Llywodraeth Cymru
Welsh Government

PISA 2015 high and low achievers

Mae’r ddogfen yma hefyd ar gael yn Gymraeg.
This document is also available in Welsh.

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Contents

Introduction

The three-yearly Programme for International Student Assessment (PISA), led by the Organisation for Economic Co-operation and Development (OECD), provides evidence on how the achievement and abilities of 15-year-olds vary across countries. To compare what pupils know and can do across the three core domains, or subjects (science, reading and mathematics), pupils sit a two-hour test that is designed to provide a comparative measure internationally. In each round, one of the core subjects is tested in more detail than the others; for 2015 this major domain was science. Pupils and their schools also complete a background questionnaire that enables more detailed analysis of how performance is shaped by pupils' characteristics, perceptions and experiences of school and teaching within and across countries. Our participation in the PISA study enables us to benchmark the performance of pupils in Wales against their peers across the rest of the world, to understand the extent to which pupil performance varies and what drives this, and to spotlight particular strengths and weaknesses in our education system.

The most recent PISA study was conducted in Wales in the autumn term of 2015. This research brief summarises the results of some further analysis of Wales' PISA 2015 results. It examines the characteristics of high and low achievers across England, Northern Ireland and Wales. This report is complementary to the 'Additional analysis of PISA 2015 results – regional performance and GCSE/BTEC published in July 2017 and is available in the following link.

http://gov.wales/docs/dcells/publications/170706-additional-analysis-of-pisa-2015-en.pdf

The original report submitted by the IoE contained some data errors in two of the tables for Wales in terms of English Medium pupils. Table 3 (c) – Demographic characteristics of low-achievers and Table 4 (c) – Demographic characteristics of high-achievers. The corrected figures are included in this report, with the original tables included as an addendum.

The Welsh policy context

The PISA 2015 results show that Wales has a similar amount of low achievers (below level 2) as is the OECD average for science mathematics and reading. However Wales was relatively fewer high achievers reaching level 5 or 6 compared to the OECD average.
Since 2006 in science the proportion of students achieving level 5 or 6 has declined, from 11 per cent in 2006 to 5 per cent in 2015. We have seen an increase in the proportion of learners below level 2, from 18 per cent in 2006 to 22 per cent in 2015. A key factor driving the decline in Wale's average science score since 2006 is a decline in the performance of its highest achievers.

In mathematics, only 5 per cent of Wales' pupils achieved level 5 or 6, a smaller percentage than the OECD average of 11 per cent. There has been little change in this distribution between PISA 2006 and 2015.

In reading, only 4 per cent of Wales' pupils achieved PISA Level 5 or 6, a smaller percentage than the OECD average of 8 per cent. Wales' results have seen a slight improvement in the lower end of the distribution since 2009, with a smaller proportion below level 2. The proportion of learners reaching level 5 or 6 has slightly decreased since 2009 and remains low. Note that reading level scales were updated in 2009, so comparisons with 2006 are not statistically valid.

Overall the results for low achievers in Wales remains fairly static since 2006 and in line with the OECD average, whereas the proportion of high achievers has declined and is below the OECD average in all three domains. There has been an improvement in the domain of mathematics between 2012 and 2015 in levels 2 to 5.

The Welsh Government has embarked on a comprehensive overhaul of our curriculum following the publication of *Successful Futures: Independent Review of Curriculum and Assessment Arrangements in Wales (2015)*, which will underpin all of our education reforms. We have introduced new and improved GCSE specifications in mathematics, English and Welsh that are designed to continue the improvements seen in the percentage of learners achieving the Level 2 inclusive (five A*-C GCSEs in English/Welsh and mathematics) since 2011 and thereby increase the support to our high achievers.

Education in Wales: Our national mission our Action Plan for delivering the education reforms was published in September 2017, which builds on Qualified for Life and takes into account the OECD rapid review undertaken in November 2016. The Action Plan includes a commitment to improve the proportion of high achievers in PISA. This will be achieved by our commitment to formative assessment, supporting personalised progress (including for our most able learners), together with our new reformed and rigorous GCSEs and A levels.

PISA high- and low-achievers

The OECD translates PISA scores into PISA proficiency levels using score cut-off points (see Table 2.3 in the England PISA 2015 national report for an overview of the proficiency levels). These proficiency levels in science range from Level 1b, the lowest, to Level 6, the highest (as of PISA 2015, Level 1 has been divided into 1a and 1b). Pupils who obtain a PISA science score below Level 2 are classified as 'low-performers', while pupils who obtain a PISA science score at Level 5 or 6 are classified as 'high-performers'.

In this additional analysis, we examine how the share of low- and high-performing pupils has changed across England, Northern Ireland, Scotland and Wales and in other PISA countries. We then examine the demographic characteristics of high- and low-achievers across the United Kingdom in order to better understand who high- and low-achievers are. Using linked GCSE-PISA data, we then turn to the potential correlates of high- and low-performance on GCSEs and PISA using a variety of scales constructed by the OECD to capture pupils' beliefs, attitudes and experience of learning science in the classroom. We conclude by constructing Year 11 progress models, again using linked GCSE-PISA data, to further probe the correlates of being a high- or low-performer on GCSEs controlling for PISA performance and a variety of other demographic characteristics.

