high-performing country. This is a particular concern of principals who lead post-primary schools with a large proportion of disadvantaged pupils.

8.5 What quality assurance processes are used in schools?

31. 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 having systems in place to be able to receive regular feedback (from both pupils and their parents). We already know that the Northern Ireland education system uses some of these quality assurance measures extensively; school inspections as a means of external evaluation, for example. However, less is known about the prevalence of others (e.g. to what extent do schools in Northern Ireland 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 post-primary schools in Northern Ireland, and how this compares to other countries.

32. Northern Ireland is clearly a country where extensive quality assurance processes are already in place. Almost every principal in Northern Ireland reports that self-evaluation, external evaluation, systematic recording of pupil data and test results, and written specification of goals and performance standards were used in their school. Indeed, the only area where less than 80 per cent of principals' answered 'yes' was with regards regular consultation with an expert aimed at school improvement (69 per cent). Consequently, it seems that most of the quality assurance processes listed are used in the majority of Northern Ireland's post-primary schools.

33. 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 Northern Ireland, relative to other countries. This includes more widespread use of consultation with external experts than the average across OECD members (69 per cent versus 48 per cent), greater use of external evaluations (100 per cent versus 75 per cent) and written specification of pupil performance standards (98 per cent versus 79 per cent). It is therefore the breadth of the quality assurance processes used in Northern Ireland's schools that is the stand out feature of Table 8.5.

Table 8.5 Principals' reports of the quality assurance processes used in post-primary schools

	Northern Ireland	OECD	H10
Self-evaluation	100%	**93%***	**97%***
External evaluation	100%	**75%***	**80%***
Written specification of the school's curricular profile and educational goals	97%	**89%***	95%
Written specification of pupil performance standards	98%	**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	88%	**69%***	82%
Teacher mentoring	87%	**78%***	89%
Regular consultation aimed at school improvement with one or more experts over a period of at least six months	69%	**48%***	**49%***
Implementation of a standardised policy for science subjects	87%	**63%***	**75%***

Source: PISA 2015 database

Notes: Figures refer to the percentage of pupils within schools where the principal reports the quality assurance process as taking place. Bold font with * indicates significant difference from Northern Ireland.

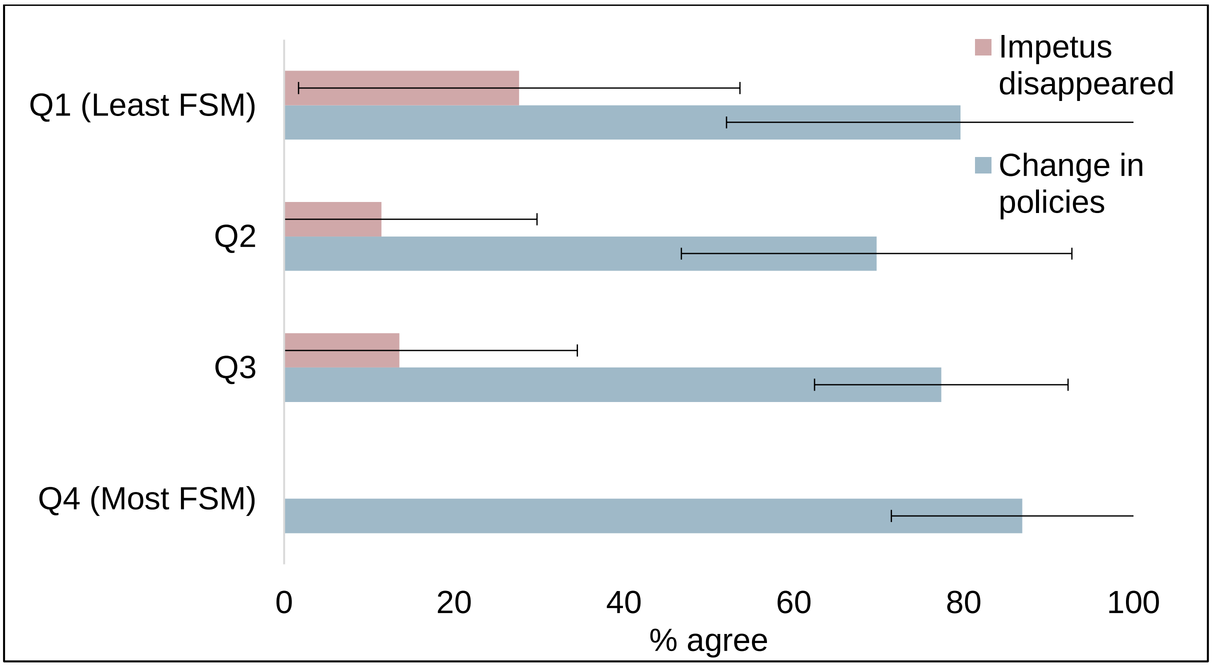
34. As Table 8.5 illustrates, external evaluations (such as those conducted by the Education Training Inspectorate - ETI) are a prominent feature of the quality assurance process used in Northern Ireland. However, to what extent do principals in Northern Ireland use the results from these inspections to drive change? Moreover, do principals perceive these inspections to have a lasting impact upon their school?

35. In the background questionnaire, principals were asked to respond yes or no to the following five statements:

- *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*

36. There was near universal agreement amongst principals in Northern Ireland that school inspections led to a specific plan of action for school development (95 per cent) and improving teaching (91 per cent), with the measures being put into place promptly (90 per cent). However, around a fifth of principals report no change in school policies as a result of the inspection (23 per cent), while around one-in-eight thinks the impetus the inspection triggered disappeared quickly (13 per cent).

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



Source: PISA 2015 database

Notes: Figures refer to the percentage of pupils within schools where the principal responds 'yes'. Thin black line through centre of each bar refers to the estimated 95 per cent confidence interval. Sample restricted to schools who reported an external inspection occurring.

37. Do these figures vary by the proportion of disadvantaged pupils within the school? Figure 8.4 suggests there was no clear association between school FSM quartile and whether the last external inspection led to a change in school policies. On the other hand, whereas no principal in a school within the highest FSM quartile report that the impetus triggered by external inspection disappeared quickly, this increases to 28 per cent of principals leading schools with the fewest FSM-eligible pupils. This difference between high and low FSM schools is statistically significant at the five per cent level. Figure 8.4 therefore suggests that external inspections may be a particularly important trigger for change in schools serving socio-economically disadvantaged communities.

Key point

Extensive quality assurance processes are already in place within the Northern Ireland education system. Principals in Northern Ireland report that external inspections lead to a lasting impetus for change, particularly within schools with a high proportion of socio-economically disadvantaged pupils.

Chapter 9. Pupils' aspirations and future plans

Most pupils in Northern Ireland view science as relevant to their future, irrespective of their gender, socio-economic status, and skills in this area. There are few notable differences between Northern Ireland and the average across the high-performing countries in this respect.

The proportion of 15-year-olds who aspire to a career in science is greater in Northern Ireland than the average across OECD members. It is also greater than the average across the top performing countries.

Northern Ireland girls are more likely to aspire to work as a health professional than boys. On the other hand, boys are more likely to want to become an engineer than girls.

The proportion of 15-year-olds in Northern Ireland who expect to obtain an undergraduate degree is similar to the average across OECD countries.

The proportion of pupils in Northern Ireland who expect to obtain a bachelor's degree is similar to the average across OECD countries.

Girls in Northern Ireland are more likely to expect to complete university than boys. Most 15-year-olds who are planning to apply to university want to attend a Russell Group institution.

1. Young people's aspirations towards future educational and occupational goals are linked to their future attainment[55]. 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[56]. This means that pupils' goals for their lives after post-primary education can have a real impact upon their outcomes. In this chapter we therefore investigate how pupils in Northern Ireland conceive of their lives after finishing post-primary 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 obtain 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 plans regarding higher education. This allows us to gain a better understanding of how pupils in Northern Ireland view their life and goals beyond post-primary 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 Northern Ireland 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?

9.1 Do pupils connect studying science with future careers?

4. The context in which pupils live shapes their aspirations and expectations for the future[57]. School forms an important part of this context, with pupils learning about their enjoyment of, and ability in, various subjects. This is then 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 true for girls and pupils from working-class backgrounds[58]. For instance, a recent study in the United Kingdom found that

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[55] See Gutman and Akerman (2008) for an overview of the literature on the determinants of aspirations and attainment.
[56] Strand and Winston (2008).
[57] Lupton and Kintrea (2011).
[58] Archer et al. (2013).

pupils aged 10-14 have '*high aspirations, just not for science*'[59]. In this sub-section, we investigate this issue by considering whether pupils in Northern Ireland believe that the material they are taught about science in school is relevant for their future careers.

Table 9.1 Percentage of pupils who connect school science subjects with future careers

	Northern Ireland		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	70%	83%	**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%	70%	56%	**63%***	-	**74%***
Studying my school science subject(s) is worthwhile for me because what I learn will improve my career prospects	72%	80%	**61%***	**67%***	-	**76%***
Many things I learn in my school science subject(s) will help me to get a job	67%	75%	**56%***	**61%***	-	**69%***

Notes: Figures refer to the percentage of pupils in schools who either 'strongly agree' or 'agree' with each statement. Bold font and * denotes statistically different from Northern Ireland at the five per cent significance level. 'H10' refers to the 10 highest performing countries in the PISA science domain. The OECD average for 2006 is the 'OECD-30' (includes 30 OECD members as of 2006) and the OECD average for 2015 is the 'OECD-35' (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]. See Appendix F for further information on trends in performance over time

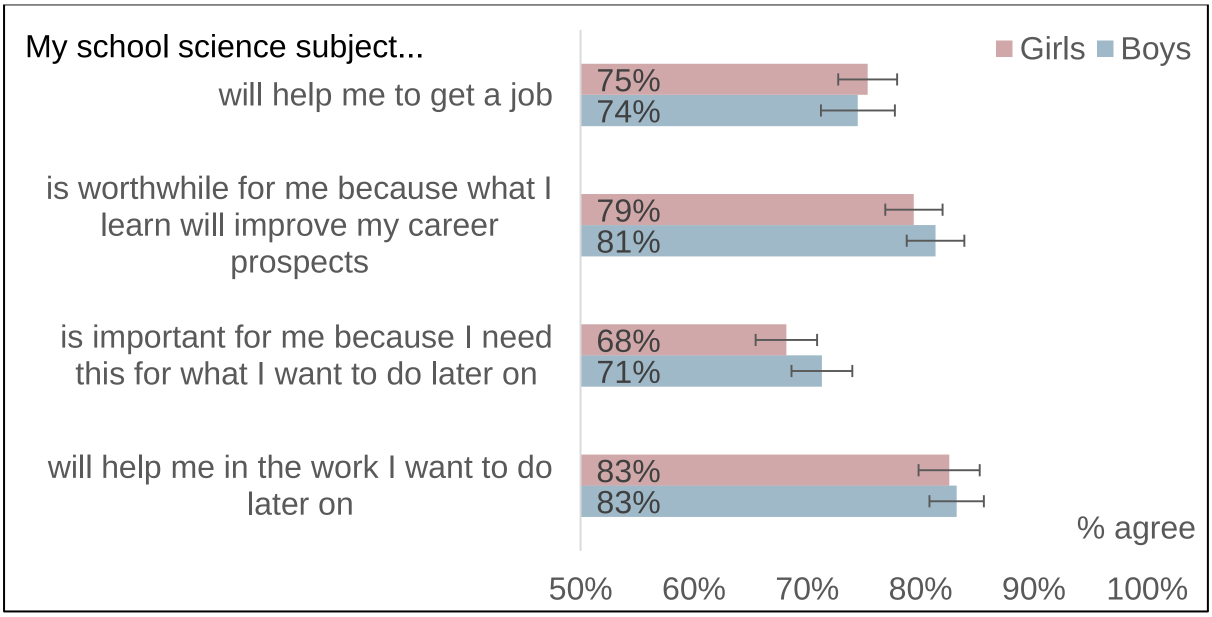
5. As part of the background questionnaire, pupils were asked several questions about how important they think school science subjects will be later on in their lives. The results in Table 9.1 show the percentage of pupils who either 'strongly agree' or 'agree' with each statement. For all four questions, the proportion of pupils in agreement is usually similar for Northern Ireland and the average across the H10 countries. For instance, 80 per cent of 15-year-olds in Northern Ireland agree or strongly agree that school science is something that will *'improve career prospects'*, compared to an H10 average of 76 per cent. On the other hand, pupils in Northern Ireland are somewhat more likely to report that school science will help to improve their career prospects than the average across OECD countries (80 per cent for Northern Ireland versus 67 per cent OECD average) and will help them to get a job (75 per cent versus 61 per cent). Interestingly, the questions where there are the

[59] Archer et al. (2013: 1).

greatest differences between Northern Ireland and the OECD average all explicitly mention words like ‘career’, ‘work’ and ‘job’. This perhaps indicates that 15-year-olds in Northern Ireland make a particularly strong connection between what they learn in school science and their future careers.

6. The PISA 2006 cycle included the same questions, which provides some comparison of how pupils’ motivation for learning science and ideas about its relevance for their future has changed over time. For every statement, pupils in Northern Ireland and the average OECD country have become more likely to view science as important to their future. In Northern Ireland, pupils in 2015 are approximately 10 percentage points more likely to respond to these statements with ‘agree’ or ‘strongly agree’ than in 2006. In 2006, pupils from Northern Ireland were also 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 findings emerge for Northern Ireland regarding pupils’ views on the relevance of school science subjects in 2015 as occurred in 2006.

Figure 9.1 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 Northern Ireland schools who either ‘strongly agreed’ or ‘agreed’ with the associated statements. Thin black line through centre of each bar refers to the estimated 95 per cent confidence interval.

7. Figure 9.1 turns to whether responses to these questions in 2015 differed by gender. Overall, Northern Ireland boys are no more likely to agree with these statements than girls (or vice-versa). For example, 83 per cent of boys and girls ‘agree’ or ‘strongly agree’ that science was something that will help them in the work they want to do later on. Likewise, boys and girls in Northern Ireland are equally likely to say that what they learn in their school science subjects will help them get a job (74 and 75 per cent). However, it should be noted that these results are not specific to Northern Ireland; gender differences in pupils’ responses to these statements are also relatively small in terms of magnitude (three to four percentage points) for the average across OECD countries. Nevertheless, in Northern Ireland, there is no evidence that boys and girls hold different views regarding the relevance of school science for their future careers.

Table 9.2 Percentage of pupils who connect school science subjects with future careers by science proficiency level

	Below Level 2	Levels 2-4	Levels 5 or 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	81%	83%	86%
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	72%	69%	77%
Studying my school science subject(s) is worthwhile for me because what I learn will improve my career prospects	74%	**81%***	**88%***
Many things I learn in my school science subject(s) will help me to get a job	71%	75%	79%

Source: PISA 2015 database

Notes: Figures refer to the percentage of pupils in Northern Ireland schools 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 and * indicates significantly different from pupils below Level 2 at the five per cent level.

8. In additional analysis, we have also found little evidence that pupils’ responses to these questions differ markedly by either socio-economic status or school type. There are, however, some interesting differences between pupils who achieved different scores on the PISA science test. Table 9.2 indicates that the top performing pupils (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 (88% versus 74%). Similarly, they are eight percentage points more likely to think that what they learn in their school science subjects will help them get a job (79% versus 71%). Yet, it is also notable how the majority of Northern Ireland pupils who lack basic science skills still believe that what they learn in their

school science classes is relevant for their future employment prospects. Indeed, even amongst pupils with low science skills, over two thirds respond positively to each of the statements.

Key point

Most pupils in Northern Ireland view school science as relevant to their future, irrespective of their gender, socio-economic status, and proficiency in this area. There are few notable differences between Northern Ireland and the average across the high-performing countries in this respect.

9.2 What types of careers interest pupils? To what extent are 15-year-olds interested in a career in science?

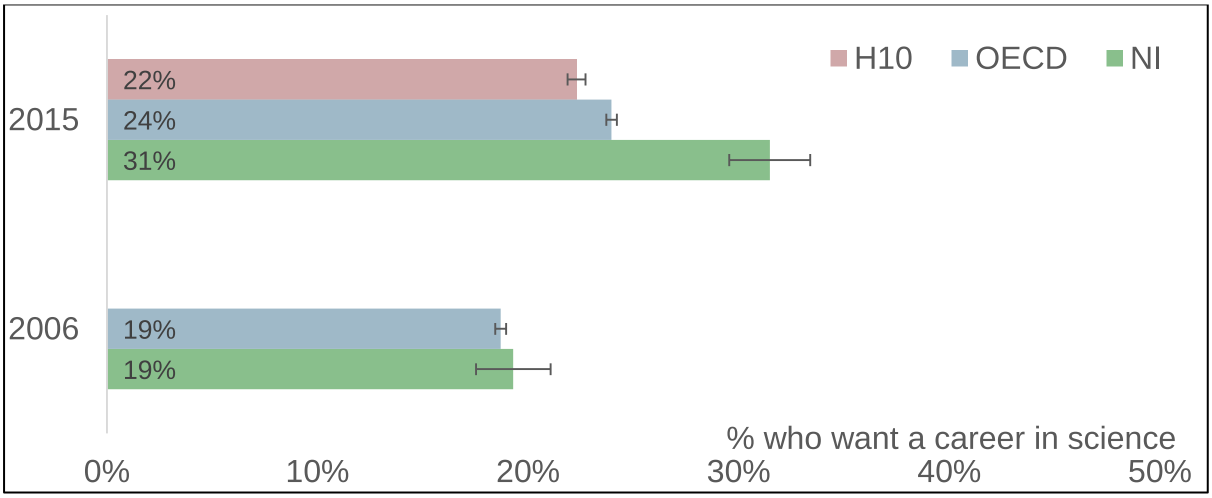
9. Adolescence and the end of post-primary school represent an important transitional period in an individual's life. Pupils have to make important career-related decisions about the direction in which their lives will go. They will decide whether to enter vocational training, pursue a university degree or enter directly into the labour market. There is evidence that pupils who set and pursue goals are better equipped to master this transition[60]. The pupils who take PISA find themselves in this crucial period, and have been asked the following question about their future occupational goals: *What kind of job do you expect to have when you are about 30 years old[61]?* In this sub-section we use pupils' responses to investigate the types of career young people hope to enter.