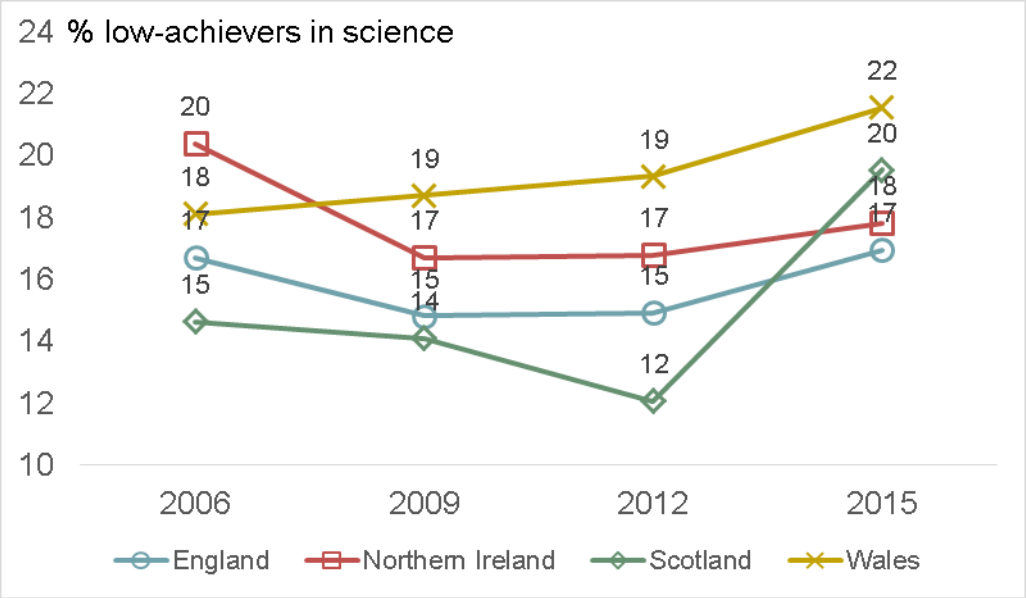
1. Change in the share of high- and low-achievers in PISA science over time

1.1 Changes across the United Kingdom

In the PISA 2015 national reports for England, Northern Ireland and Wales, we present and discuss in chapter 2 the shares of high- and low-achievers in PISA 2015 science. Another metric of interest is how this share has changed over time. We calculate the share of pupils in England, Northern Ireland, Scotland and Wales who are low- and high-achievers in science for each PISA cycle from 2006. Figure 1 plots the shares of low-achievers over time in England, Northern Ireland, Scotland and Wales and Figure 2 plots the shares of high-achievers over time.

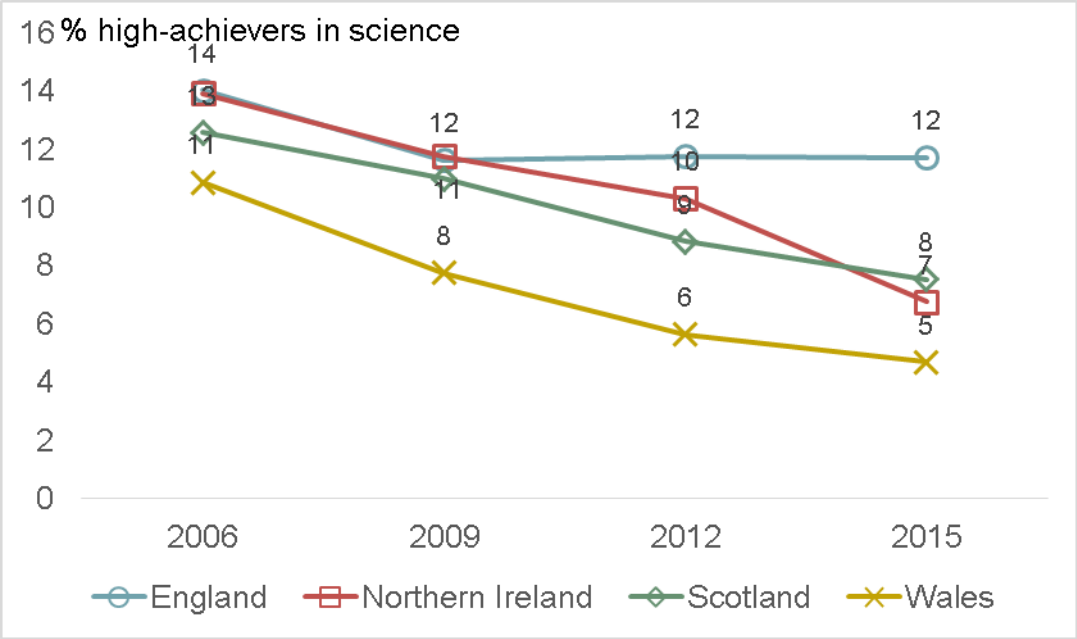
Figure 1 shows a mixed picture across the United Kingdom. Whilst England has seen almost no change in its share of low-achievers over time (17 per cent in 2006, 15 per cent in 2009, 15 per cent in 2012 and 17 per cent in 2015) and Northern Ireland has seen a slight decrease (from 20 per cent in 2006 to 18 per cent in 2015), Wales has seen a steady increase in its share of low-performers. This has meant an increase of four percentage points from 18 to 22 per cent. The share of low-achievers in Scotland echoes its sharp drop in mean PISA science scores in 2015 as compared to previous cycles; there has been a large spike in the proportion of pupils scoring below Level 2 (from 12 per cent in 2012 to 20 per cent). It remains to be seen if this is a one-time spike or if one-in-five pupils continues to be a low-achiever in PISA science in Scotland.

Figure 1. The change is in the share of low-performers in PISA science across the UK



Notes: 'Low-achievers' refers to pupils obtaining PISA science scores below Level 2.

Figure 2. The change in the share of high-performers in PISA science across the UK



Notes: 'High-achievers' refers to pupils reaching PISA proficiency Level 5 or 6.

1.2 Changes across other countries

Since 2006, there have been changes in the shares of low- and high-achievers in other countries participating in PISA as well. Panel (a) of Table 1 presents the countries with an absolute value of five or more percentage point change in the share of low-achievers and panel (b) presents those countries with a less than absolute value of five percentage point change. As a point of reference, amongst OECD countries, the percentage of pupils classified as

low-achievers has increased by two percentage points from 19 in 2006 to 21 in 2015, indicating that large changes are not the norm.

Panel (a) of Table 1 shows that most large changes in the shares of low-achievers across countries have been positive.[1] In fact, only two countries, Israel and Portugal, have decreased their share of low-achievers by five percentage points or more. Notably, although Finland is a top-performing country in PISA science (with a mean score of 531 in 2015), its share of low-achievers in science has increased by seven percentage points from 2006 to 2015.

Table 1. Changes in the share of low-achievers from 2006 to 2015

(a) Countries with a change five percentage points or greater

	2006	2009	2012	2015	Change 06-15
Hungary	15%	14%	18%	26%	11%
Slovak Republic	20%	19%	27%	31%	11%
Greece	24%	25%	26%	33%	9%
Finland	4%	6%	8%	11%	7%
Netherlands	13%	13%	13%	19%	6%
Sweden	16%	19%	22%	22%	5%
Czech Republic	16%	17%	14%	21%	5%
Australia	13%	13%	14%	18%	5%
Iceland	21%	18%	24%	25%	5%
Israel	36%	33%	29%	31%	-5%
Portugal	24%	17%	19%	17%	-7%

[1] We do not report results for any countries that have had an absolute value change of one percentage point or less.

(b) Countries with a change less than five percentage points

	2006	2009	2012	2015	Change 06-15
Austria	16%	21%	16%	21%	4%
Lithuania	20%	17%	16%	25%	4%
Luxembourg	22%	24%	22%	26%	4%
New Zealand	14%	13%	16%	17%	4%
Korea	11%	6%	7%	14%	3%
Belgium	17%	18%	18%	20%	3%
Switzerland	16%	14%	13%	18%	2%
OECD average	19%	18%	18%	21%	2%
Germany	15%	15%	12%	17%	2%
Italy	25%	21%	19%	23%	-2%
Macao	10%	10%	9%	8%	-2%
Norway	21%	16%	20%	19%	-2%
Japan	12%	11%	8%	10%	-2%
Denmark	18%	17%	17%	16%	-3%
Russia	22%	22%	19%	18%	-4%
United States	24%	18%	18%	20%	-4%

Notes: 'Low-achievers' refers to a PISA score below Level 2.

Panel (b) of Table 1 illustrates the fact that most changes in the shares of low-achievers across countries have been small. Japan, another of the top 10 performing countries in science, has seen a decrease of two percentage points in its share of low-achievers from 2006 to 2015. Across the OECD, the average country has increased its share of low-performers by approximately two percentage points, which is similar in magnitude to the change across the United Kingdom.[2]

Table 2 presents the change in the share of high-achievers from 2006 to 2015. Panel (a) shows that few countries have experienced large changes in the share of high-achievers over this period. Only Portugal and Macao have experienced steady increases in the share of high-achievers from 2006 to 2015. Again, it is notable that although Finland is a top 10 performing country in science, their share of high-achievers has decreased by seven percentage points from 2006 to 2015. Not all countries in Panel (a) have experienced a sustained change in the share of high-achievers. Hong Kong, for example, has experienced a large decline in the share of high-achieves, nine percentage points, but this change has essentially occurred from 2012 to 2015 since the share of high-achievers was relatively constant from 2006 to

[2] A similar picture emerges when we examine the change in the share of low-achievers from 2012 to 2015. The OECD average change across this period is three percentage points, which is again similar to the change across the United Kingdom during this period. We do not present these results here and instead focus on the change from 2006 to 2015 because it is more likely to represent a sustained change as opposed to a blip in performance. In 2006 and 2015, science was also the major domain, again providing a more interesting point of comparison.