10. The most popular future occupation amongst 15-year-olds in Northern Ireland is 'medical doctor'; five per cent of pupils expect to be working in this role at age 30. The second most popular occupation is 'other health professionals', with approximately five per cent of pupils, followed by 'engineer' in third place, also with approximately five per cent. 'Software developers' also made it into the top 10 with four per cent of pupils. Interestingly, the top three most aspired to careers in Northern Ireland are all science related. Pupils in Northern Ireland exhibit some uncertainty in their future career aspirations; 15 per cent of 15-year-olds either did not answer the question or answered with 'do not know' or something vague as their response.

[60] See Weiss et al. (2014) for an overview of the motivational, personal and contextual factors affecting the completion of post-primary school and the transition to life after post-primary school.
[61] Pupils provided a free text answer, with these then converted by the survey organisers into International Standard Classification of Occupations 2008 (ISCO-08) codes.

11. Figure 9.2 illustrates that, in total, around a third of pupils in Northern Ireland (31 per cent) expect to work in a STEM ('science, technology, engineering and mathematics') career[62]. This is around eight percentage points above the average across OECD members (24 per cent) and the average across H10 countries (22 per cent). Interestingly, Figure 9.2 also reveals that this is somewhat different to the situation in PISA 2006, when science was last the focus of PISA[63]. For instance, only one-in-five (19 per cent) Northern Ireland pupils aspired to a science career in 2006, which was little different to the average across OECD countries[64] (19 per cent). It therefore seems that there has been a notable increase in the proportion of Northern Ireland pupils who are interested in pursuing a STEM career over the last decade.

Figure 9.2 The percentage of pupils who aspire to a career in science: a comparison between PISA 2006 and 2015



Notes: Figures refer to the percentage of pupils in schools who aspire to career in science at age 30. 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' (includes 30 OECD members as of 2006) and the OECD average for 2015 is the 'OECD-35' (includes all 35 OECD members as of 2015). Thin black line through centre of each bar refers to the estimated 95 per cent confidence interval. It should be noted that the 2015 figure presented here for Northern Ireland differs 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 33 per cent of pupils aspiring to a science career while we report 31 per cent. See Appendix F for further information on trends in performance over time

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[62] 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.

[63] 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.

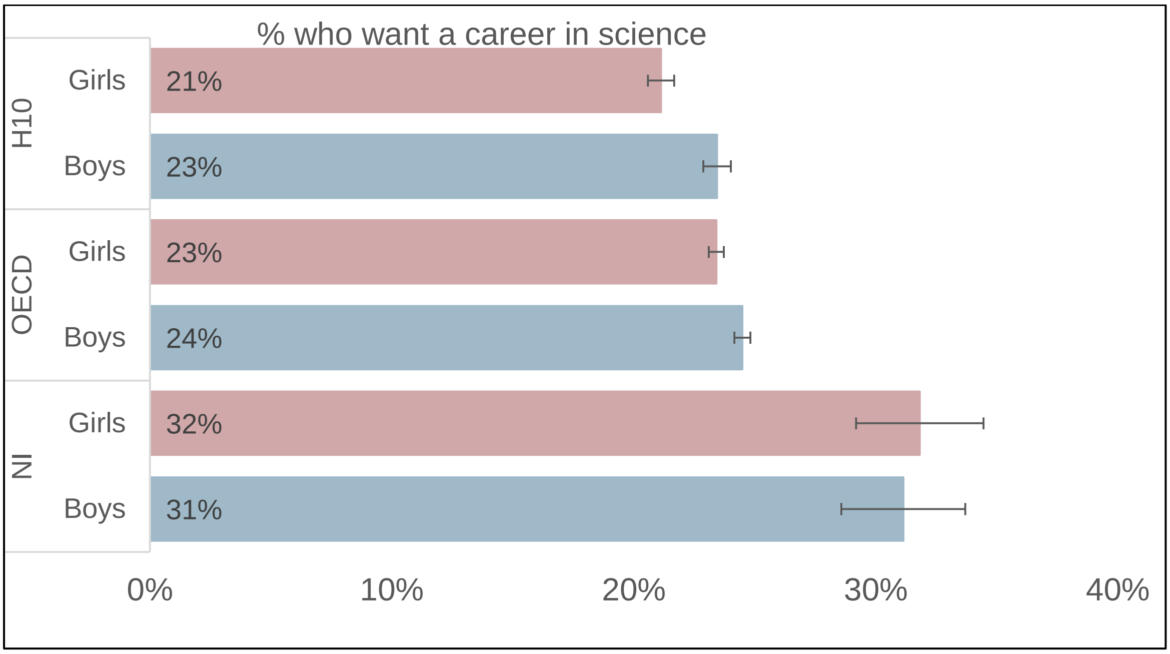
[64] The OECD average for 2006 is the 'OECD-30' (which includes all 30 OECD members as of 2006) and the OECD average for 2015 is the 'OECD-35' (which includes all 35 OECD members as of 2015).

12. Are there significant socio-economic differences in aspirations towards a STEM career in Northern Ireland? Our analysis shows that pupils from disadvantaged backgrounds in Northern Ireland are 15 percentage points less likely to aspire to a STEM career than their peers from advantaged backgrounds (26 per cent versus 41 per cent). This gap exists amongst OECD countries on average as well, where there is a 13 percentage point difference between pupils from socio-economically advantaged and disadvantaged backgrounds (18 versus 31 per cent). These results indicate that 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 9.1).

13. Figure 9.3 illustrates whether there are gender differences in 15-year-olds' aspirations to be working in a science career[65]. There is little evidence that this is the case. Specifically, in Northern Ireland, 32 per cent of girls aspire to a STEM career at age 30, compared to 31 per cent of boys. Although a similar finding holds for the OECD and H10 averages, there are some important 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). 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 favour of girls (31 per cent of boys versus 37 per cent of girls).

[65] See Mau (2003) and Sadler et al. (2012) for an overview of evidence on STEM career choice and gender.

Figure 9.3 Gender differences in aspirations towards a science career



Source: PISA 2015 database

Notes: Figures refer to the percentage of pupils in schools who aspire to a career in science at age 30. Thin black line through centre of each bar refers to the estimated 95 per cent confidence interval. It should be noted that the figures presented here for Northern Ireland 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.

14. In Table 9.3 we break down the type of science career pupils aspire to into four broad groups: scientist/engineer, health professional, ICT professional and technician. Around a quarter (23 per cent) of Northern Ireland girls are interested in a career as a health professional, compared to 10 per cent of boys. On the other hand, Northern Ireland boys are more likely to aspire to become a scientist/engineer than girls (14% versus 7%). The magnitude of these gender differences is similarly large for the average across OECD members; there is an 11 percentage point difference between boys and girls aspirations towards working in a health related profession, for instance. There are hence pronounced gender differences in the specific types of scientific career 15-year-olds in Northern Ireland hope to enter, despite boys and girls having broadly equal skills across the PISA ‘physical’ and ‘living’ scientific system domains (see chapter 6 for further details).

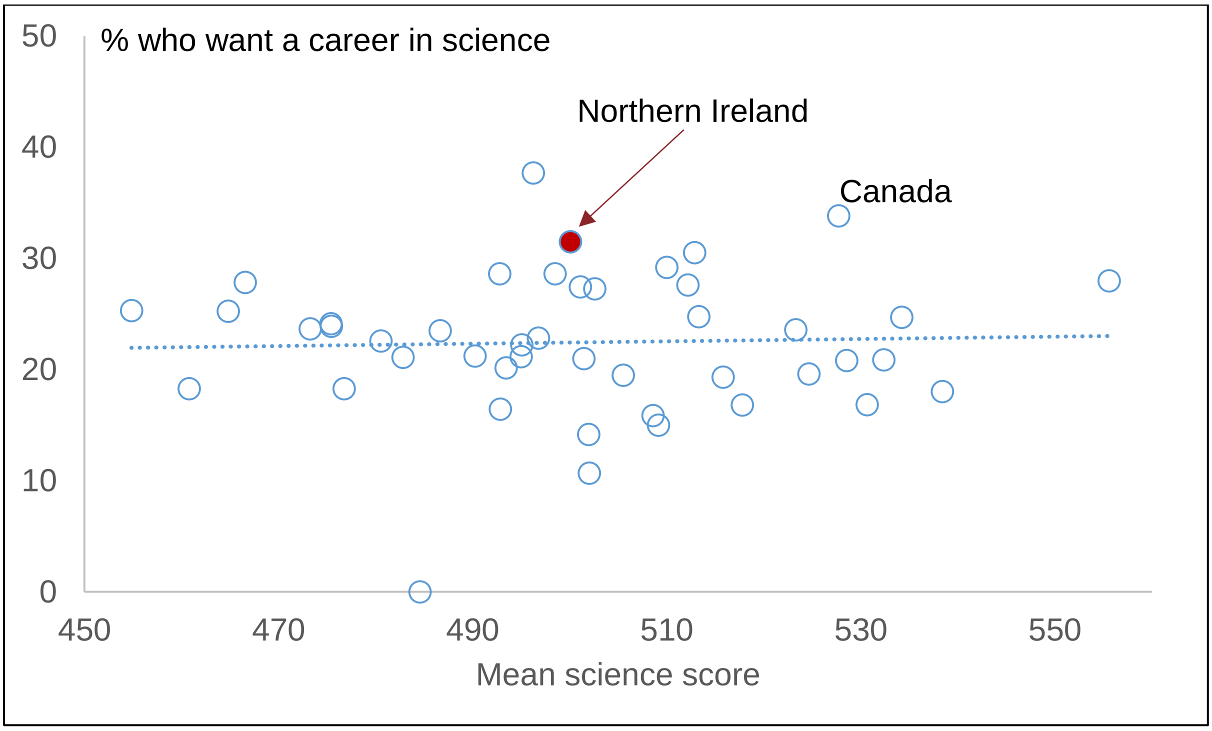
Table 9.3 Gender differences in aspirations towards different STEM careers

	Northern Ireland			OECD			H10		
	Total	**Boys**	**Girls**	**Total**	**Boys**	**Girls**	**Total**	**Boys**	**Girls**
Scientist/engineer	10%	14%	**7%***	9%	12%	**5%***	8%	11%	**4%***
Health professional	17%	10%	**23%***	11%	6%	**17%***	11%	7%	**16%***
ICT professional	4%	7%	**2%***	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 in schools who aspire to a career in science in one of these four categories at age 30. It should be noted that the figures presented here for Northern Ireland 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. Bold font and * denotes girls statistically different from boys at the five per cent significance level.

Figure 9.4 PISA science performance and STEM aspirations



Source: PISA 2015 database.

Notes: Figures refer to the percentage of pupils in schools who aspire to a career in science at age 30 and the country average score in the PISA science domain. We exclude countries with a PISA science score below 450. It should be noted that the figure presented here for Northern Ireland differs 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.

15. Do the countries with the highest average scores also have the greatest proportion of pupils who want to become scientists? Figure 9.4 provides the answer by plotting average PISA science scores (horizontal axis) against the percentage of pupils who aspire to a career in science (vertical axis). The flat trend line in Figure 9.4 indicates that there is essentially no correlation; countries with the strongest performance in PISA do not necessarily have the highest percentage of pupils who want to work in a STEM career. In fact, of the 10 countries with the highest average PISA science scores, only Canada has a greater proportion of 15-year-olds who aspire to a science career than Northern Ireland.

Key point

15-year-olds in Northern Ireland are more likely to aspire to a science career than pupils in the average high-performing and average industrialised 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.

9.3 What are the characteristics of pupils who plan to attend university? What factors are associated with their plans?

16. In this sub-section we gain further insight into university aspirations and the university application process in Northern Ireland. 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[66]. 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[67]. 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.

17. As part of the background questionnaire, pupils were asked what level of education they expect to complete. Table 9.4 shows that 45 per cent of pupils in Northern Ireland expect to obtain at least a bachelor's degree[68]. This is the same as

[66] Boliver (2011).
[67] Anders (2012).
[68] This corresponds to International Standard Classification of Education (ISCED) level 5A or 6, which is a framework created by the United Nations 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.

the average across members of the OECD (45 per cent), but below the average across the top-performing countries (52 per cent). Still, there is a lot of variation between countries; less than one-in-five German 15-year-olds expects to complete university compared to 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 9.4 The percentage of 15-year-olds who expect to obtain at least an undergraduate degree

	Northern Ireland	OECD	H10
Overall	45%	45%	52%
Boys	40%	40%	49%
Girls	**49%***	**49%***	**56%***

Source: PISA 2015 database

Notes: Figures refer to the percentage of pupils in schools who expect to obtain at least an undergraduate degree. Bold font and * indicates girls are significantly different from boys at the five per cent level. Due to lack of data for Slovakia and Vietnam and inconsistencies in the data for Finland and Taiwan, we have excluded them from the calculation of the H10/OECD averages

18. Table 9.4 also illustrates how Northern Ireland girls are nine percentage points more likely to expect to complete university than boys. This difference is statistically significant at the five per cent level, and is consistent with the 2013/14 Higher Education Initial Participation Rate[69], where there is a nine percentage point 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).

19. Similarly, we also find differences in university expectations depending upon pupils' socio-economic background. Specifically, two-thirds (66 per cent) of Northern Ireland pupils from the most advantaged backgrounds expect to complete university, compared to 28 per cent of their peers from the least advantaged backgrounds. This is a difference of nearly 40 percentage points, and 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).

[69] 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).

Relatedly, pupils at grammar schools are more than 30 percentage points more likely to expect to complete university (62 per cent) than pupils in non-grammar schools (29 per cent), with this difference statistically significant at the five per cent level[70].

20. Pupils in Northern Ireland also answered a series of questions on the university application process - see Table 9.5[71]. Only pupils who stated that they were likely to apply to university were given the opportunity to respond to these questions. A total of 69 per cent of the full sample indicated that they were 'fairly likely' or 'very likely' to apply to university. The remaining 31 per cent of the sample was divided between pupils who said they were 'not very likely' or 'not likely at all' to attend university (16 per cent) and pupils who skipped this question (15 per cent). This should be kept in mind when interpreting the following results.

21. Course / course content (98 per cent), employment prospects after graduation (97 per cent) and realistic entry requirements (96 per cent) are the three most important factors influencing 15-year-olds' higher education plans. This holds true for both boys and girls. On the other hand, factors related to social life are somewhat less important to the plans of 15-year-olds, as are university costs. For instance, one-in-eight (12 per cent) pupils in Northern Ireland do not view cost to be an important factor (at least amongst those who are likely to apply). Finally, the least important issue is distance from home, with 40 per cent of 15-year-olds in Northern Ireland saying this will not be an important factor in determining which higher education institution they will apply to. Young people in Northern Ireland therefore seem to take a pragmatic approach when thinking about which university, focusing upon the practicalities of the course and the application process, as well as eventual employment outcomes. Nevertheless, for all factors more than half of the pupils who responded report the factor to be either 'fairly' or 'very' important, highlighting how pupils in Northern Ireland take into account a wide range of factors when forming their higher education plans.

[70] In additional analysis, we continue to find a statistically significant difference of 11 percentage points between pupils at grammar schools and pupils at non-grammar schools, after controlling for differences in pupils' socio-economic status.
[71] These questions were only posed to pupils in England, Wales and Northern Ireland, and not in other countries.

Table 9.5 Percentage of pupils who feel certain factors matter for university application decisions

	Percentage who feel it is important				
	Total	**Boys**	**Girls**	**Bottom 25% SES**	**Top 25% SES**
Course / course content	98%	97%	**99%***	97%	99%
Employment prospects afterward	97%	97%	98%	96%	99%
Realistic entry requirements	96%	95%	96%	95%	95%
Challenging entry requirements	88%	88%	88%	87%	88%
Local employment prospects while a student	85%	82%	**87%***	89%	**80%***
Costs (as affected by fees, scholarships and bursaries)	88%	88%	89%	91%	**85%***
Academic ranking / 'league table' ranking	79%	77%	80%	77%	81%
Social life	81%	83%	80%	81%	83%
Fitting in	74%	73%	74%	70%	75%
Distance from home	60%	58%	62%	66%	**55%***

Source: PISA 2015 national database.

Notes: Figures refer to the percentage of pupils in Northern Ireland schools who responded to these questions, not the entire sample, and feel that these factors are either ‘very important’ or ‘fairly important’. Bold font and * indicates significantly different from boys when in the column for girls or significantly different from the bottom quartile of socio-economic status when in the column for the top quartile of socio-economic status at the five per cent level.

22. There is surprisingly little difference in how pupils from different socio-economic backgrounds responded to these questions. The main exceptions are with respect to ‘distance from home’ (55 per cent of advantaged pupils versus 66 per cent of disadvantaged pupils reported this to be an important factor), local employment prospects (80 per cent of advantaged pupils versus 89 per cent of disadvantaged pupils) and cost (85 per cent of advantaged pupils versus 91 per cent of disadvantaged pupils). This result suggests that financial considerations may have slightly more influence upon the higher education plans of pupils from disadvantaged socio-economic backgrounds. Nevertheless, for the most part, differences between 15-year-olds from advantaged and disadvantaged backgrounds were found to be relatively small.

23. Pupils were also asked to list three universities to which they plan to apply[72]. Three-quarters (76 per cent) of pupils in Northern Ireland who are planning to apply to university put a university in Northern Ireland as their first choice. The Queen's University Belfast was listed by 35 per cent of pupils, followed by the University of Ulster (eight per cent). Of the remainder, nearly a fifth intend to apply to a university elsewhere in the UK, with seven per cent mentioning a higher education institution abroad. There is no evidence of gender differences in pupils' responses.