2012. It is still too early to say if this is a one-off occurrence or the beginning of a sustained decline.

Table 2. Changes in the share of high-achievers from 2006 to 2015
(a) Countries with a change five percentage points or greater

	2006	2009	2012	2015	Change 06-15
Portugal	3%	4%	5%	7%	4%
Macao	5%	5%	7%	9%	4%
Czech Republic	12%	8%	8%	7%	-4%
New Zealand	18%	18%	13%	13%	-5%
Finland	21%	19%	17%	14%	-7%
Hong Kong	16%	16%	17%	7%	-9%

(b) Countries with a change less than five percentage points

	2006	2009	2012	2015	Change 06-15
Estonia	11%	10%	13%	14%	2%
Netherlands	13%	13%	12%	11%	-2%
Canada	14%	12%	11%	12%	-2%
Slovakia	6%	6%	5%	4%	-2%
Austria	10%	8%	8%	8%	-2%
Hungary	7%	5%	6%	5%	-2%
Slovenia	13%	10%	10%	11%	-2%
Ireland	9%	9%	11%	7%	-2%
Iceland	6%	7%	5%	4%	-3%
United Kingdom	14%	11%	11%	11%	-3%
Australia	15%	15%	14%	11%	-3%

Notes: 'High-achievers' refers to pupils reaching PISA proficiency Levels 5 or 6.

Panel (b) of Table 2 again shows that few countries have managed to increase the proportion of high-achieving pupils from 2006 to 2015. Only Estonia (another of the top 10 performing countries with an average science score of 534) has seen a positive increase of two percentage points in the share of high-achievers during this period. The United Kingdom on the other hand as seen a three percentage point decline during this period. As a point of reference, during this same period, the average OECD country has experienced a one percentage point decline in the share of high-achieving pupils.

2. Demographic characteristics of high- and low-achievers in England, Northern Ireland and Wales

In order to better understand which factors are associated with high and low performance, it is useful to examine the demographic characteristics of high- and low-performing pupils. We begin by looking at the demographic characteristics of low-achievers. For England, Northern Ireland and Wales, we classify pupils who participated in PISA into categories, low-achievers and non-low-achievers (everyone else), and explore their characteristics along a variety of dimensions including gender, socio-economic status and school type. We then do the same for high-achievers and non-high-achievers. Table 3 presents these results for low-achievers with each country in a separate panel.

Panel (a) of Table 3 presents these results for England. They indicate no gender bias in the breakdown of low-achievers, but show that nearly 40 per cent of low-achievers in England come from disadvantaged backgrounds as opposed to 11 per cent from advantaged backgrounds. This is different from the breakdown of socio-economic status amongst non-low-achievers. Similarly a higher percentage of low-achievers are Free School Meals pupils (17% versus 9%) and first generation immigrants (13% versus 8%) than their non-low-achiever counterparts.

Panel (b) of Table 3 presents the same results for Northern Ireland. This panel shows that slightly more than half of low-achievers in Northern Ireland are boys. Similarly to England, over 40 per cent come from disadvantaged backgrounds. Nearly half of low-achievers (48%) in Northern Ireland attend a school in the top quartile of the distribution of Free School Meals, indicating that low-achievers seem to be clustered together in schools with many disadvantage pupils. Similarly, the vast majority (93%) of low-achievers attend a secondary school with only six per cent of low-achievers attending a grammar school. There does not appear to be any difference between low-achievers and other pupils in terms of religion.

Panel (c) presents the same results for Wales and shows some differences when compared to England and Northern Ireland. There is similarly no difference in the gender breakdown of low-achievers nor in their socio-economic status (approximately 40 per cent come from a disadvantaged socio-economic background and one in five are FSM eligible), however, there is no difference between low-achievers and other pupils in terms of immigrant status. Only six per cent of low-achievers are first generation immigrants, which is similar to the five per cent first generation immigrants of other pupils. There also does not appear to be any difference between low-achievers and other pupils in terms of the proportion of pupils studying in Welsh and English.

Table 3. Demographic characteristics of low-achievers
(a) England

	Low-achievers	Non-low-achievers
Proportion of which are…		
Girls	50%	49%
Boys	50%	51%
Low SES (Q1 of ESCS)	39%	22%
High SES (Q4 of ESCS)	11%	28%
FSM pupils	17%	9%
First generation immigrants	13%	8%
Second generation immigrants	9%	9%
Native born	67%	79%
Academy converter pupils	25%	43%
Academy sponsor led pupils	34%	18%
Community school pupils	24%	16%
Voluntary school pupils	7%	8%
Independent school pupils	2%	8%

(b) Northern Ireland

	Low-achievers	Non-low-achievers
Proportion of which are…		
Girls	48%	50%
Boys	52%	50%
Low SES (Q1 of ESCS)	44%	22%
High SES (Q4 of ESCS)	8%	27%
FSM Q1 pupils (least)	2%	30%
FSM Q4 pupils (most)	48%	19%
Secondary school pupils	93%	46%
Grammar school pupils	6%	54%
Protestant	36%	37%
Catholic	59%	53%

(c) Wales

	Low-achievers	Non-low-achievers
Proportion of which are…		
Girls	50%	48%
Boys	50%	52%
Low SES (Q1 of ESCS)	37%	25%
High SES (Q4 of ESCS)	13%	25%
FSM eligible	21%	11%
First generation immigrants	6%	5%
Second generation immigrants	2%	2%
Native born	83%	88%
Welsh medium pupils	17%	17%
English medium pupils	83%	83%

Notes: 'Low-achievers' refers to pupils with a PISA proficiency score below Level 2. The categories for immigrant status do not sum to 100% because we do not report the proportion of low-achievers with a 'missing' immigrant status.

Table 4 presents analogous results to Table 3, but this time focusing on the demographic characteristics of high-achievers. The results in panel (a) for England show that more than half of high-achievers are boys (six percentage points more) and that nearly half are from an advantaged socio-economic background (49%). Only nine per cent of high-achievers are from the bottom of the socio-economic status distribution in England. More than half of high-achievers in England attend an academy converter (51%), followed by 15 per cent at independent schools, 13 per cent at community schools, nine per cent at academy sponsor led schools and six per cent at voluntary schools. Given the distribution of pupils at these school types, these results are unsurprising.
Panel (b) presents the demographic characteristics of high-achievers in Northern Ireland. Here there is an even larger gender split than in England. Fifty eight per cent of high-achievers in Northern Ireland are boys, compared to 42 per cent girls. The socio-economic status results are similar to England. Forty five per cent of high-achievers in Northern Ireland are from an advantaged background and 57 per cent attend a school in the bottom quartile of FSM pupils, again indicating that high-achievers are clustered in advantaged schools just as low-achievers in Northern Ireland are clustered together in disadvantaged schools. This result is further highlighted by the fact that 88 per cent of high-achievers in Northern Ireland attend a grammar school. Again, there is little difference on the basis of religion.

Table 4. Demographic characteristics of high-achievers
(a) England

	High-achievers	Non-high-achievers
Proportion of which are…		
Girls	47%	50%
Boys	53%	50%
Low SES (Q1 of ESCS)	9%	27%
High SES (Q4 of ESCS)	49%	22%
FSM pupils	3%	82%
First generation immigrants	7%	9%
Second generation immigrants	6%	9%
Native born	86%	76%
Academy converter pupils	51%	38%
Academy sponsor led pupils	9%	22%
Community school pupils	13%	18%
Voluntary school pupils	6%	8%
Independent school pupils	15%	6%

(b) Northern Ireland

	High-achievers	Non-high-achievers
Proportion of which are…		
Girls	42%	50%
Boys	58%	50%
Low SES (Q1 of ESCS)	11%	27%
High SES (Q4 of ESCS)	45%	22%
FSM Quartile 1 pupils (least)	57%	23%
FSM Quartile 4 pupils (most)	4%	26%
Secondary school pupils	12%	58%
Grammar school pupils	88%	42%
Protestant	42%	37%
Catholic	44%	55%

(c) Wales

	High-achievers	Non-high-achievers
Proportion of which are…		
Girls	41%	49%
Boys	59%	51%
Low SES (Q1 of ESCS)	17%	28%
High SES (Q4 of ESCS)	47%	22%
FSM eligible	10%	13%
First generation immigrants	6%	5%
Second generation immigrants	2%	2%
Native born	90%	87%
Welsh medium pupils	12%	17%
English medium pupils	89%	83%

Notes: 'High-achievers' refers to pupils with a PISA proficiency score at Level 5 or 6. The categories for immigrant status do not sum to 100% because we do not report the proportion of high-achievers with a 'missing' immigrant status.

Panel (c) presents analogous results for Wales. Similarly to Northern Ireland, 59 per cent of high-achievers in Wales are boys. Interestingly, this gender disparity is present in Wales and Northern Ireland, but not in England. The picture for socio-economic status is similar across all three countries, with nearly half of high-achievers in Wales coming from an advantaged background (47%) and only 10 per cent of high-achievers being FSM eligible. Whilst the proportion of English medium pupils across high-achievers and non-high-achievers in Wales is similar, the proportion of Welsh medium pupils amongst high-achievers is five percentage points lower than amongst non-high-achievers (12% versus 17%).

3. The factors associated with high and low performance in PISA and GCSEs

After describing the demographic characteristics of low- and high-achievers in England, Northern Ireland and Wales, we now turn our attention to how pupils' attitudes and beliefs about science as well as their experience of learning science in the classroom are correlated with the probability of being a high- or a low-performer.

3.1 Measures

The PISA background questionnaire includes a number of questions asking pupils about the practise of their science teachers, their attitudes and beliefs about science, as well as their home environment and attitudes towards school. Based upon pupils' responses, the survey organisers create a number of quasi-continuous scale scores. This includes:

- ADINST = Extent to which pupils believe their science teacher adapts their instruction

- ANXTEST = Pupils' anxiety surrounding tests
- BELONG = Pupils sense of belonging in school
- DISCLISCI = Pupils' reports of the disciplinary climate in their science class
- EMOSUPS = Pupils' reports of the emotional support they receive from their parents
- EPIST = Pupils' epistemic beliefs about science
- IBTEACH = Pupils' reports of whether their science teacher uses Inquiry-based teaching
- INSTSCIE = Instrumental motivation in science
- INTBRSCI = Pupils' self-reported interest in science
- JOYSCIE = Pupils' enjoyment of science
- MOTIVAT = Pupils' self-reported achievement motivation
- PERFEED = Pupils' perceptions of the feedback they receive from their science teacher
- SCIEACT = Pupils' science related activities
- SCIEEFF = Pupils' self-efficacy in science
- TDTEACH = Pupils' reports of their science teachers use of teacher-directed science instruction
- TEACHSUP = Pupils' reports of the amount of support they receive in class from their science teacher

In this document, we investigate the association between these scales and pupils' performance in (i) the PISA 2015 science test and (ii) GCSE science examinations (England and Wales only).