24. A total of 70 per cent of pupils who answered this question list a Russell Group university as their first choice[73]. As a point of comparison, in 2014/15, 23 per cent of undergraduate pupils in the UK were enrolled in a Russell Group university[74]. It is therefore clear that many more 15-year-olds aspire to the top universities than the proportion who will go on to attend. There is also evidence of a socio-economic gap in terms of the type of the institution 15-year-olds hope to attend. Specifically, young people from the most advantaged socio-economic backgrounds are nine percentage points more likely (75 per cent) to aspire to attend a Russell Group university than their peers (66 per cent) from disadvantaged socio-economic backgrounds.

Key point

The proportion of pupils in Northern Ireland who expect to obtain a bachelor's degree is similar to the average across OECD countries. Girls in Northern Ireland are more likely to expect to complete university than boys. Most 15-year-olds who are planning to apply to university want to attend a Russell Group institution.

[72] These answers were entered as free text, so pupils had to draw on their own knowledge of universities to answer these questions. Again, pupils only provided answers to these questions if they stated they were planning on applying to university.
[73] 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).
[74] Based on authors' calculation using Higher Education Statistics Agency (HESA) data on undergraduate university enrolments from 2014/15 (HESA, 2016).

Chapter 10. Pupils' experiences of learning science in school

15-year-olds in Northern Ireland report spending more time studying science in-school per week than young people in other OECD countries.

The total amount of time 15-year-olds in Northern Ireland report spending on additional study across all subjects is higher than the average across OECD countries and the average across the 10 countries with the highest average PISA test scores.

Pupils in Northern Ireland feel they have similar opportunities to express themselves and draw conclusions from experiments during their science lessons as their peers in OECD countries. However, they spend less time constructing arguments and engaging in debates.

The frequency of low-level disruption in Northern Ireland's science classrooms is similar to the average across OECD countries. Within Northern Ireland, low-level disruption is a particular challenge facing non-grammar schools, especially those with a high proportion of pupils who are eligible for Free School Meals.

Around a third of 15-year-olds in Northern Ireland report receiving feedback from their teacher in most or in every science lesson. This is similar to the average across OECD members and the average across the top-performing PISA countries.

Pupils in Northern Ireland generally perceive their science teachers to be supportive. However, lower achieving pupils believe that their science teacher is less willing to provide individual support and adapt their lessons than their high 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[75]. Yet there remains important gaps in our knowledge about pupils' experiences whilst in school, including the activities they complete in the science classroom. For instance, how much time do pupils in Northern Ireland 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? The aim of this chapter is to provide new evidence on these issues for Northern Ireland, and whether 15-year-olds' experiences of learning science in school 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 out-of-school? How does this compare to other subject areas?*
- *What kind of activities take place in science classrooms in Northern Ireland? Does this differ markedly from other countries?*
- *Is low-level disruption in science classrooms a more common occurrence in Northern Ireland than in other countries?*
- *How do pupils in Northern Ireland perceive the feedback that they receive from their science teachers?*
- *Do pupils in Northern Ireland feel that they receive sufficient support from their teachers during their science classes?*

2. 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. The subjective nature of their views, and limitations in their ability to accurately recall and report information, should be considered when interpreting the results.

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

10.1 How much time do pupils spend studying science per week? How does this compare to other subject areas?

3. It has been suggested that increasing instruction time in school can, up to a point, improve pupils' learning outcomes (particularly for those from disadvantaged socio-economic backgrounds)[76]. At the same time, certain forms of out-of-school study, such as intensive one-to-one tuition, are thought to be particularly effective in raising pupils' attainment[77]. It is therefore important to know how much time pupils in Northern Ireland spend studying different subjects, both within their compulsory 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.

4. Table 10.1 documents the average number of hours pupils report spending on a selection of subjects as part of their core timetable per week. Figures are provided for science, English, mathematics and 'other' subject areas[78].

Table 10.1 The average number of in-school instruction hours per week

	Northern Ireland	OECD	H10
Science	4.2 hours	**3.5 hours***	**4.0 hours***
English/test language	3.8 hours	**3.6 hours***	**4.1 hours***
Mathematics	3.7 hours	3.6 hours	**4.3 hours***
Other	15.9 hours	**16.6 hours***	15.9 hours
Total	27.2 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. 'Other' is the difference between the sum of reported subjects and the reported total. Bold font and * denotes statistically different from Northern Ireland at the five per cent significance level. Due to missing values, the reported subjects and the 'other' category do not sum to the reported total. Data not available for Vietnam.

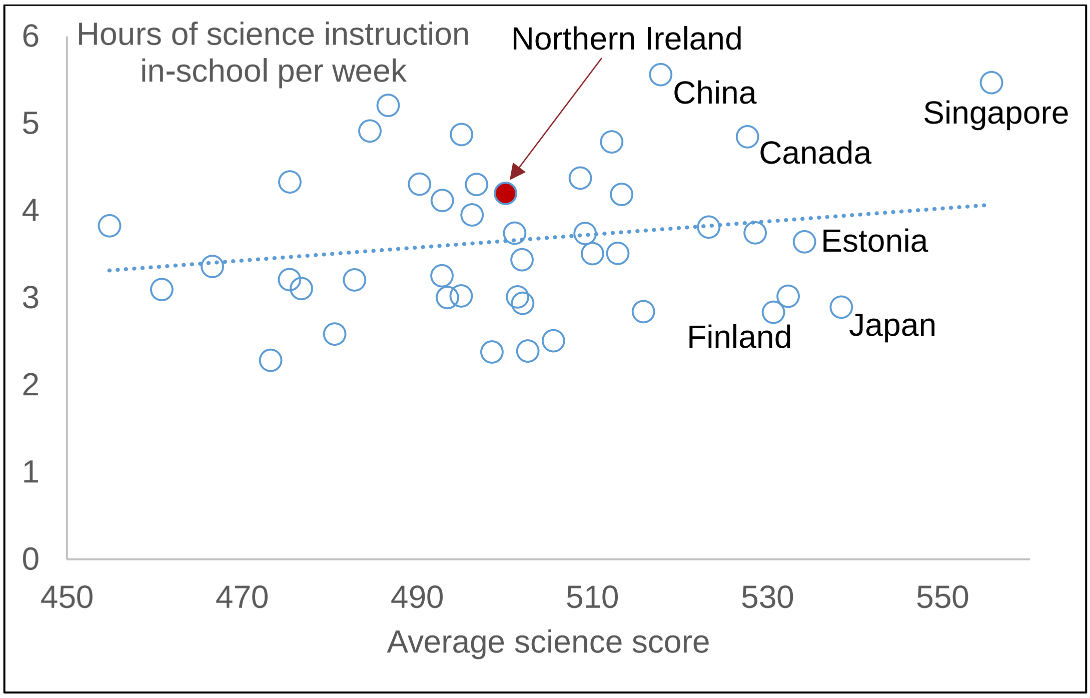
5. Pupils in Northern Ireland receive, on average, 4.2 hours of science instruction per week. This equates to approximately 15 per cent of their 27 hour weekly timetable. This is around 24 minutes more than they report for English, and half an hour more than mathematics. In OECD and the highest performing 10

[76] See Hanushek (2015) for an overview of the evidence on instruction time and pupil performance.
[77] Higgins et al. (2014)
[78] The online data tables provide additional estimates based upon the median number of hours reported, 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 in school and out-of-school.

countries (H10), the average number of hours is roughly the same for science, test language and mathematics.

6. Overall, pupils in Northern Ireland have a similar amount of total timetabled hours in-school per week as pupils in the average industrialised country, but fewer timetabled hours than the average across the top-performing countries. However, there are some differences in how these hours are distributed across the various subject areas. For example, pupils in Northern Ireland have 40 minutes more instruction in science per week than the average across OECD members, but 40 minutes less per week in the 'other' category. Moreover, pupils in Northern Ireland have fewer timetabled hours in mathematics than the average across the high-performing countries (3.7 hours versus 4.3 hours).

Figure 10.1 The relationship between hours of science instruction in-school and average PISA science scores



Source: PISA 2015 database

Notes: The sample of countries has been restricted to those with an average science score above 450 points. 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. Figure 10.1 therefore investigates whether in-school instruction time in science is linked to performance in this subject at the country level.

8. There are two noteworthy features of this graph. First, there are many points below Northern Ireland, indicating greater weekly science instruction time in-school as compared to many countries. Indeed, 15-year-olds in most other countries typically spend, on average, 30 minutes less time learning science in school per week. Second, as illustrated by the dashed regression line, the relationship between in-school instruction hours and average PISA test scores in science is relatively weak at the country level (Pearson correlation = 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. Canada, China, Singapore) the average amount of time spent is greater than the four hours in Northern Ireland. Consequently, there is little evidence that countries with more timetabled hours for science tend to achieve higher average PISA test scores.

Table 10.2 Average hours spent on additional learning per week

	Northern Ireland	OECD	H10
Science	3.8 hours	**3.1 hours***	**3.4 hours***
English/test language	3.5 hours	**3.1 hours***	**3.2 hours***
Mathematics	4.0 hours	**3.8 hours**	**4.3 hours***
Foreign language	1.8 hours	**3.1 hours***	**3.1 hours***
Other subjects	5.2 hours	**3.9 hours***	**3.8 hours***
Total	18.4 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. 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 calculation of the H10 average. Due to missing values, the reported subjects do not necessarily sum to the reported ‘total’ category. Bold font and * denotes statistically different from Northern Ireland at the five per cent significance level.

9. It is of course possible for pupils to increase the amount of time they spend studying per week via out-of-school learning. This information was also captured in the PISA 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. Table 10.2 presents the average amount of time pupils report spending on science, mathematics, English, foreign language and ‘other’ subject areas[79]. Analogous results for the median are provided in the online data tables.

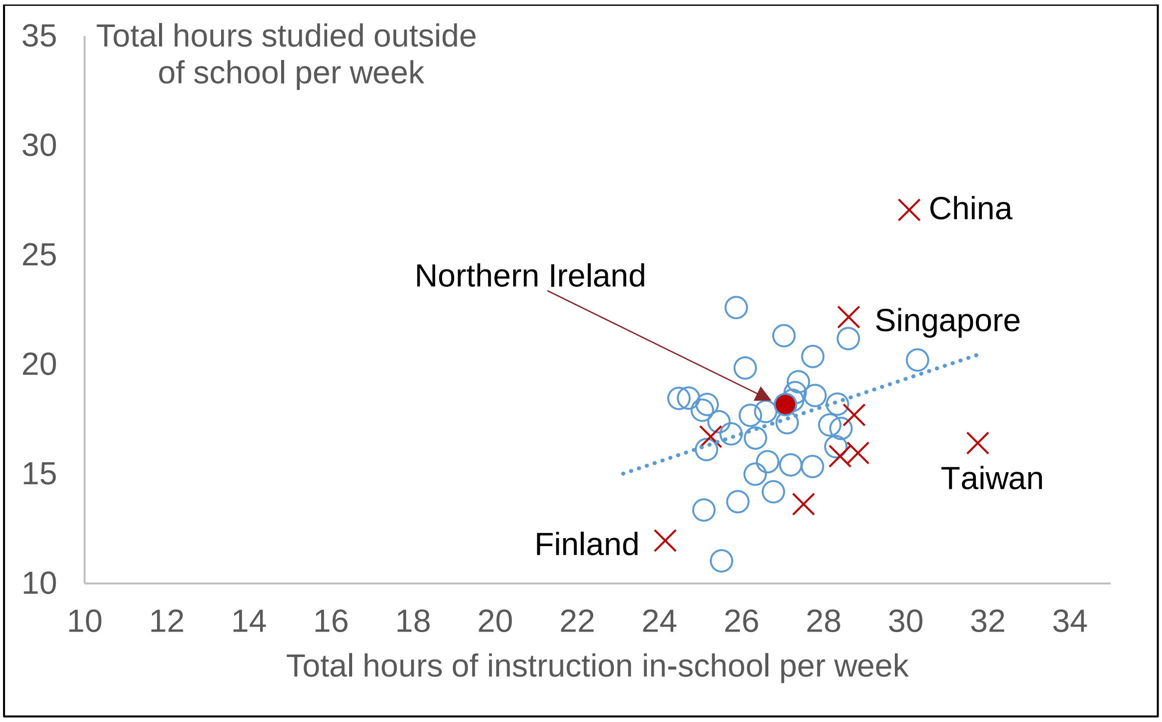
[79] Any pupil who reported spending more than 70 hours per week on additional study is treated as reporting an illogical value, and therefore excluded from this part of our analysis.

10. There are some key points of difference between the figures for Northern Ireland and the average across OECD / H10 countries. Specifically, the average number of additional learning hours is higher for Northern Ireland than the H10/OECD average in science (around 25-40 minutes higher per week) and in the 'other' category (over an hour higher per week). In contrast, less additional time in Northern Ireland is spent on learning foreign languages (approximately 80 minutes less per week). Therefore, although the total number of additional learning hours is similar for the average pupil in Northern Ireland and the average across H10 countries (approximately 18 hours), there are some differences in how this is distributed across the various subject areas.

11. Do pupils spend less time on additional study in countries with a longer school day? In other words, is there evidence of a substitution effect, whereby more hours in the school timetable is offset by less time spent on additional study? Figure 10.2 provides the answer by plotting the total timetabled hours per week for the average pupil (horizontal axis) against the total additional learning hours (vertical axis). The sample has been restricted to countries with an average PISA science score above 450 points, with the 10 countries with the highest average PISA science scores highlighted using a red cross.

12. All countries sit towards the bottom right hand corner of Figure 10.2. This indicates how, in every country, the average pupil spends more time studying in-school than they do on additional instruction outside of regular school hours. However, there is also substantial cross-national variation in these figures, including across the high-performing countries. At one extreme sits China, where the average pupil reports spending 30 hours per week studying in-school, accompanied by 27 hours of additional study. This is notably higher than the 27 hours (in-school) and 18 hours (additional instruction) in Northern Ireland. Weekly hours are, on the other hand, much lower in Finland, where the average 15-year-old spends 24 hours learning in-school and 12 hours on additional instruction. There are also some notable outliers, 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). When these facts are brought together, they highlight two important points for Northern Ireland: (a) the 18 hours of additional instruction time reported by the average 15-year-old in Northern Ireland does not stand out as particularly high or low relative to pupils in most other countries and (b) China and Singapore are the only high-performing countries where total additional study hours are reported to be much higher than in Northern Ireland.

Figure 10.2 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 points. Data not available for Malta and Vietnam. Red crosses refer to the 10 countries with the highest average PISA science score.

13. The other key conclusion to be drawn from Figure 10.2 is that there is little evidence of a trade-off between in-school and additional learning hours at the country level. In fact, the cross-country correlation is weakly positive (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. In additional analysis, we have investigated how the average number of additional hours of instruction varies by gender and socio-economic status. The results for Northern Ireland suggest that there are few gender differences in any subject area (including science), or for total hours overall. The same also holds true for socio-economic status, with the exception of time spent learning a foreign language; 15-year-olds from advantaged socio-economic backgrounds spend one hour more per week learning a foreign language out-of-school on average than their peers from disadvantaged backgrounds. Previous research in Northern Ireland also found that pupils of higher socio-economic status were more likely to study a foreign

language and that this may be driven by greater opportunity to travel abroad[80]. Nevertheless, the more general lack of an association between additional learning hours and socio-economic status is somewhat surprising, given that pupils were explicitly asked to include factors such as private tuition in their responses. However, we remind readers that this information has been gathered directly from pupils, and that there may be a certain amount of error in their responses.

Key point

15-year-olds in Northern Ireland spend 40 minutes longer studying science in-school per week than the average pupil across OECD members. The total amount of time 15-year-olds in Northern Ireland report spending on additional study is above the OECD and H10 average.

10.2 What activities take place in science classrooms in Northern Ireland? Is this similar to other countries?

15. The science curriculum in Northern Ireland is designed to help pupils 'develop skills in scientific methods of enquiry' and 'develop creative and critical thinking'[81]. Science teachers play 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 Northern Ireland? 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 Northern Ireland, allowing us to better understand the types of tasks that pupils complete.

16. Table 10.3 illustrates the extent to which a series of different practices and activities are used in science classrooms in Northern Ireland, and how this compares to other parts of the world. This includes the opportunities pupils have to explain their ideas, to design their own experiments, and the extent to which pupils believe that their teacher clearly explains the relevance of science concepts to their lives. All figures refer to the proportion of 15-year-olds who stated that the activity or practice happens in 'every' or in 'most' science lessons (as opposed to in 'some' or 'never').

17. There are some important similarities between Northern Ireland and the average across OECD countries. First, pupils in Northern Ireland (65 per cent)

[80] Wright (1999)
[81] Stewart (2014: 6)

typically report being given the same opportunities to explain their ideas in science lessons as pupils across the OECD (69 per cent). Similar findings emerge for the statements regarding the opportunity to draw conclusions from an experiment (44 per cent in Northern Ireland versus an OECD average of 42 per cent), teachers explaining how an idea from science can be applied to a range of phenomena (58 per cent versus 59 per cent), and whether pupils are asked to conduct investigations to test an idea (28 per cent versus 26 per cent). It therefore seems that pupils in Northern Ireland have similar experiences of linking data to theory and drawing conclusions as in classrooms across the OECD, at least in these particular ways.

Table 10.3 Percentage of pupils who report the use of different activities and teaching practices within school science classes

	Northern Ireland	OECD	H10
Pupils are given opportunities to explain their ideas	65%	**69%***	63%
Pupils spend time in the laboratory doing practical experiments	16%	**21%***	17%
Pupils are required to argue about science questions	14%	**30%***	**21%***
Pupils are asked to draw conclusions from an experiment they have conducted	44%	**42%***	**35%***
The teacher explains how a school science idea can be applied to a number of different phenomena	58%	59%	**53%***
Pupils are allowed to design their own experiments	7%	**16%***	**13%***
There is a class debate about investigations	13%	**26%***	**17%***
The teacher clearly explains the relevance of broad science concepts to our lives	50%	50%	**47%***
Pupils are asked to do an investigation to test ideas	28%	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. Bold font and * denotes statistically different from Northern Ireland at the five per cent significance level.

18. There are also some pronounced differences between science classrooms in Northern Ireland and the average across members of the OECD. This includes pupils in Northern Ireland being less likely to argue about science questions (14 per cent in Northern Ireland versus 30 per cent OECD average) and less likely to debate about science investigations (13 per cent versus 26 per cent). Both of these activities involve applying reasoning to scientific fact and constructing arguments. This therefore suggests that there may be less of an atmosphere of debate in Northern Ireland’s science classrooms relative to the average across OECD countries, even though pupils in Northern Ireland generally report having regular opportunities to explain their ideas. It also seems that pupils in Northern Ireland are not afforded the same level of autonomy as the average across OECD and H10 countries.

19. In additional analysis, we have also investigated whether there is variation in pupils' experiences of learning science in the classroom by school type. Grammar school pupils report being more likely to draw conclusions from experiments they conduct (50 per cent) than non-grammar school pupils (40 per cent), but were less likely to argue about science questions (10 per cent for grammar school pupils and 18 per cent for non-grammar school pupils) and engage in class debates (8 per cent and 18 per cent respectively). Together, this suggests that pupils in grammar schools may have greater opportunity to link data to theory, but are less likely to articulate this verbally in a formal discussion.

Key point

Pupils in Northern Ireland are not afforded the same level of autonomy in their science classes as the average across OECD and H10 countries, and spend less time constructing arguments and engaging in debates.

10.3 Is low-level disruption in science classrooms a more common occurrence in Northern Ireland than in other countries?

20. Low-level disruption is reported by 79 per cent of members of the Association of Teachers and Lecturers to be a problem they face in the classroom[82]. This includes teachers in Northern Ireland. Being aware of low-level disruption is important as the school learning environment is linked to pupils' attainment, with evidence suggesting that interventions which aim to improve pupil behaviour can also lead to increases in academic achievement[83]. The PISA background questionnaire allows us to consider the frequency that low-level disruption occurs in school science lessons in Northern Ireland, and how this compares to other countries.

[82] ATL (2013)
[83] EEF (2016)

Table 10.4 Percentage of pupils who report low-level disruption occurring frequently during their school science classes

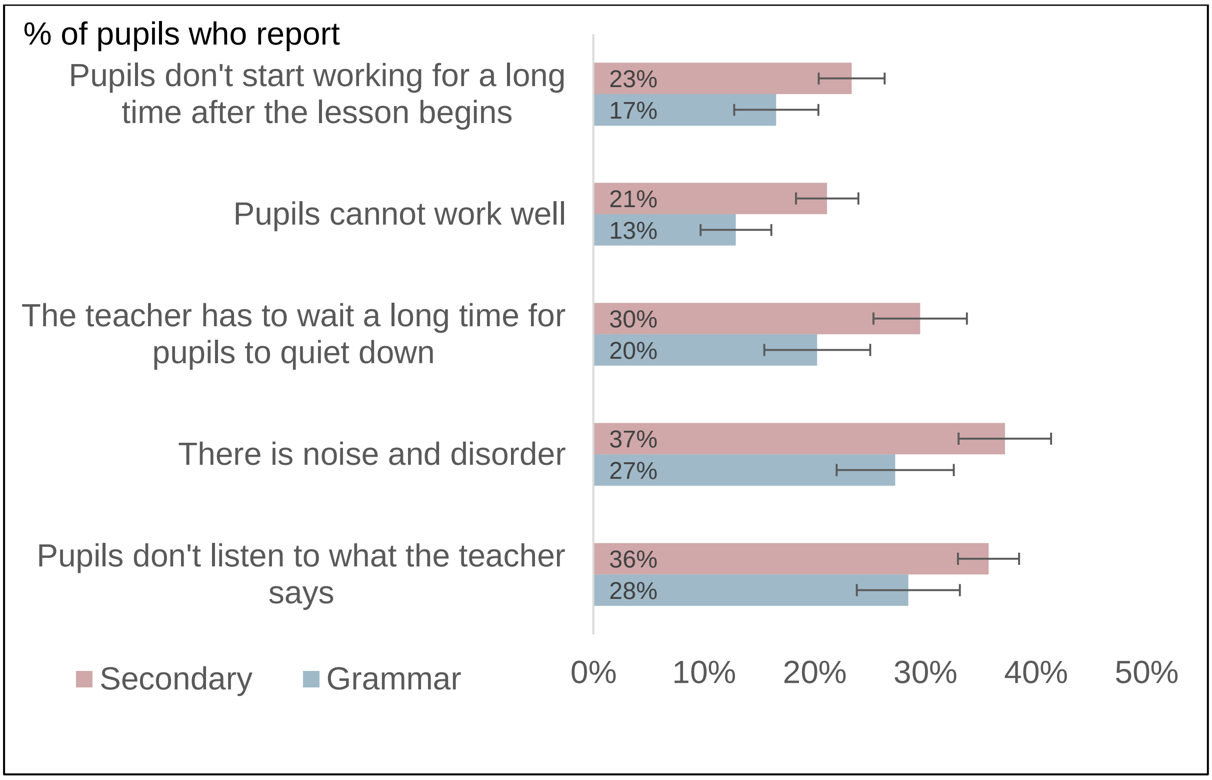
	Northern Ireland	OECD	H10
Pupils don't listen to what the teacher says	32%	32%	**21%***
There is noise and disorder	32%	33%	**22%***
The teacher has to wait a long time for pupils to quiet down	25%	**29%***	**18%***
Pupils cannot work well	17%	**22%***	15%
Pupils don't start working for a long time after the lesson begins	20%	**26%***	**17%***

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. Bold font and * denotes statistically different from Northern Ireland at the five per cent significance level.

21. The results in Table 10.4 indicate that low-level disruption is a problem in most or in every science lesson for approximately 30 per cent of pupils. The amount of low-level disruption faced by pupils in Northern Ireland is similar to that of their peers in the average OECD country. However, pupils in Northern Ireland are more likely to regularly experience noise and disorder (32 per cent) and pupils not listening to the teacher (32 per cent) during than science classes than pupils in the top performing PISA countries (22 per cent and 21 per cent respectively for each category). This is a difference of at least 10 percentage points, though there is variation even within the H10 countries. For instance, issues such as ‘noise and disorder’ in the science classroom are 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). Consequently, although low-level disruption in science classrooms stands out as a key difference between Northern Ireland and the high-performing East Asian countries, pupils in Northern Ireland experience similar amounts of low-level disruption to other industrialised nations (including some of those with the highest average PISA science scores).

Figure 10.3 Percentage of pupils who report low-level disruption in the science classroom by school type

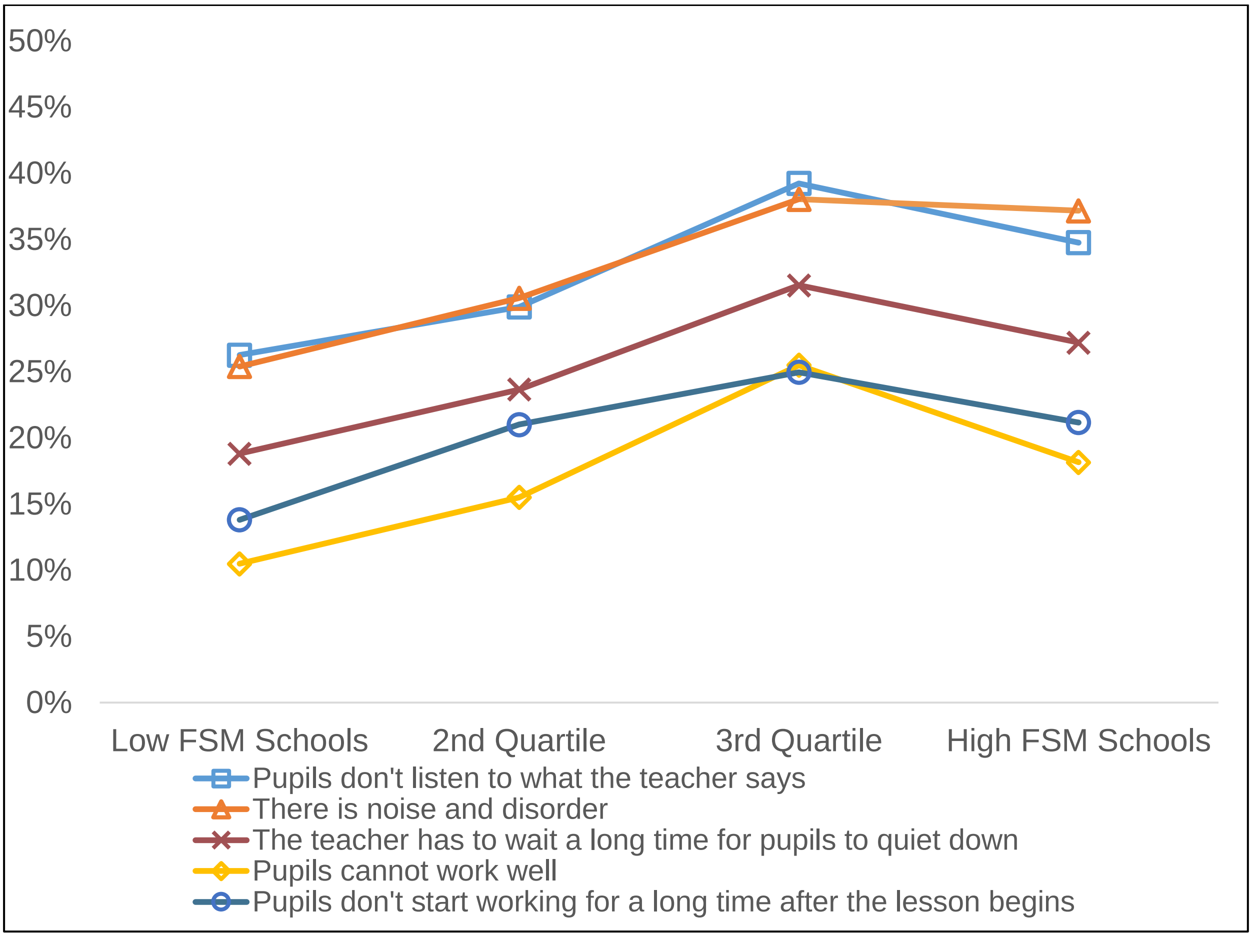


Source: PISA 2015 database

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

22. Figure 10.3 turns to variation in pupils' responses within Northern Ireland, depending upon the type of school they attend. For all five statements, pupils who attend a grammar school were less likely to report low-level disruption as a problem in their science class than pupils who attend a non-grammar school. In fact, the values reported by grammar school pupils to the first three statements in Figure 10.3 are much more similar to the values reported by pupils from the H10 countries in Table 10.4. For instance, 13 per cent of pupils at grammar schools reported that pupils cannot work well in all or in most science lessons, compared to approximately 20 per cent of pupils in non-grammar schools. One-in-five pupils at grammar schools reports that their teacher has to wait for pupils to quiet down compared to 30 per cent of pupils at non-grammar schools. There is also less noise and disorder in grammar school science lessons (27 per cent) as compared to non-grammar schools (37 per cent). Together this indicates that non-grammar school pupils may be losing out on learning time in science due to low-level disruption compared to their peers in grammar schools.

Figure 10.4 Percentage of pupils who report low-level disruption in the science classroom by school FSM quartile



Source: PISA 2015 database

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

23. How big of a problem is low-level disruption in science classrooms at high and low FSM schools? The results in Figure 10.4 show moderate differences, with high FSM schools experiencing more low-level disruption during science lessons. For every statement, the difference between schools in the top and bottom quartile is nearly 10 percentage points, as illustrated by the upward sloping lines. Pupils in schools with a large share of low-income pupils, as indicated by the level of FSM eligibility, therefore face further disadvantage as a result of lost learning time in science caused by low-level disruption.

Key point

Low-level disruption is a problem similar in Northern Ireland's science classrooms as to other OECD countries, but more so than the average across the H10 countries. Within Northern Ireland, low-level disruption is a particular challenge facing post-primary schools with a high proportion of FSM pupils.

10.4 How do pupils in Northern Ireland perceive the feedback they receive from their science teachers?

24. 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[84]. How do pupils in Northern Ireland perceive the amount of feedback they receive from their science teachers? Moreover, is there any evidence that the type and regularity of feedback science teachers provide differs between higher and lower achieving pupils? How does Northern Ireland compare to other countries in terms of pupils' perceptions of the feedback they receive from their science teachers?

Table 10.5 Percentage of pupils who receive regular feedback from their teachers

	Northern Ireland	OECD	H10
The teacher tells me how I am performing in this course	31%	**28%***	**26%***
The teacher gives me feedback on my strengths in this school science subject	31%	**25%***	**26%***
The teacher tells me in which areas I can still improve	36%	**30%***	**30%***
The teacher tells me how I can improve my performance	34%	32%	35%
The teacher advises me on how to reach my learning goals	35%	**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 and * denotes statistically different from Northern Ireland at the five per cent significance level.

25. Table 10.5 starts to answer some of these questions by illustrating the percentage of pupils who report that they are given various different types of

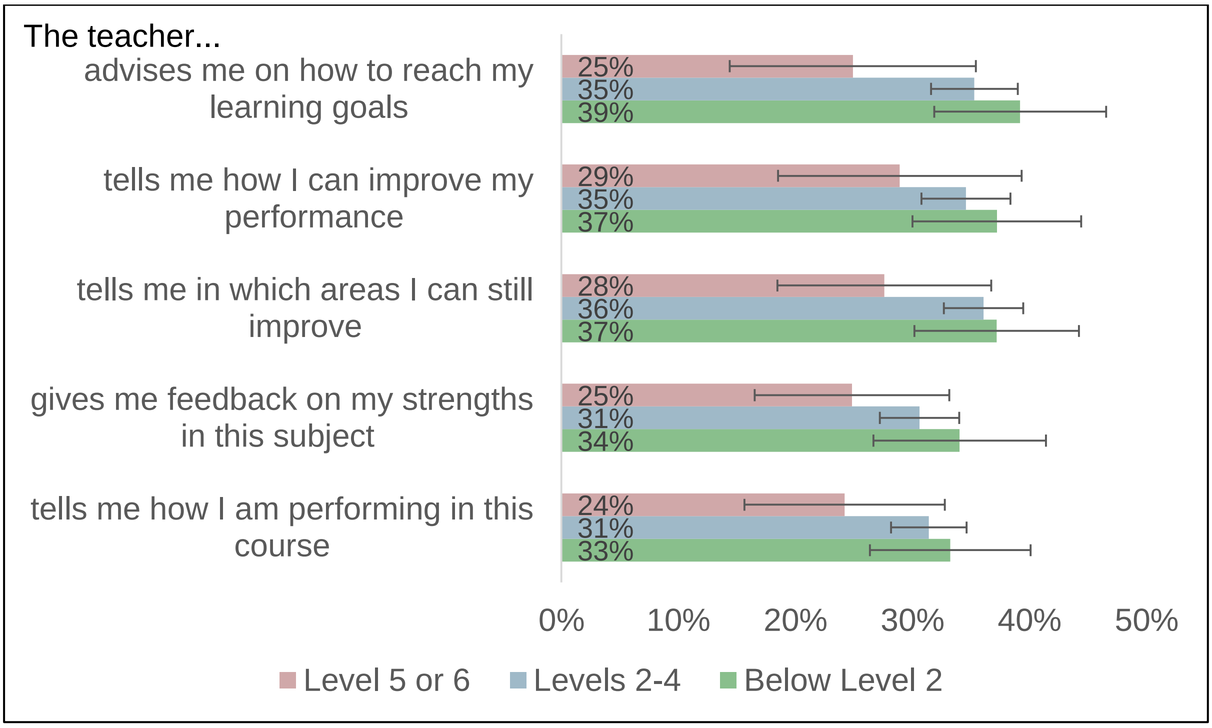
[84] See Airasian (2000) for an overview of the literature on assessment, feedback and pupil performance.

feedback in ‘every’ or in ‘most’ science lessons (as opposed to in ‘some lessons’ or ‘never’). For each of the five statements, around one third of pupils in Northern Ireland report receiving regular feedback. For the second and third statements, the OECD and H10 averages are approximately five percentage points below the value for Northern Ireland. For instance, pupils in Northern Ireland are more likely to say that their science teacher gives them feedback on their areas of strength (31 per cent versus 25 per cent) and upon aspects that they might improve (36 per cent versus 30 per cent).

26. Although the figures for Northern Ireland are generally similar to the H10 average, there are some interesting points of difference when one considers specific countries. For instance, pupils in Canada (36 per cent) report a similar frequency of feedback on strengths to pupils in Northern Ireland (31 per cent), while the proportion was much lower in Finland (17 per cent) and Japan (10 per cent). Nevertheless, the overall conclusion we draw from Table 10.5 is that pupils in Northern Ireland report receiving broadly similar amounts of regular feedback from their science teachers as their peers in many other industrialised and high-performing countries.

27. Do pupils’ perceptions of the feedback they receive from their science teacher differ by gender? Boys in Northern Ireland are six to eight percentage points more likely than girls to report that they receive each type of feedback, with these differences statistically significant at the five per cent level. The same pattern also emerges for the average across OECD members and the average across high-performing countries. This finding could be driven by (a) boys perceiving the level of feedback they receive to be more frequent and/or (b) actual differences in how regularly science teachers provide feedback to girls or boys. Unfortunately, the data available within the PISA background questionnaire are not sufficiently detailed to allow us to disentangle these two potential explanations.