Within our analysis, we standardise the scales to mean 0 and standard deviation 1 within each country. All our results can therefore be interpreted in terms of the impact of a one-standard deviation increase in the scale upon the outcomes of interest.

3.2 The raw correlation between each scale and PISA science scores

Table 5 reports the Pearson correlation between each of the aforementioned scales and performance on the PISA science test. Pearson correlations range between -1 (perfect negative correlation) and +1 (perfect positive correlation) with a value of 0 indicating no relationship at all. A common rule of thumb is that correlations with an absolute value below 0.3 are weak, between 0.3 and 0.7 are moderate, and those above 0.7 are strong.

Table 5. The correlation between the pupil background questionnaire scales and PISA science scores

	England	Northern Ireland	Wales
ADINST	0.12	0.08	0.17
ANXTEST	-0.13	-0.10	-0.17
BELONG	0.02	-0.02	0.05
DISCLISCI	0.22	0.18	0.23
EMOSUPS	0.11	0.08	0.11
EPIST	0.35	0.34	0.39
IBTEACH	-0.04	-0.06	-0.02
INSTSCIE	0.15	0.14	0.19
INTBRSCI	0.28	0.35	0.34
JOYSCIE	0.31	0.33	0.38
MOTIVAT	0.13	0.13	0.18
PERFEED	-0.06	-0.06	0.02
SCIEACT	0.14	0.16	0.17
SCIEEFF	0.33	0.25	0.27
TDTEACH	0.10	0.12	0.15
TEACHSUP	0.04	-0.02	0.10

Notes: Figures refer to the Pearson correlation between each scale and PISA science scores.

Most of the correlations between these scales and pupils' PISA science scores are not particularly strong. Only the scales for epistemic beliefs, science self-efficacy and enjoyment of science have a correlation with PISA science scores above 0.3, indicating a moderate relationship. For some of the scales, such as whether their teacher uses science-based inquiry (IBTEACH), the support pupils receive from their science teacher (TEACHSUP), pupils' perceptions of the feedback they receive (PERFEED) and pupils' sense of belonging in school (BELONG) there is no relationship at all (Pearson correlations are approximately zero).

There are, however, significant limitations with these results in terms of informing policy and practise. These are basic correlations only, and do not reveal cause and effect. Hence we cannot rule out there being other factors associated with these variables and pupils' outcomes. For instance, it could be that pupils who are of higher socio-economic status tend to have more self-confidence in science, while also achieving higher PISA test scores. Hence there is no way to know whether the correlation between self-efficacy and PISA scores (reported in Table 1 and Appendix A) is actually due to some other factor, such as socio-economic status.

In section 3.3 we therefore try to take this possibility into account by estimating a cross-sectional OLS regression model, which attempts to control for such possible confounders. Although still providing correlational evidence only, they are likely to at least be a step closer to establishing a causal relationship.

3.3 Cross-sectional linear probability models

In this section, we report results for each country from a 'linear probability model' (LPM). This refers to an OLS regression model with a binary dependent variable. The model is specified as follows:

$$P_{ij} = \alpha + \beta . D_i + \gamma . Scale_i + u_j + \varepsilon_{ij} \quad (1)$$

Where:

P_{ij} = A binary indicator, taking the value of 1 if the pupil is a low/high-achiever (and 0 otherwise)

D_i = A vector of demographic characteristics (including gender, parental education, immigrant status, ethnicity, English as an additional language [England only], Welsh language [Wales only] and religion [Northern Ireland only])

Scale = One of the 16 explanatory scales listed above. Note that this implies that 16 separate versions of model (1) are estimated – once for each of the different background explanatory scales.

u_j = School fixed-effects (a dummy variable for each school)

ε_{ij} = Random error

i = Pupil i

j= School j

Two separate versions of this model are estimated for each country: one model for 'high-achievers' (Level 5 or 6 on the PISA test) and one model for 'low-achievers' (below Level 2 on the PISA test). The coefficient of interest is β, which gives the increase in the probability of being a high- or low-achiever, per a one standard deviation increase in the PISA background explanatory scale.

The results from this model essentially show the association between each of the explanatory scales and whether the pupil is a high- or low-performer in the PISA test, amongst those who attend the same school and who have similar background demographic characteristics. For instance, for the model including the DISCLISCI scale, the estimates tell us whether children with similar demographic characteristics in the same school achieve higher PISA science scores if their science classroom has a positive disciplinary climate.