Figure 10.5 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 in Northern Ireland schools who reported receiving the feedback in many or in every science lesson. 'Level' refers to PISA science proficiency level. Thin black line through centre of each bar refers to the estimated 95 per cent confidence interval.

28. Are pupils with low-level science skills the individuals who receive the most input from their teachers on how they might improve? Or do teachers tend to provide more feedback to average or higher performing pupils? Figure 10.5 provides the results, with pupils divided into three groups: low-achievers (below Level 2), average pupils (Level 2 to Level 4) and top-performers (Level 5 and 6). For all five statements, a greater proportion of low-achievers reported receiving more feedback from their science teacher than top-performers. However, due to the limited sample size within each group, differences between the low-achievers and top-performers are statistically significant for only one statement: *'the teacher advises me on how to reach my learning goals'* (25 per cent for high achievers versus 39 per cent for low-performers). Nevertheless, Figure 10.5 provides some indication that science teachers in Northern Ireland may be more likely to give feedback to lower performing pupils, especially in helping them to understand what they need to do in order to reach their future learning goals.

Key point

Around a third of 15-year-olds in Northern Ireland report receiving feedback from their science teacher in most or in every lesson. This is similar to the average across OECD members and the average across the top-performing PISA countries. Within Northern Ireland, there is some suggestion that low-achieving pupils receive more regular feedback from their science teacher than their high-performing peers.

10.5 Do pupils in Northern Ireland feel that they receive regular support from their teachers during their science classes?

29. 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'[85]. 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 pupils in Northern Ireland interact with their science teachers. This includes whether pupils in Northern Ireland believe that their science teacher is supportive, and is able to adapt their lesson to meet the needs of those that they teach.

Table 10.6 The extent to which teachers use different classroom practices

	Northern Ireland	OECD	H10
The teacher explains scientific ideas	60%	**55%***	59%
A whole class discussion takes place with the teacher	33%	**40%***	**41%***
The teacher discusses our questions	59%	**55%***	**54%***
The teacher demonstrates an idea	56%	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. Bold font and * denotes statistically different from Northern Ireland at the five per cent significance level.

[85] See Hanushek and Rivkin (2010) for further discussion on the teacher value-added literature and existing evidence.

30. Table 10.6 begins by exploring the extent to which a series of classroom practices (for example, whether a whole class discussion takes place) are used in ‘every’ or in ‘most’ science lessons. These classroom practices are used to support learning and focus on explanation, demonstration and discussion. Around three-in-five pupils in Northern Ireland report that their science teacher regularly explains scientific ideas (60 per cent), demonstrates an idea (56 per cent) and discusses pupils’ questions (59 per cent). On the other hand, whole class discussions occur somewhat less frequently; one third of pupils in Northern Ireland report that they take place in most or every lesson. This result is consistent with pupils’ reports of infrequent classroom debates (see sub-section 10.2).

31. There are relatively few substantial points of difference between the results for Northern Ireland and the OECD and H10 averages. One exception is that 33 per cent of pupils in Northern Ireland report whole classroom discussion regularly taking place, compared to an H10 average of 41 per cent (and an OECD average of 40 per cent). The difference between Northern Ireland and the high-performing Western countries in response to this statement is particularly striking, with a greater proportion of pupils in Canada (51 per cent), Estonia (49 per cent) and Finland (46 per cent) reporting regular whole classroom discussions than in Northern Ireland (33 per cent). Nevertheless, on the whole, pupils’ perception of their teacher’s use of supportive classroom practices is similar in Northern Ireland to the situation in many other countries.

32. Table 10.7 presents further evidence on pupils’ perception of whether their science teacher is supportive. Here pupils were asked to state how often their teacher engages in supportive classroom practices, including providing help, showing interest and making sure all pupils understand the subject matter. Again, there is little substantial difference between Northern Ireland and the OECD and H10 averages. One notable exception is that pupils in Northern Ireland are around 10 percentage points more likely to say that their science teacher *‘helps pupils with their learning’* than in the average OECD country (82 per cent versus 71 per cent). Despite this exception, the overall indication from Table 10.7 is that Northern Ireland does not typically stand out from the average OECD or average high-performing country in the amount of support science teachers provide to their pupils.

Table 10.7 Percentage of pupils who perceive their teachers as supportive

	Northern Ireland	OECD	H10
The teacher shows an interest in every pupil's learning	75%	**69%***	**72%***
The teacher gives extra help when pupils need it	79%	**73%***	79%
The teacher helps pupils with their learning	82%	**71%***	**80%***
The teacher continues teaching until the pupils understand	74%	**69%***	72%
The teacher gives pupils an opportunity to express opinions	62%	**68%***	**72%***

Source: PISA 2015 database

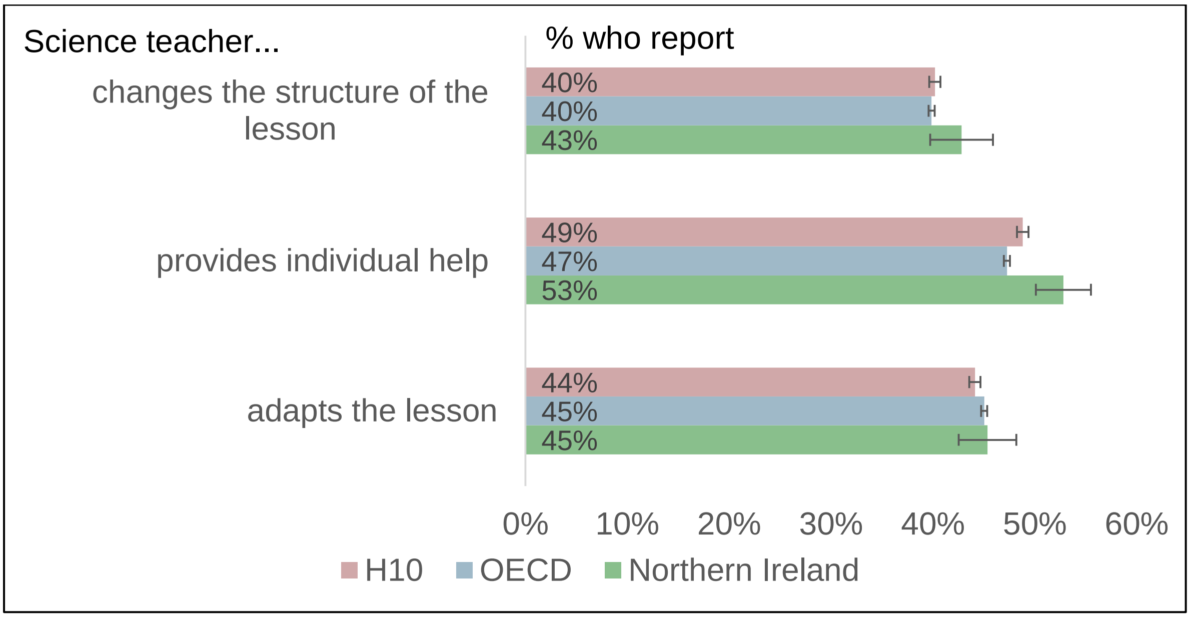
Notes: Figures refer to the percentage of pupils in schools who say this happens in 'every' or in 'most' of their science lessons. Bold font and * denotes statistically different from Northern Ireland at the five per cent significance level.

33. In order to better support their pupils, teachers may adapt their approach in the classroom depending upon the needs of those that they teach. Within the background questionnaire, pupils were asked whether they felt their science 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

34. Figure 10.6 indicates that pupils in Northern Ireland are no more likely to report that their science teacher adapts their lessons depending upon pupils' needs than the average across OECD and H10 countries. The largest difference is for the second statement, with science teachers in Northern Ireland being more likely to provide individual help (53 per cent in Northern Ireland versus an H10 average of 49 per cent and OECD average of 47 per cent). This is a relatively small difference in terms of magnitude, but corresponds with the perceptions presented in Table 10.7 on teachers providing extra individual help.

Figure 10.6 Pupils' perception of whether their science teacher adapts their lessons to pupils' needs



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

35. Although boys are more likely to report getting feedback from their teachers than girls (see sub-section 10.4) we find no evidence of gender differences in pupils' perceptions of their teacher's ability to adapt. Likewise, there is little variation in pupils' responses to the statements given above whether they attend high or low FSM schools, or between grammar and non-grammar schools. There are, however, some striking differences according to pupils' PISA science proficiency level. Around 61 per cent of top performing pupils (scoring at Level 5 or 6) report that their science teacher provides individual help during most lessons. This is nearly 20 percentage points higher than pupils who obtain PISA test scores below Level 2 (43 per cent). However, this finding is not unique to Northern Ireland; a similar difference also arises across other Western countries, including England (46 per cent of low proficiency pupils versus 67 per cent of high proficiency pupils) and the Republic of Ireland (44 per cent versus 57 per cent), for example. Northern Ireland pupils who lack basic science skills are also much less likely to agree that their science teacher '*adapts the lesson to [their] class's needs and knowledge'* (36 per cent) relative to pupils with high level skills (56 per cent).

36. In Northern Ireland, there is a much smaller difference in pupils' views of how willing their science teacher is to change the structure of the lesson on a challenging topic (46 per cent for high proficiency pupils versus 38 per cent for low proficiency pupils). This smaller difference is driven by fewer top-performers reporting their teachers as willing to change the structure of the lesson as compared to the other statements on adaptation in the classroom. In high achieving Western countries, pupils with the lowest levels of science proficiency are also less likely to report that their teachers change the structure of the lesson for difficult topics (for example, Finland with 35 per cent for low-achieving pupils and 47 per cent for high achieving pupils and Canada with 45 per cent and 53 per cent). Taken together, these results may indicate that low-achieving pupils in Northern Ireland feel left behind during some of their science lessons, and do not perceive their science teachers as able to adapt to their needs.

Key point

Pupils in Northern Ireland generally perceive their science teachers to be supportive. However, lower achieving pupils believe that their science teacher is less willing to provide individual support and adapt their lessons than their high achieving peers.

Chapter 11. PISA in the UK

The average PISA science score is highest in England (512) and lowest in Wales (485). Scotland (497) and Northern Ireland (500) fall in-between.

Differences in average PISA mathematics scores between England (493), Northern Ireland (493) and Scotland (491) are not statistically significant. On the other hand, the average PISA mathematics score is significantly lower in Wales (478) than the rest of the UK.

There is no statistically significant difference in average PISA reading scores across England (500), Northern Ireland (497) and Scotland (493). However, the mean reading score is significantly lower in Wales (477) than the rest of the UK.

There has been a sustained decline in average PISA science scores in Wales, from 505 points in 2006 to 485 points in 2015.

Since 2006, the science skills of the highest achieving pupils in Northern Ireland, Scotland and Wales have steadily declined.

Around one-in-four pupils in the UK lacks basic skills in mathematics. Moreover, around one-in-five lack basic skills in science and reading.

Principals' views on the factors hindering instruction within their school are generally similar across the UK. However, teachers not meeting individual pupils' needs is significantly less of a concern in Northern Ireland than in other parts of the UK, while teacher absenteeism stands out as a particular concern amongst principals in Northern Ireland.

Across the UK, 15-year-olds spend more time studying science than English and mathematics. Scottish, Welsh and Northern Ireland pupils report spending over an hour more time studying outside of school per week (on average) than their English peers.

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, through its annual publication of school 'league tables'. Other more recent policy developments, such as the academies programme, are specific to England and have not been introduced elsewhere. These are just a selection 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. There are, for instance, 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[86]. PISA is an important exception. By drawing separate samples for England, Northern Ireland, Scotland and Wales, PISA provides a three-yearly update of how academic achievement, pupils' attitudes and principals' concerns vary across different parts of the UK.

4. In this concluding chapter, we therefore focus upon differences in PISA test scores and background questionnaire responses across these four countries. The following research questions will be addressed:

- *How do average PISA test scores compare across the UK?*
- *What proportion of 15-year-olds in the UK do not have basic science, mathematics and reading skills?*
- *How have average PISA scores changed across the UK since 2006?*

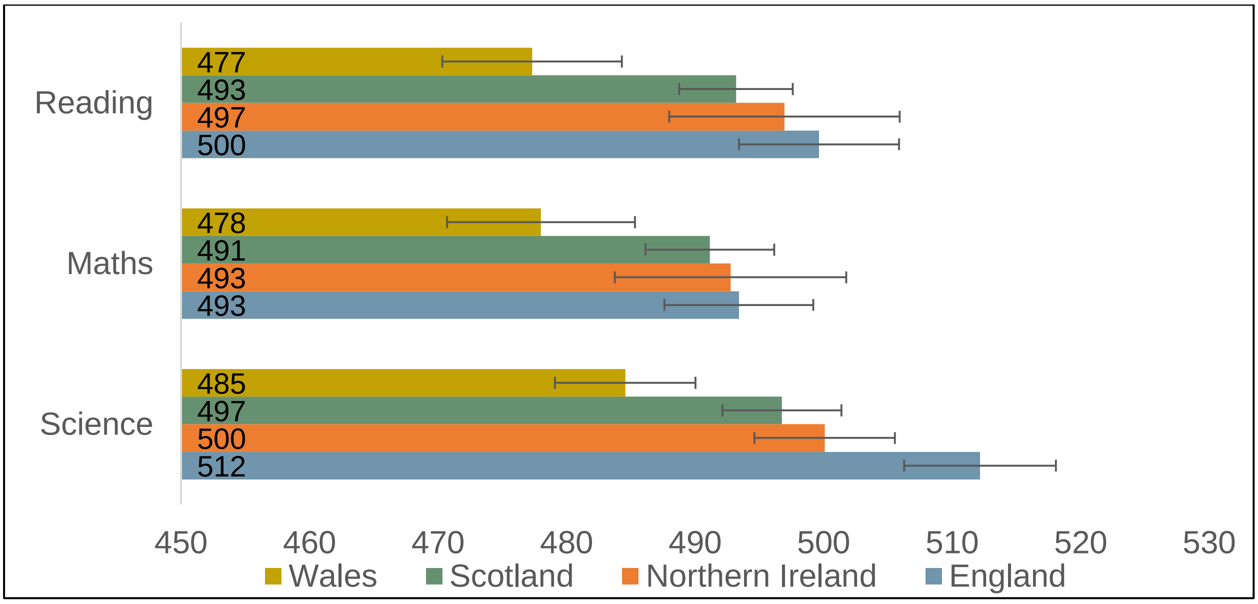
[86] Though see Taylor, Rees and Davies (2013).

- *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 principals' 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 PISA test scores compare across the UK?

5. Do 15-year-olds in certain parts of the UK achieve higher average PISA science scores than others? The answer can be found in Figure 11.1. Average science scores are highest in England (512) and lowest in Wales (485). These two countries are significantly different to both Northern Ireland (500) and Scotland (497) at the five per cent level. There is hence a clear hierarchy across the UK, with the strongest average science performance in England, the weakest in Wales, with Northern Ireland and Scotland sitting in-between.

Figure 11.1 Average PISA test scores across the UK



Source: PISA 2015 database.

Note: Thin black line running through centre of bars refers to the estimated 95 per cent confidence interval.

6. There is less variation in average scores across the UK in the PISA mathematics domain (see the middle set of bars in Figure 11.1). For instance, England (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. In contrast, the average mathematics score in Wales is 478. This 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 just under 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. Finally, the uppermost set of bars in Figure 11.1 shows average PISA reading scores. There is little evidence of variation across England (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 PISA test 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. As science was the focus of PISA 2015, we are also able to consider how achievement in this subject varies across the science sub-domains. For instance, are the comparatively high science scores of English pupils driven by a particular strength in one specific aspect of scientific literacy? Or do English pupils achieve higher science test scores than the rest of the UK across the board? Table 11.1 provides the results. In this table, darker shading refers to greater distances from the average score in England.

9. 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.

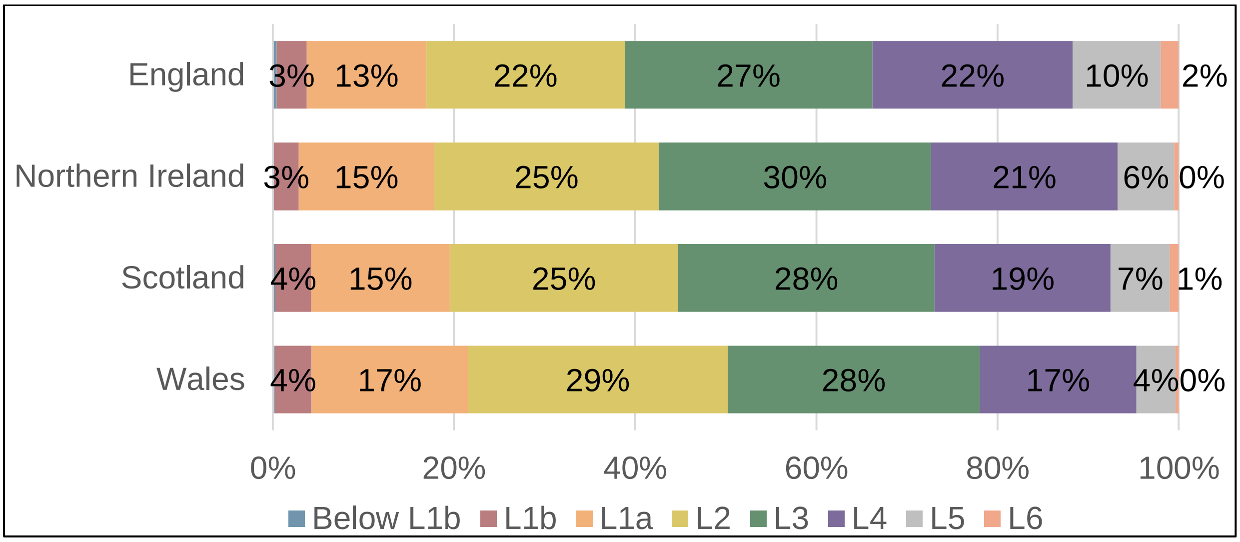
Key point

The average PISA 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 What proportion of 15-year-olds across the UK do not have basic science, mathematics and reading skills?

10. Although average PISA test scores may be similar across most of the UK, does the same hold true for the distribution of 15-year-olds across the PISA proficiency levels? In particular, do certain parts of the UK have a greater proportion of 'low-achievers'; 15-year-olds who have not reached the OECD's baseline level of achievement? Figure 11.2 provides the answer for science. Wales has the greatest proportion of 15-year-olds performing below Level 2 (22 per cent), followed by Scotland (20 per cent), Northern Ireland (18 per cent) and England (17 per cent). Together this means that around one-in-five young people from across the United Kingdom do not have basic science skills. In terms of 'top-performers', England has the greatest proportion of young people working at PISA Levels 5 and 6 (12 per cent), compared to eight per cent in Scotland, seven per cent in Northern Ireland and five per cent in Wales.

Figure 11.2 The percentage of UK pupils reaching each PISA science level

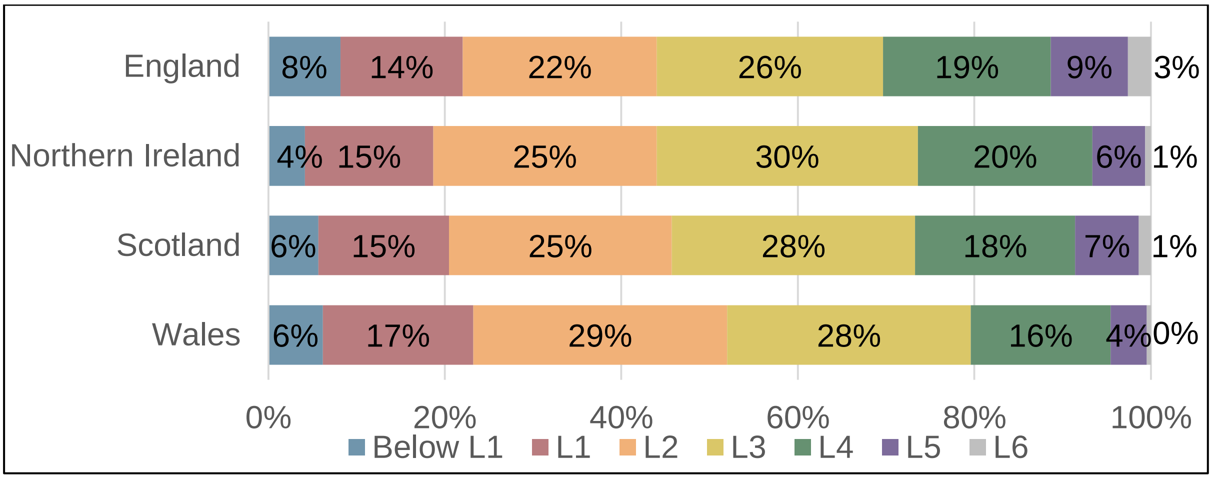


Source: PISA 2015 database.

11. Analogous results for PISA mathematics are provided in Figure 11.3. Within the UK, 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). Consequently, across the United Kingdom as a whole, between a fifth and a quarter of 15-year-olds do not have basic proficiency in mathematics.

12. At the other extreme, Wales also has fewer 15-year-olds reaching the highest mathematics proficiency levels than the rest of the UK. Specifically, just five per cent of Welsh pupils obtain a PISA mathematics score at Level 5 or 6, compared to 11 per cent of pupils in England, nine per cent in Scotland and seven per cent in Northern Ireland. Overall, around one in 10 pupils across the UK is a ‘top-performer’ in mathematics.

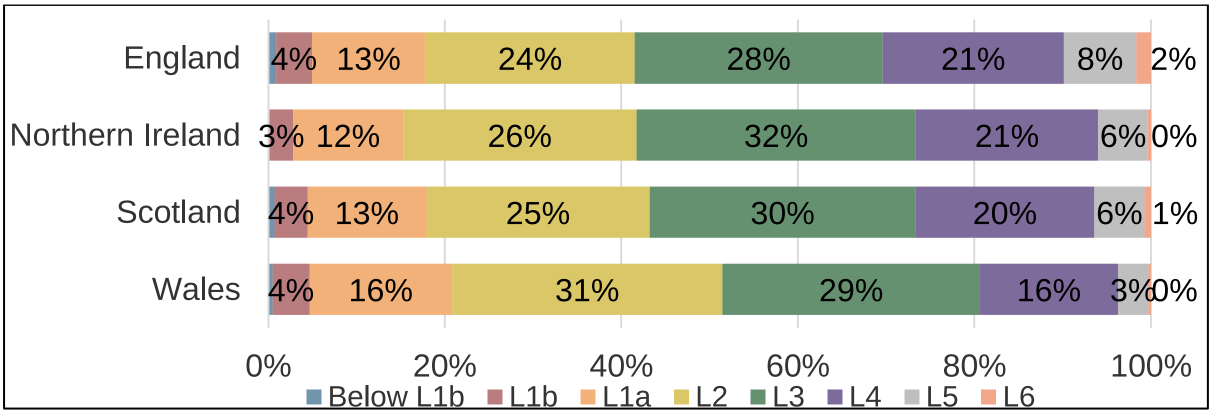
Figure 11.3 The percentage of UK pupils reaching each PISA mathematics level



Source: PISA 2015 database.

13. Finally, Figure 11.4 presents results for the distribution of PISA reading scores. The most notable difference is that 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 who lack basic 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.

Figure 11.4 The percentage of UK pupils reaching each PISA reading level



Source: PISA 2015 database.

Key point

Almost 30 per cent of pupils in the UK lack basic skills in at least one PISA subject area (science, mathematics and reading). One-in-ten pupils in the UK lack basic skills in all three domains.

11.3 How have average PISA scores changed across the UK since 2006?

14. Chapters 2, 4 and 5 of this report illustrated how average PISA scores in Northern Ireland have changed since 2006. Table 11.2 demonstrates how this compares to the trend observed across the rest of the UK. Two particular issues stand out.

15. There is evidence of a sustained decline in average scores during the 2006 to 2015 period for Wales in the science domain (see Table 11.4). In this country, the average science score has gradually fallen from 505 points in 2006 to 485 points in 2015. This represents a fall of 20 test points (roughly equivalent to half a year of schooling) and is statistically significant at the five per cent level. There is also evidence of a fall in mathematics scores in Scotland since 2006, with the mean falling from 506 in 2006 to 499 in 2009, 498 in 2012 and 491 in 2015. The three-year average trend in Scotland is therefore downwards, and statistically significant at the five per cent level. For Northern Ireland, the evidence, as provided by PISA, indicates that between 2006 and 2015 the performance of pupils in the academic domains of reading, science and mathematics has remained at a similar level.

Table 11.2 Average PISA scores across the UK from 2006 to 2015

		2006	2009	2012	2015
Science	England	516	515	516	512
	Northern Ireland	508	511	507	500
	Scotland	515	514	513	497
	Wales	505	496	491	485
Mathematics	England	495	493	495	493
	Northern Ireland	494	492	487	493
	Scotland	506	499	498	491
	Wales	484	472	468	478
Reading	England	496	495	500	500
	Northern Ireland	495	499	498	497
	Scotland	499	500	506	493
	Wales	481	476	480	477

Source: PISA 2006 to 2015 databases.

Note: See Appendix F for further information on trends in performance over time

16. The second notable feature of Table 11.2 is that there has 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 16 test points (around

half a year of schooling) in 2015. Although this is a sizeable difference compared to the last time science was the focus of PISA in 2006, some caution is needed when interpreting this result. 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 the Republic of Ireland dropped sharply between 2006 and 2009 before returning to their previous level in 2012[87]). Evidence from the next round of PISA, due to be conducted in 2018, is therefore needed to provide appropriate context for this result.

Key point

There has been a sustained decline in average PISA science scores in Wales during the last decade. In Northern Ireland average PISA scores across all domains showed no statistically significant change over the period 2006 - 2015.

11.4 How has the performance of the highest and lowest achieving pupils changed across the UK since 2006?

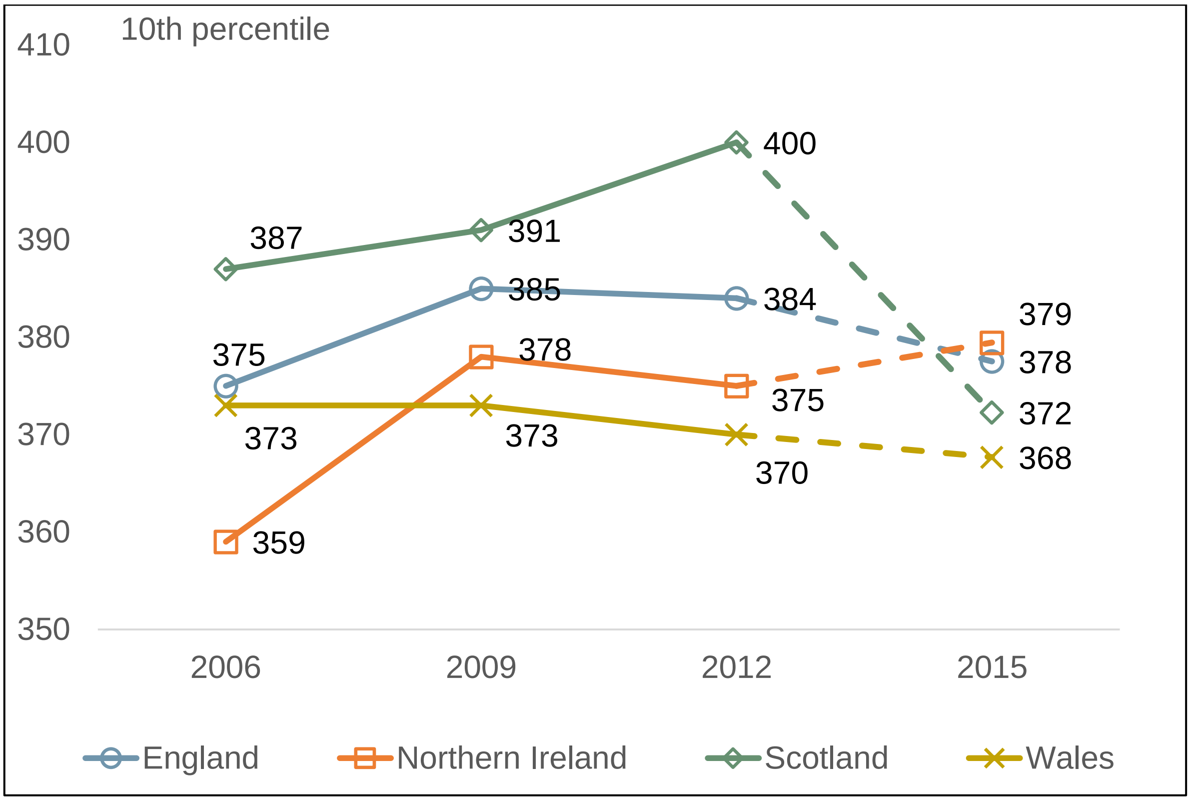
17. The previous sub-section illustrated the change in *average* PISA scores across the UK over the last decade. Now we turn our attention to changes in the *distribution* of achievement over time, paying particular attention to the performance of the highest and lowest achieving pupils. For brevity, our discussion focuses upon science, with analogous results for reading and mathematics provided in the online data tables.

18. Figure 11.5 begins by illustrating how the 10th percentile of the PISA science distribution has changed between 2006 and 2015. These results therefore refer to the science proficiency of the lowest achieving pupils. There are few clear consistent trends emerging for any part of the UK. Northern Ireland saw a 19 point (half a year of schooling) increase in the 10th percentile between 2006 and 2009, though this has remained at the same level ever since. Scotland, on the other hand, saw the 10th percentile improve from 387 in 2006 to 400 in 2012, before a marked decline to 372 in 2015 (a difference compared to 2012 of almost three quarters of a year of schooling). Similarly, the performance of the lowest science achievers in Wales remained stable from 2006 to 2012 at around 370 PISA test points, with a slight

[87] See Cosgrove and Cartwright (2014) for a detailed discussion of the experience of Ireland in 2009.

(statistically insignificant) decline to 368 points in 2015. Meanwhile, the 10th percentile in England has remained broadly around the same level throughout this period. Overall, there appears to have been some sharp one-off movements in the 10th percentile in certain parts of the UK, though little consistent evidence of a sustained upwards or downwards trend.

Figure 11.5 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.

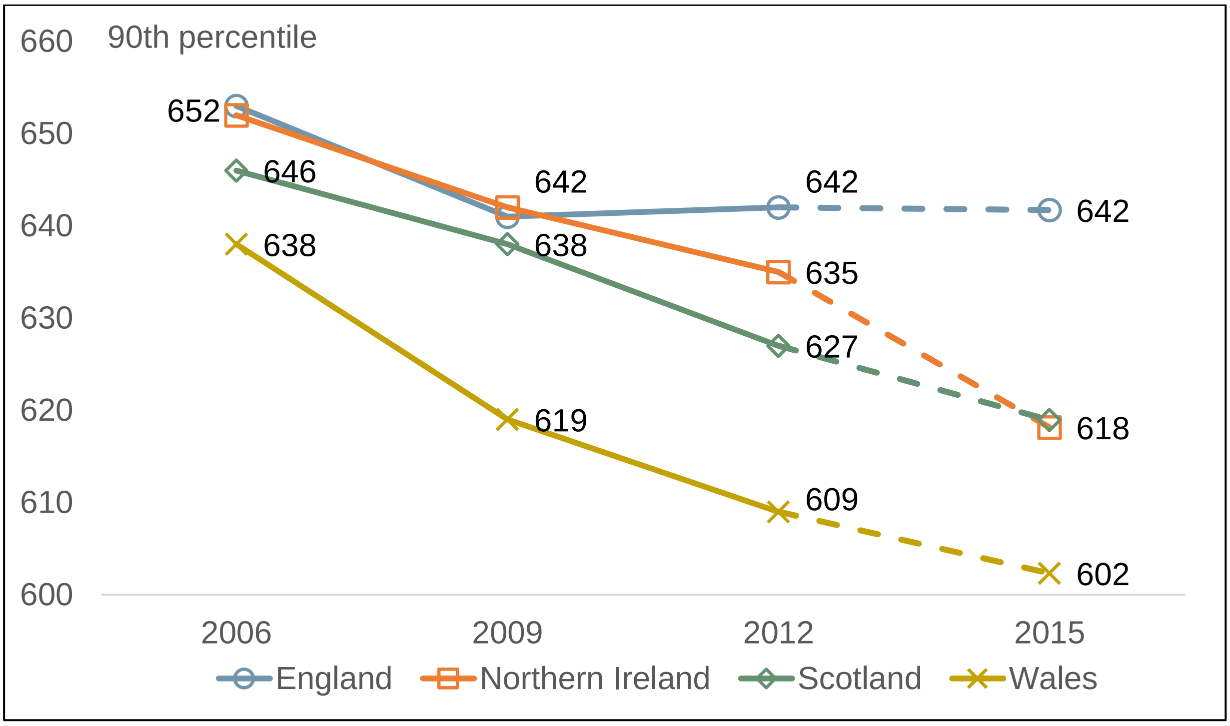
Note: Dashed line refers to the introduction of computer based testing in 2015. See Appendix F for further information on trends in performance over time

19. However, the same is not true for change in the 90th percentile of the science achievement distribution, as illustrated in Figure 11.6. In Northern Ireland, Scotland and Wales there is evidence of a sustained decline in performance amongst the highest science achievers. 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). Consequently, in these three countries, the highest achieving pupils in science in 2015 are around one year of schooling behind the highest achieving pupils who took

the PISA test in 2006. Interestingly, the same is not true in England, where there is little evidence of sustained change in the 90th percentile of science achievement over the last decade.

20. A couple of additional implications of Figure 11.5 and 11.6 are also worth highlighting. First, there has been a reduction in inequality of science achievement (as measured by the difference between the 90th and 10th percentile) within certain parts of the UK over the last decade. For instance, 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. Second, 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 90th percentile of the science distribtuion declined by eight points between 2012 and 2015, the 10th percentile dropped by around 28 test points. Hence it seems that certain parts of the science achievement distribution in Scotland have changed more in this short period of time than others.

Figure 11.6 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.

Note: Dashed line refers to the introduction of computer based testing in 2015. See Appendix F for further information on trends in performance over time

Key point

The science skills of the highest achieving pupils have 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?

21. Chapter 6 discussed the gender gap in 15-year-olds' PISA scores, and considered how Northern Ireland compares to the rest of the world in this respect. In this sub-section, we bring gender differences across the UK into sharper focus. This will provide an insight into whether differences in achievement between the four constituent countries of the UK are being driven by a comparatively strong or weak performance amongst boys or girls. Table 11.3 provides the results, with panel (a) referring to science, panel (b) to mathematics and panel (c) to reading.

22. There is no statistically significant difference in average PISA science scores between boys and girls in any country within the UK. For both genders, England has the highest average score, Wales the lowest, while Northern Ireland and Scotland fall in-between.

23. Boys achieve a higher average score than girls in the PISA mathematics test across all parts of the UK, though the gender difference only reaches statistical significance at the five per cent level in England and Wales. Nevertheless, the magnitude of the 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. Thus, for both mathematics and science, the similarity of the size and direction of the gender gap across the UK is more striking than any difference.

24. Turning to the results for reading (Table 11.3 panel c), average PISA scores for girls are significantly higher than for boys across each of the four constituent countries. However, there is also evidence of some variation within the UK. In particular, the gender gap in reading is around 10 points smaller in Wales (11 point difference between boys and girls) than England (23 point difference) and Scotland (21 point difference). This is partly the result of the particularly low reading skills of Welsh girls, who achieve an average PISA reading score around the same level as English, Scottish and Northern Ireland boys.