Table 6 begins by providing the results for high-achievers. Across all three countries, a number of factors are quite strongly associated with the probability of being a high-achiever in science. For instance, pupils with greater science self-efficacy (SCIEEFF), who have more instrumental motivation in science (MOTIVAT), who enjoy and are interested in science (JOYSCIE), and who have greater epistemic beliefs (EPIST) are between three and five percentage points more likely to be a high-achiever. This holds true across England, Northern Ireland and Wales, and may indicate that interventions or policy initiatives attempting to raise such factors could lead to an increase in the proportion of high-achieving pupils.

There also appears to be lessons for teachers. Although there is no relationship between inquiry-based teaching practises and the probability of being a high-achiever, there are small positive effects (of around one or two percentage points) for the use of teacher-directed science instruction (TDTEACH), the amount of support pupils receive in class (TEACHSUP) and the disciplinary climate in the science classroom (DISCISCI). Likewise, reducing test anxiety might be key in increasing the proportion of high-achieving pupils; in England and Wales, 15-year-olds are around two to three percentage points less likely to be a high-achiever if they are more anxious about tests.

Table 6. The association between the PISA pupil background questionnaire scales and the probability of being a *high-achiever* in PISA science.

	England		Northern Ireland		Wales	
	Effect	Sig	Effect	Sig	Effect	Sig
ADINST	3.1%	**	1.5%	**	1.8%	**
ANXTEST	-3.3%	**	-0.7%	-	-2.0%	**
BELONG	-1.2%	**	-1.2%	**	-0.2%	-
DISCLISCI	3.0%	**	1.4%	**	1.6%	**
EMOSUPS	1.0%	*	-0.5%	-	1.2%	**
EPIST	5.7%	**	3.8%	**	4.0%	**
IBTEACH	-0.1%		0.5%	-	0.0%	-
INSTSCIE	3.5%	**	2.1%	**	3.0%	**
INTBRSCI	4.7%	**	3.4%	**	3.0%	**
JOYSCIE	6.3%	**	4.1%	**	3.9%	**
MOTIVAT	3.3%	**	1.0%	-	2.1%	**
PERFEED	0.1%		-0.7%	-	0.3%	-
SCIEACT	4.0%	**	3.1%	**	2.2%	**
SCIEEFF	6.5%	**	3.4%	**	3.5%	**
TDTEACH	2.4%	**	1.0%	-	1.3%	**
TEACHSUP	1.7%	**	0.9%	-	1.1%	**

Notes: Controls for gender, parental education, immigrant status, ethnicity (England only), EAL (England only), Welsh language (Wales only), religion (Northern Ireland only). * and ** indicate statistical significance at the five per cent and 10 per cent levels respectively. Effect refers to the increase in the probability of being a high-achiever in PISA science, per a one standard deviation increase in the scale. Estimates produced using 16 separate regression models; only a single scale is included in the model at a time (they are *not* all entered simultaneously). High-achiever refers to a PISA science score of Level 5 or 6.

Table 7 presents similar associations, but this time for the probability of being a low-achiever in PISA science. Again, across all three countries there are a few factors that are strongly associated with being a low-performer in science. Pupils with a more disciplined science classroom climate (DISCLISCI), greater epistemic beliefs (EPIST), stronger interest in science (INTBRSCI) and greater science self-efficacy (SCIEEFF) are between three and eight percentage points less likely to be low-achievers in PISA science. Again this indicates that policies targeting classroom climate and individual interest and beliefs about self-efficacy across all three countries may protect against low science performance.

Table 7. The association between the PISA pupil background questionnaire scales and the probability of being a *low-achiever* in PISA science.

	England		Northern Ireland		Wales	
	Effect	Sig	Effect	Sig	Effect	Sig
ADINST	-1.9%	**	-2.5%	**	-3.5%	**
ANXTEST	2.8%	**	1.8%	*	3.9%	**
BELONG	-1.5%	**	-0.9%	-	-1.5%	**
DISCLISCI	-4.8%	**	-3.9%	**	-6.3%	**
EMOSUPS	-1.6%	**	-1.4%	-	-2.7%	**
EPIST	-6.2%	**	-4.2%	**	-9.0%	**
IBTEACH	1.8%	**	1.5%	-	0.9%	-
INSTSCIE	-3.2%	**	-2.2%	**	-3.7%	**
INTBRSCI	-5.7%	**	-6.9%	**	-8.2%	**
JOYSCIE	-5.3%	**	-5.6%	**	-8.3%	**
MOTIVAT	-2.6%	**	-2.7%	**	-4.3%	**
PERFEED	0.5%	-	-1.3%	-	-0.8%	-
SCIEACT	-1.7%	**	-2.6%	**	-3.8%	**
SCIEEFF	-5.9%	**	-3.7%	**	-5.2%	**
TDTEACH	-1.4%	*	-2.8%	**	-3.3%	**
TEACHSUP	-0.7%	-	-1.1%	-	-1.7%	**

Notes: Controls for gender, parental education, immigrant status, ethnicity (England only), EAL (England only), Welsh language (Wales only), religion (Northern Ireland only). * and ** indicate statistical significance at the five per cent and 10 per cent levels respectively. Effect refers to the increase in the probability of being a low-achiever in PISA science, per a one standard deviation increase in the scale. Estimates produced using 16 separate regression models; only a single scale is included in the model at a time (they are *not* all entered simultaneously). Low-achiever refers to a PISA science score of below Level 2.