Table 11.3 Gender differences in PISA 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: * indicates difference significantly different from zero at the five per cent level.

Key point

The comparatively low reading skills of girls stands out as a particular challenge facing Wales. There are significant differences between genders in reading in all UK countries – in Northern Ireland the gender gap is less than in other countries but girls scored 14 percentage points higher than boys.

11.6 How does the relationship between socio-economic status and achievement vary across the UK?

25. Chapter 6 introduced two ways of measuring the association between socio-economic status and pupils' academic achievement. These are the 'impact' (how much test scores change per one-unit increase in the PISA Economic, Social and

Cultural Status index) and the ‘strength’ (the amount of variation in PISA test scores explained by pupils’ family background). Table 11.4 considers how these two measures of socio-economic inequality in science achievement differ across the UK. Results for mathematics and reading are provided in the online data tables.

26. There is no evidence that the strength and the impact of socio-economic status varies across England, Scotland and Northern Ireland. In all three countries, a one-unit change in the ESCS index is associated with around a 40 test point increase in PISA science scores, with approximately 11 per cent of the variance in pupils’ achievement explained. On the other hand, both measures are notably lower in Wales, where a one-unit increase in ESCS is associated with a 25 test point increase in PISA science scores. Moreover, in Wales socio-economic status explains only around six per cent of the variation in pupils’ science scores; around half the amount that is explained in England, Northern Ireland and Scotland. Hence both measures suggest that socio-economic inequality in 15-year-olds’ science achievement is greater in England, Scotland and Northern Ireland than in Wales. A similar, though slightly less pronounced, result holds for mathematics and reading as well (see online data tables for further details).

Table 11.4 The ‘strength’ and ‘impact’ of socio-economic status upon pupils’ science test 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

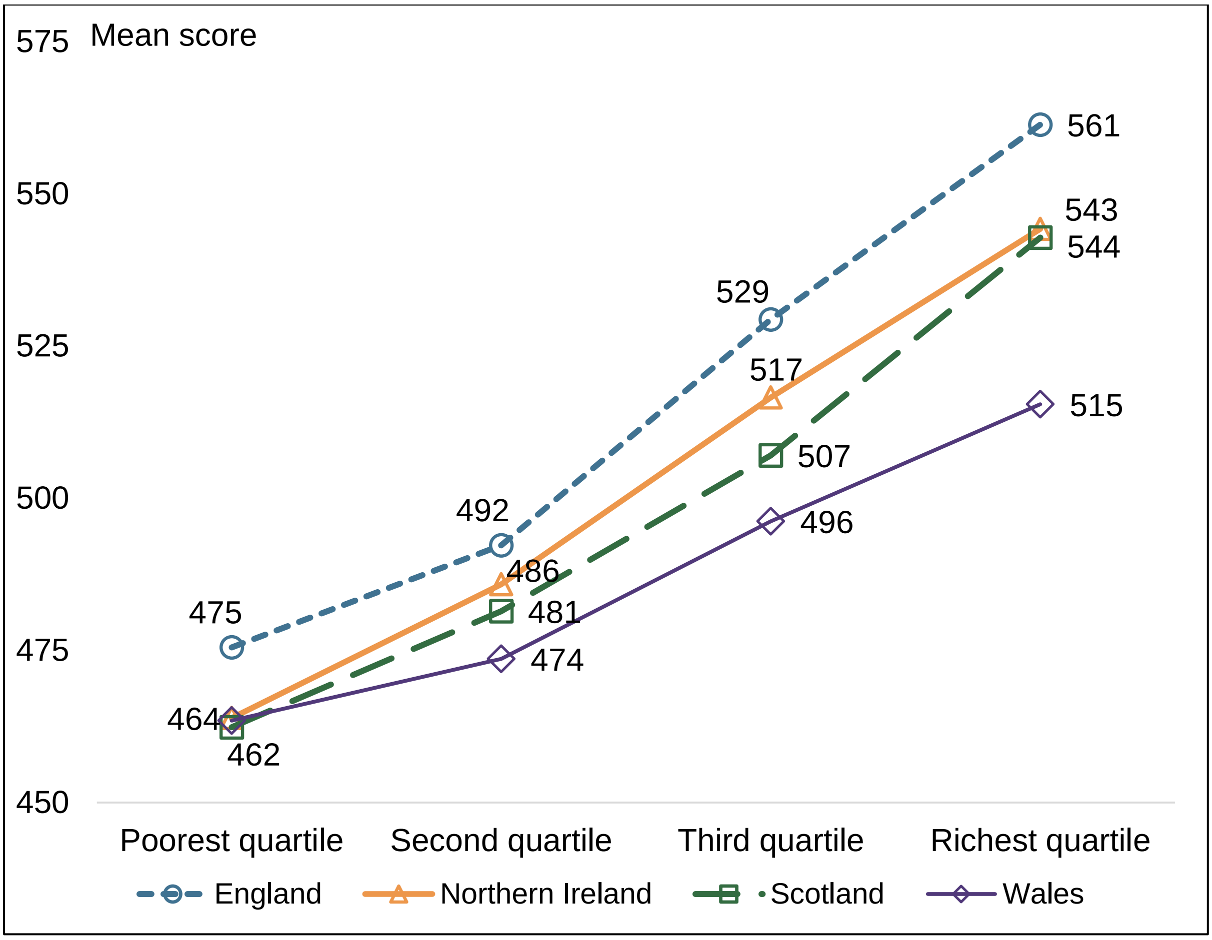
Source: PISA 2015 database.

27. A deeper exploration of this issue is provided in Figure 11.7. Here we have divided 15-year-olds in each country into four equal groups (quartiles) based upon their ESCS index score. Average PISA science scores are then plotted along the vertical axis, with socio-economic status quartiles running along the horizontal axis.

28. A striking feature of Figure 11.7 is that differences across the four countries are much more pronounced for pupils from advantaged socio-economic backgrounds (‘richest quartile’) than for the least advantaged socio-economic group (‘poorest quartile’). For instance, socio-economically disadvantaged pupils in Northern Ireland, Scotland and Wales achieve roughly the same average science

score (around 460) with those in England slightly ahead (around 475). Hence the four UK nations 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. Together, this suggests that England's comparatively high mean science score relative to the rest of the UK (recall Figure 11.1) 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.

Figure 11.7 The relationship between socio-economic status quartile and average PISA science scores across the UK



Source: PISA 2015 database.

Notes: Socio-economic groups refer to quartiles of the ESCS across the UK.

Key point

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 Welsh pupils not achieving as highly as their English, Scottish and Northern Ireland peers.

11.7 How do principals' views on the factors hindering instruction differ across the UK?

29. Chapter 8 examined principals' views of whether their school is adequately resourced. In Table 11.5 we review their responses, and consider how Northern Ireland compares to the rest of the UK.

30. For most questions, results across the four constituent countries are similar. In England, Northern Ireland and Wales, just under half of principals report challenges with regards to the physical infrastructure of their school, compared to around a quarter of principals (24 per cent) in Scotland. Likewise, just under a third of principals across the UK suggest that instruction was being hindered by a lack of educational material. However, one important point of difference is in respect to a lack of teaching staff. Almost half of principals in England (45 per cent) 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 principals in England agree that 'inadequate or poorly qualified teachers' is 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. Hence a lack of appropriately qualified teaching staff seems to be a particularly pressing concern amongst principals in England (compared to the rest of the UK).

Table 11.5 Principals' 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. Principals 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, principals' responses are similar across the different parts of the UK (see Table 11.6). The main point of departure is in respect to the statement '*teachers not meeting individual pupils' needs*'. According to principals, 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 11.6 Principals' 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

Principals' views on the factors hindering instruction within their school are similar across the UK, with the exceptions of teacher absenteeism being a larger concern and teachers not meeting individual pupils' needs being less of a concern in Northern Ireland than in other parts of the UK.

11.8 Are there differences across the UK in the amount of instruction 15-year-olds receive - both inside and outside of school?

32. Is there variation across the UK in the amount of time pupils spend learning science, mathematics and English per week? This is important as previous research has suggested that pupils who receive more instruction time in a subject achieve higher PISA test scores[88]. Figure 11.8 therefore investigates whether the number of minutes studying science, mathematics and English differs (on average) across England, Northern Ireland, Scotland and Wales[89].

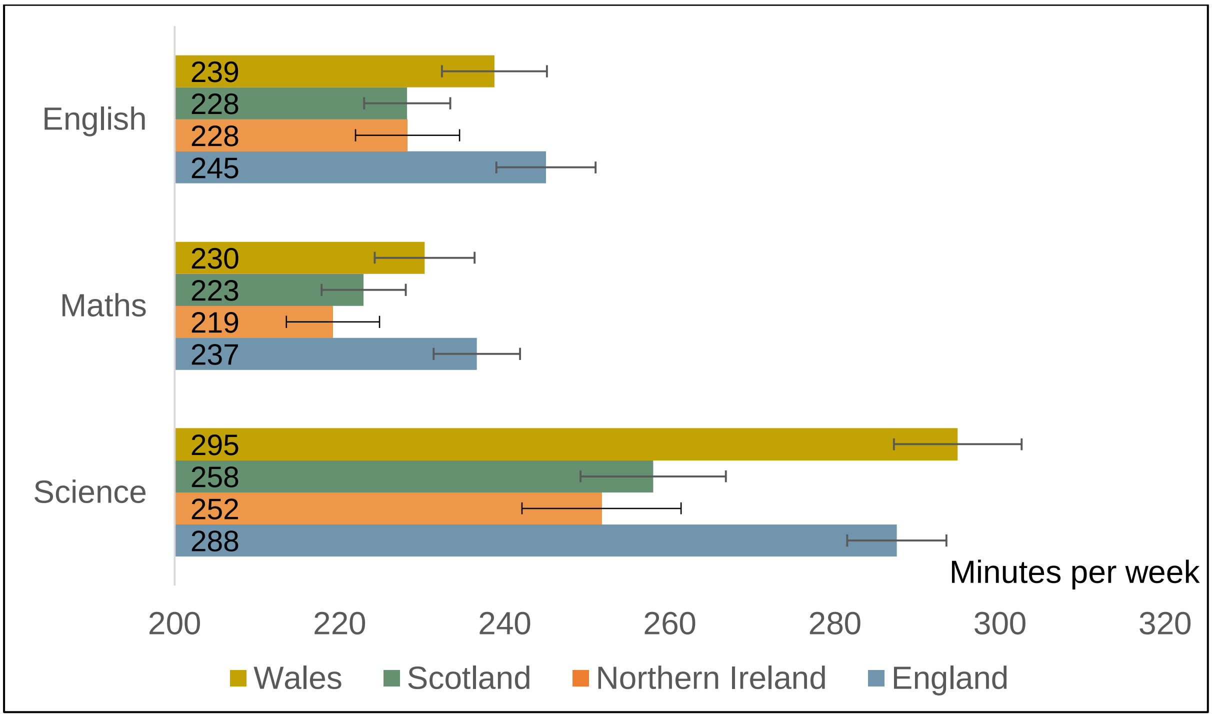
33. In all four parts of the UK, young people report spending more time learning science in school than either English or mathematics. The difference is typically between 30 and 60 minutes per week, with 15-year-olds in England and Wales indicating they receive around four weekly hours of in-school instruction in English and mathematics, compared to five hours of science.

34. Interestingly, pupils in Northern Ireland and Scotland report significantly less instruction time per week across all three subject areas than pupils in England and Wales. For instance, Figure 11.8 indicates that they receive around 40 minutes less instruction in science per week (on average) than their peers in England and Wales. The same holds true, though the difference less pronounced, in English (around 15 minutes less per week) and mathematics (around 15 minutes less per week).

35. The PISA background questionnaire also asked pupils how much time they spend per week learning various subjects outside of their required school schedule. This encompasses a wide range of activities, including homework, private tutoring and independent study. Table 11.7 illustrates how these average additional study hours vary across the four constituent countries.

[88] Lavy (2015).
[89] This is based upon self-reported information from pupils.

Figure 11.8 The amount of time pupils report spending learning science, English and mathematics in school: a comparison across the UK



Source: PISA 2015 database

Note: Thin black line running through centre of bars refers to the estimated 95 per cent confidence interval.

36. On average, 15-year-olds report spending around 18 hours of additional study per week in Northern Ireland and Wales, with this increasing to over 19 hours for pupils in Scotland. This is significantly more than their peers in England, who report spending, on average, around 16 and a half hours on additional study per week. Note that a similar finding holds if one considers the median number of additional hours rather than the mean (median = 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.

Table 11.7 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
Maths	3.5 hours	4.0 hours	4.0 hours	4.0 hours
Test language	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.

37. Further inspection of Table 11.7 indicates that the additional study hours of Scottish, Welsh and Northern Ireland pupils (relative to their English peers) is spread across different subject areas. However, the biggest difference is in English and mathematics. Young people in 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 at the five per cent threshold. Although differences between these countries tend to be smaller in other subject areas (science, foreign languages, other), point estimates still tend to be lowest in England.

Key point

Across the UK, school pupils spend more time studying science than any other subject. Scottish, Welsh and Northern Ireland 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 by the Organisation for Economic Co-operation and Development (OECD). The following sections outline the development of the study, what PISA measures, how to interpret the PISA scales, how PISA is administered and details of the PISA sample in Northern Ireland. These sections outline some of the detailed international requirements that countries must meet in order to ensure confidence in the findings.

A.1. Development of the study

2. 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). By using standardised survey procedures and tests, the PISA study aims to collect data from around the world that can be compared, despite differences in language and culture.

3. The framework and specification for the study were agreed internationally by the PISA Governing Board, which comprises of representatives from each participating country. Both the international consortium and participating countries submitted test questions for inclusion in the assessment. After the questions were reviewed by an expert panel (convened by the international PISA consortium), countries were invited to comment on their difficulty, cultural appropriateness, and curricular and non-curricular relevance.

4. 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. 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 PISA 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 https://www.oecd.org/pisa/pisaproducts/2015-Integrated-Design.pdf

5. Strict international quality standards are applied to all stages of the PISA survey to ensure equivalence in translation and adaptation of instruments, sampling procedures and survey administration in all participating countries.

A. 2. What does PISA measure?

<u>Science</u>

6. Science was the main focus in PISA 2015, as it was in PISA 2006. Full details on the PISA 2015 science framework are available from http://www.oecd-ilibrary.org/docserver/download/9816021ec003.pdf?expires=1462366012&id=id&accname=guest&checksum=DF06918825ED39FEF30E42BB8F8BC573

7. PISA aims to measure not just science as it may be defined within the curriculum of participating countries, but the scientific understanding which is needed in adult life. 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 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*). However, the PISA 2015 test was weighted towards the first of these knowledge types. Specifically, content knowledge was tested in around 60 per cent of the assessment, procedural knowledge in around 25 per cent and epistemic knowledge in 15 per cent.

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.

- Interpret data and evidence scientifically. Analyse and evaluate data, claims and arguments in a variety of representations and draw appropriate scientific conclusions.

  Approximately 40 per cent to 50 per cent of the total test score points were targeted within the 'explaining phenomena scientifically' domain. A total of 30 per cent to 40 per cent of total test score points were targeted within 'interpreting data and evidence scientifically', with the remaining 20 per cent to 30 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. Around a third of PISA 2015 science test items were found within each of the following three categories:

- Open constructed response. 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 interactive tasks, such as manipulating variables in a simulated scientific experiment.

Mathematics

12. Mathematics was the main focus in the 2012 and 2003 PISA cycles and a minor domain in PISA 2015. Full details on the PISA 2015 mathematics framework are available from http://www.oecd-ilibrary.org/docserver/download/9816021ec005.pdf?expires=1462366094&id=id&accname=guest&checksum=0B6059225B81CAC7E6FE8CE8A02EAD1E

13. PISA aims to assess pupils' ability to put their mathematical knowledge to functional use in different situations in adult life, rather than 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 wellfounded 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.

15. PISA recognises the limitations of using a timed assessment in collecting information about something as complex as mathematics. It aims to tackle this by having a balanced range of questions that assess different elements of pupils' mathematical processing ability. This is the process through which a pupil interprets a problem as mathematical and draws on his/her mathematical knowledge and skills to provide a sensible solution to the problem.

16. PISA prefers context-based questions which require the pupil to engage with the situation and decide how to solve the problem. Most value is placed on tasks that could be met in the real world, in which a person would authentically use mathematics and appropriate mathematical tools, to solve these problems. Some more abstract questions that are purely mathematical are also included in the assessment.

Reading

17. Reading was the main focus in the first PISA study in 2000 and also in 2009. It was a minor domain in PISA 2015. Full details on the PISA 2015 reading framework are available from http://www.oecd-ilibrary.org/docserver/download/9816021ec004.pdf?expires=1462366215&id=id&accname=guest&checksum=FC03724295B8824B7A78A7560C1DCDB1

18. 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).

19. 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.

20. 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.

21. 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.

22. 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.

A.3. What do the PISA proficiency levels mean?

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 PISA subject area.

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	334.94 to 409.54	357.77 to 420.07	334.75 to 407.47
Level 1b	260.54 to 334.94	357.77<	262.04 to 334.75

A.4. The PISA test design

25. PISA uses a complex test design. Test questions are first separated into distinct 30 minute ‘clusters’. 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 were ones used in previous cycles. It is this that facilitates measurement of change in PISA test scores over time. A summary of the PISA 2015 assessment design is provided in Figure A1.

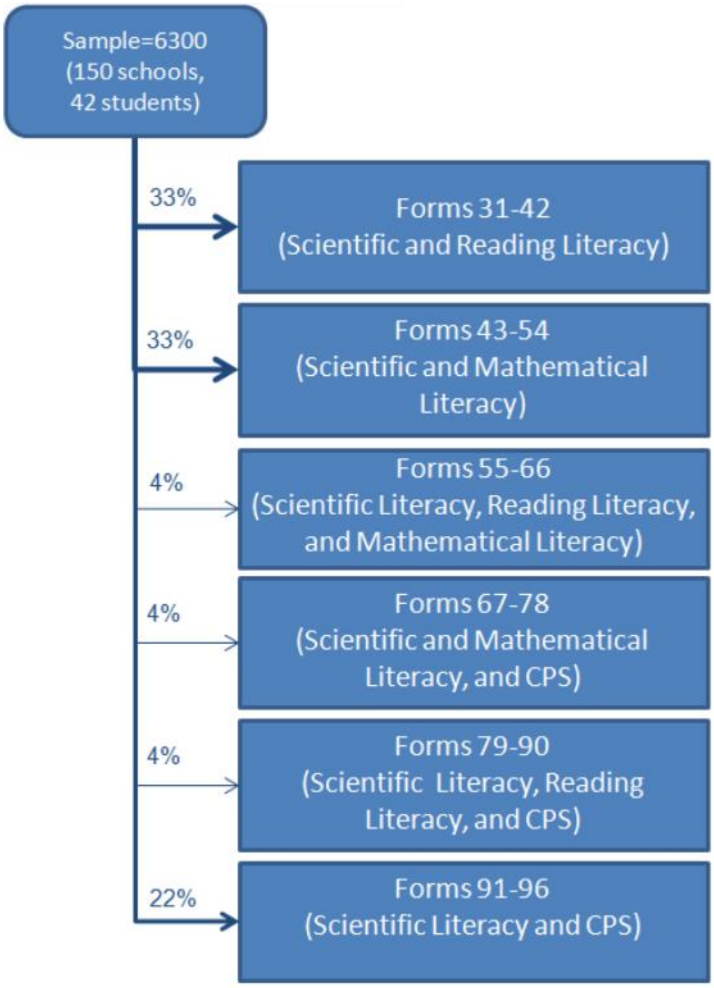
26. Roughly a third of pupils answered one hour of science and one hour of reading test questions (form 31 to 42). A further third of pupils answered one hour of science and one hour of mathematics questions (form 43 to 54), while just over a fifth (22 per cent) received one hour of science and one hour of Collaborative Problem Solving (CPS) questions (form 91 to 96)[90]. 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

[90] 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).

science questions, plus two 30 minute clusters of questions covering two out of the three other domains. These combinations were:

- Form 55-66: One hour science, 30 minutes reading and 30 minutes mathematics
- Form 67-78: One hour science, 30 minutes mathematics and 30 minutes CPS
- Form 79-90: One hour science, 30 minutes reading and 30 minutes CPS

Figure A1. A summary of the PISA 2015 test design



27. The main implication of this complex design is that no single pupil is presented with all PISA 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 (OECD, forthcoming).

A.5. 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 Northern Ireland the National Centre was formed of three organisations: RM Education, World Class Arena Limited and the UCL Institute of Education.

29. National Centres were responsible for making local adaptations to test questions, manuals and the background questionnaires. They were also responsible for translation where necessary.

30. 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.

31. In 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.

32. 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.

33. In each country participating in PISA, the minimum number of participating schools was 150. For countries using computer-based assessment and participating in the CPS study, 42 pupils were then 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 therefore 6,300 pupils in countries involved in the CPS study (including the UK) and 5,250 in countries that were not.

34. 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. This alternative sample design was used in the UK due to the need to over-sample certain parts of the country; for example, larger samples were drawn for Wales, Scotland and Northern Ireland than strictly required. This is to make sure it was possible to provide separate PISA results for the four constituent parts of the UK. 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 post-primary schools were included).

35. 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 Northern Ireland 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.

36. Countries were required to carry out the study during a six-week period between March and August 2015. However Northern Ireland 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 Northern Ireland the study took place between November 5th and December 7th 2015. This is consistent with how PISA has been administered in Northern Ireland since 2006.

37. Each participating school in Northern Ireland was assigned a test date during this period by the National Centre. Before this date schools received two packages. One package contained the USB sticks used to deliver the PISA 2015 test (and had the PISA 2015 test questions loaded on), post-testing certificates and return materials. The second package was a list of user logins for pupils on the test day. This was issued in advance in order that the set-up on the morning of the test was as efficient as possible. Schools were then asked to conduct a system diagnostic test using one of the USB sticks provided by the National Centre. This allowed the school to run a number of checks on their hardware to ensure that the PISA test would run on the school's computers on the actual test day. Although the data gathered

allowed the National Centre to determine whether the equipment at schools had the potential to run the PISA 2015 test software, it did not provide data on a number of key elements in order to plan and run test days (e.g. whether the computers to be used in the testing could all be found within a single room or were spread across the school).

38. To assist schools on the day of the PISA 2015, a Test Administrator (TA) was assigned to every school. Their responsibility was to help set-up the tests on the school's computers, assist in invigilating the test session(s) and help resolve any problems that may arise. All TAs were either ex-teachers or had worked within a school environment before, and were hence accustomed to the day-to-day running within a school. All received training prior to the testing period. Typically, one test administrator was assigned per school. However, an additional TA was provided in a small number of instances where schools did not have the capacity to test all participating pupils in a single room. 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.

39. On the actual test day, TAs arrived at schools from 7.30am/8.00am to complete set up tasks. However this was reliant on the school being prepared, with their School Co-ordinator and IT Network Manager being available, and with the relevant materials (e.g. USB sticks and log-in details) to hand. On occasion this was not the case, which delayed the start of the test. At schools where pupil behaviour proved to be disruptive, this was managed by the TA along with senior members of school staff. TAs worked at the school until mid-afternoon completing administrative duties, including making the packages to be returned to the National Centre by courier.

40. At the end of each test session, the TAs were require 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 students affected)

- Were there any pupils unable to start the session at all due to computer failure? (If yes, write the number of pupils affected)

41. In Northern Ireland, 118 test sessions took place across the 95 participating schools. A total of 72 schools (76 per cent) completed the PISA assessment in a single test session, while two test sessions were used in 23 schools (24 per cent). TAs reported some issues with assessment conditions in two (two per cent) test sessions. There were 19 pupils whose tests were interrupted, 13 for computer failure and six for other reasons (e.g. pupil arrived late, challenging behaviour). TAs reported one pupil who they believed to not be answering any test questions at all.

42. Following the final day of testing at each school, a collection of the packages put together by the TA was requested by the National Centre. It was imperative that these materials were returned quickly so that these could be reconciled and any manual test uploads completed as soon as possible. As with deliveries, collections were tracked from request through to the delivery of the school package at the National Centre via an Excel spreadsheet. Once received the package was logged in and USBs reconciled. A number of schools required a revised collection date due to the school either being closed when the courier arrived, or the reception not having the package available. However these instances were minimal and on the whole the process was efficient and effective.

Appendix B. Sample design and response rates

Sample design

1. PISA requires each country to randomly recruit a minimum of 150 schools, with a minimum of 6,300 pupils completing the tests[91]. In the UK, and some other countries, the number of pupils and schools drawn exceeds this. Specifically, larger samples have been drawn from Wales, Scotland and Northern Ireland than strictly necessary to generate a representative, well-powered sample for the UK. This has been done to ensure it is possible to report robust, highly powered estimates separately for England, Scotland, Wales and Northern Ireland. Some other countries draw larger samples for other purposes, such as reporting results for particular sub-groups (e.g. Australia has traditionally oversampled indigenous pupils to ensure separate PISA results can be reported for this group). In very small countries with less than 150 schools (e.g. Iceland), PISA is essentially a school-level census, including a sample of pupils from every post-primary school.

2. Throughout the national report we describe PISA as a study of 15-year-olds. There is actually a small difference in this definition, which depends upon the time of the test. In England, Wales and Northern Ireland 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.

3. 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 pupils 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.

4. 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 that were used in Northern Ireland. This 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 test scores. This is

[91] This minimum number of pupils refers to countries that participated in the Collaborative Problem Solving (CPS) assessment in PISA 2015. For those countries that chose not to complete the CPS assessment, the minimum number of pupils was 5,250.

known as implicit stratification, with historic GCSE performance of the school the most important variable used for this purpose in Northern Ireland.

5. 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 Northern Ireland this list comprised of 116 main study schools. By the time of the test, 10 of these schools had been dropped. This was mainly due to school closure, although some were excluded as no pupils met the PISA age definition, or had a significant number of pupils with special educational needs. There were thus a total of 106 schools which counted towards the PISA response rate.

Appendix Table B1. The variables used to stratify the PISA sample in Northern Ireland

Explicit strata	Implicit strata
Schools Type	**GCSE school performance**
Grant aided grammar	Band 1 (lowest)
Grant aided non grammar	Band 2
Independent	Band 3
Region	Band 4
Belfast	Band 5 (highest)
North Eastern	Band not known
South Eastern	**Geographic region**
Southern	Varies within region
Western	
Gender composition	
Boys school	
Girls school	
Mixed school	

6. 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 young people were in Year 11.

7. 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. (At the time of writing, the most recent technical report available is for PISA 2012. See OECD 2014:76 for details on the use of replacement schools).

8. 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

9. 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 these 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).

10. Conversely, if the response rate of initially selected schools falls below 65 per cent, the sample 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. Hence the country will be excluded from the international report, due to poor data quality.

11. 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.

12. 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.

13. 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 (e.g. assuming all 30 pupils selected within a school are indeed eligible for the study, at least 15 must complete the PISA test). Second, an overall response rate of 80 per cent amongst selected students within participating schools is required.

Response rates in PISA 2015

14. A total of 95 schools and 2,401 pupils completed the PISA 2015 study in Northern Ireland. 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[92]). The final response rate for Northern Ireland was 85 per cent of the initially sampled schools and 90 per cent after replacements were considered. This places Northern Ireland on the edge of the 'intermediate' and 'acceptable' zone. After consideration by the international consortium, the school response rate for Northern Ireland was deemed to be consistent with the OECD requirements, and that a formal non-response bias analysis need not be conducted.

Appendix Table B2. School response rates

	Northern Ireland
Participating main sample schools	90
Participating first-replacement schools	5
Participating second-replacement schools	0
Non-participating schools	11
Total initially sampled	**106**

Notes: Schools with less than 50 percent of eligible pupils completing the test are considered non-participants. Figures refer to the number of schools.

15. The international report produced by the OECD includes the United Kingdom as a single country, rather than in its four constituent parts. Hence it is the 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

[92] Here a 'non-participant' refers to where neither the initially selected school, nor its two replacement schools, took part in the PISA study.

sample schools, and 93 per cent after replacement. This fully met the participation requirements.

16. Appendix Table B3 provides details on pupil level response. Of the 2,820 pupils initially selected to participate in Northern Ireland, 2,401 successfully completed the PISA study. A total of 131 pupils were excluded for reasons of SEN, enrolment elsewhere, or ineligibility. Finally, 288 pupils were absent on the day of the test. This represents a final response rate (among eligible pupils) of 89 per cent. This exceeds the 80 per cent threshold required by the international contractors for inclusion in the international report.

Appendix Table B3. Pupil-response rates in Northern Ireland

	Number of pupils
Assessed	2,401
Absent	288
Excluded	115
Ineligible	16
Total initially sampled	**2,820**

Source: PISA 2015 national data file.

Appendix C. Testing statistical significance in PISA across cycles

1. To test statistical significance across two independent samples (e.g. a comparison of mean test 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:

$$T - stat = \frac{(\mu_A - \mu_B)}{\sqrt{SE_A^2 + SE_B^2}} \quad \text{(C1)}$$

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

2. 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:

$$T - stat = \frac{(\mu_1 - \mu_2)}{\sqrt{SE_1^2 + SE_2^2 + LE_{1,2}^2}} \quad \text{(C2)}$$

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

3. 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. 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

4. We demonstrate the use of these link errors by working through an example. The mean PISA science score for Northern Ireland in 2006 is equal to 508.14 with a standard error of 3.34. In 2015, the mean science score in Northern Ireland is equal to 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:

$$\frac{(500.09 - 508.14)}{\sqrt{2.79^2 + 3.34^2 + 4.48^2}} = -1.289$$

5. 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[93] (based upon a standard two-tailed test with a five per cent significance threshold), one should fail to reject the null hypothesis that average PISA 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 below the critical value in absolute magnitude).

6. A 95 per cent confidence interval can also be constructed for the change between two PISA test sore statistics over time using the following formula:

[93] 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 5 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

7. 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 PISA 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

8. 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.

9. 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. To illustrate this point, Anders et al. (2016) highlight how PISA scores in Shanghai and Taiwan increase by very little (typically by less than 10 test points) over one particular academic year.

Appendix E. The PISA proficiency levels

Appendix Table E1. The PISA science proficiency levels

Level	Description of the science proficiency levels
Level 6	At Level 6, students are able to use content, procedural and epistemic knowledge to consistently provide explanations, evaluate and design scientific enquiries and interpret data in a variety of complex life situations that require a high level of cognitive demand. They can draw appropriate inferences from a range of different complex data sources, in a variety of contexts 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 or any experimental design of their own. 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. They can develop arguments to critique and evaluate explanations, models, interpretations of data and proposed experimental designs in a range of personal, local and global contexts.
Level 5	At Level 5, students are able to use content, procedural and epistemic knowledge to provide explanations, evaluate and design scientific enquiries and interpret data in a variety of life situations in some but not all cases of high cognitive demand. 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 or any experimental design of their own. 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. They can develop arguments to critique and evaluate explanations, models, interpretations of data and proposed experimental designs in some but not all personal, local and global contexts.
Level 4	At Level 4, students are able to use content, procedural and epistemic knowledge to provide explanations, evaluate and design scientific enquiries and interpret data in a variety of given life situations that require mostly a medium level of cognitive demand. They can draw inferences from different data 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 scientific enquiry or in an experimental design of their own. 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. Students can also develop simple arguments to question and critically analyse explanations, models, interpretations of data and proposed experimental designs in some personal, local and global contexts.
Level 3	At Level 3, students are able to use content, procedural and epistemic knowledge to provide explanations, evaluate and design scientific enquiries and interpret data in some given life situations that require at most a medium level of cognitive demand. 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 or in an experimental design of their own. 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. Students can develop partial arguments to question and critically analyse explanations, models, interpretations of data and proposed experimental designs in some personal, local and global contexts.

Level 2	At Level 2, students are able to use content, procedural and epistemic knowledge to provide explanations, evaluate and design scientific enquiries and interpret data in some given familiar life situations that require mostly a low level of 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 or in a simple experimental design of their own. They can transform and describe simple data, identify straightforward errors, and make some valid comments on the trustworthiness of scientific claims. Students can develop partial arguments to question and comment on the merits of competing explanations, interpretations of data and proposed experimental designs in some personal, local and global contexts.
Level 1a	At Level 1a, students are able to use a little content, procedural and epistemic knowledge to provide explanations, evaluate and design scientific enquiries and interpret data in a few familiar life situations that require a low level of cognitive demand. They are able to 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 or in a simple experimental design of their own. They can partially transform and describe simple data and apply them directly to a few familiar situations. Students can comment on the merits of competing explanations, interpretations of data and proposed experimental designs in some very familiar personal, local and global contexts.
Level 1b	At Level 1b, students demonstrate a little evidence to use content, procedural and epistemic knowledge to provide explanations, evaluate and design scientific enquiries and interpret data in a few familiar life situations that require a low level of 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 or in a simple design of their own. They attempt to transform and describe simple data and apply them directly to a few familiar situations.

Appendix Table E2. The PISA mathematics proficiency levels

Level	Description of the mathematics proficiency levels
Level 6	At 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.

Appendix Table E3. The PISA reading proficiency levels

Level	Description of the reading proficiency levels
Level 6	Tasks at this level typically require the reader to make multiple inferences, comparisons and contrasts that are both detailed and precise. They require demonstration of a full and detailed understanding of one or more texts and may involve integrating information from more than one text. Tasks may require the reader to deal with unfamiliar ideas, in the presence of prominent competing information, and to generate abstract categories for interpretations. Reflect and evaluate tasks may require the reader to hypothesise about or critically evaluate a complex text on an unfamiliar topic, taking into account multiple criteria or perspectives, and applying sophisticated understandings from beyond the text. A salient condition for access and retrieve tasks at this level is precision of analysis and fine attention to detail that is inconspicuous in the texts.
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 4	Tasks at this level that involve retrieving information require the reader to locate and organise several pieces of embedded information. Some tasks at this level require interpreting the meaning of nuances of language in a section of text by taking into account the text as a whole. Other interpretative 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 at this level require the reader to locate, and in some cases recognise the relationship between, several pieces of information that must meet multiple conditions. Interpretative tasks at this level 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 at this level require the reader to locate one or more independent pieces of explicitly stated information; to recognise the main theme or author's purpose in a text about a familiar topic, or to make a simple connection between information in the text and common, everyday knowledge. Typically 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 in the 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.

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.

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. 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. 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

Post publication of the PISA 2012 national reports, an anomaly was spotted in the data for Wales. The gender of pupils was incorrectly coded for those who took the assessment through the medium of Welsh. This affected 415 pupils, representing less than one per cent of the UK population, but 13 per cent of the PISA 2012 sample for Wales. Due to the way in which the PISA scale scores are produced, this could potentially have had an impact upon the PISA 2012 results for England, Wales and Northern Ireland.

To investigate this issue further, the PISA 2012 international contractor, the Australia Council of Australian Research (ACER), was commissioned to provide further details on the technical implications and the size of any changes. ACER re-ran the PISA scale score model for England, Wales and Northern Ireland, once the data anomaly had been resolved.

Appendix Table F1 compares the original scale scores at the time of PISA 2012 publication (December 2013) to the revised scores published in May 2015[94]. As the tables illustrate, in all three countries, the impact upon mean scores, percentiles and gender differences was negligible in science and minimal for maths and reading; estimates of most of these statistics differed by 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.

[94] See http://www.oecd.org/pisa/keyfindings/PISA-2012-UK-revised%20scores.xlsx

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.