As compared to England and Northern Ireland, there are several more statistically significant associations for Wales in Table 7. The strongest associations in Wales seem to lie in domains related to pupils' positive self-perception, for example epistemic beliefs (EPIST), enjoyment of science (JOYSCIE) and interest in science (INTBRSCIE). In all of these cases, having a higher score on the scale is associated with an eight to nine percentage point decrease in the probability of being a low-achiever. On the other hand, higher test anxiety (ANXTEST) is positively associated with being a low-achiever at nearly four percentage points. Teachers also play a role in this story, with greater teacher-directed learning leading to a three percentage point decrease in the probability of being a low-achiever in Wales and Northern Ireland. Although class disciplinary climate and teacher-directed learning are related to the probability of being a low-achiever in science, teacher support (TEACHSUP) is not statistically significant in England or Northern Ireland and only has a small effect in Wales.

3.4 Year 11 'progress' models

Although the models in the previous section have started to reveal potential levers we might use to increase the proportion of high-achievers and decrease the proportion of low-achievers across the UK, the strength of the evidence that they produce remains limited. A key challenge with PISA is that the data are cross-sectional, and do not follow young people over time. Therefore, we are unable to make any statements with regards to the *progress* young people make, and the factors that may help them to *improve*

their skills. Consequently, we are unable to control for pupils' prior attainment and skills in the models in section 3.3, which makes it difficult to know whether increasing young people's self-assessments on the explanatory scales (e.g. increasing their enjoyment in science) really would improve their chances of being a high-achiever (and reducing their chances of being a low-achiever).

However, by using the PISA data linked to GCSE grades, we can start to overcome this issue. In particular, note that the PISA test is taken by 15-year-olds in the November/December before their GCSEs (which are sat the following June). Consequently, using the linked data, we have two measures of Year 11 pupils' achievement measured just six months apart. Consequently, we are able to investigate whether any of the 16 PISA pupil background questionnaire scales are linked to the learning gains young people make during their final six months in compulsory education. This therefore starts to overcome some of the significant limitations with existing analysis based on the PISA data outlined above, and potentially helps policymakers and teachers better understand what they can do in Year 11 to help pupils make greater progress.

The following Linear Probability Model is estimated to try and better understand this issue:

$$GCSE_{ij} = \alpha + \beta.D_i + \gamma.Scale_i + \tau.PISA + \delta.KS2 + u_j + \varepsilon_{ij} \quad (1)$$

Where:

$GCSE_{ij}$ = A binary indicator, taking the value of 1 if the pupil is a low-/high-achiever in their science GCSE. (In England, a high-achiever is defined as having a Key Stage 4 science pillar score of 7 and above, and a low-achiever a pillar score of 4 or below. In Wales, a high-achiever is defined as obtaining an A*/A as their highest grade in single science GCSE and a low-achiever as gaining a grade below C).

D_i = A vector of demographic characteristics (including gender, parental education, immigrant status, ethnicity, English as an additional language [England only], Welsh language [Wales only]).

Scale = One of the 16 explanatory scales listed above. Note that this implies that 16 separate versions of model (1) are estimated – once for each of the different background explanatory scales.

PISA = Pupils' achievement in the PISA science, mathematics and reading test

KS2 = Pupils' Key Stage 2 scores / level in mathematics and science (England only)

u_j = School fixed-effects (a dummy variable for each school)

ε_{ij} = Random error

i = Pupil i

j= School j

Two separate versions of this model are estimated on each country: one model for 'high-achievers' in their GCSEs and one model for 'low-achievers'. The coefficient of interest is β, which gives the increase in the probability of being a high-/low-achiever in GCSE science, per a one standard deviation increase in the PISA background explanatory scale. Note that as we have now included controls for pupils' prior achievement, as measured by their PISA and Key Stage 2 scores, these are a type of 'value-added' model that

can help us to better understand the factors associated with the progress young people make during Year 11.

Table 8 presents the model for being a 'high-achiever' in GCSE science. For England, almost all of the 16 scales are statistically significant, though with fairly modest effect sizes. A one standard deviation increase in most of the scales increases the probability of being a high-performer by one or two percentage points. Notable exceptions include the interest, enjoyment, motivation and self-efficacy scales; here the effect is around three to four percentage points. As we have now included controls for prior achievement, and are capturing progress made over a short six month time horizon, effects of this magnitude are actually quite sizeable. Likewise, it is interesting to note that higher-levels of test anxiety continue to be associated with a lower probability of high science achievement.

Moreover, there continues to be evidence that teaching approaches to science instruction have an effect. For instance, in England, using teacher-directed science instruction (TDTEACH), providing greater support to pupils in class (TEACHUP) and enforcing a stricter disciplinary climate in class (DISCISCI) all continue to increase the likelihood of being a high-achiever in science by between one and two percentage points. Interestingly, in these models the use of inquiry-based teaching is also positive (around two percentage points) and statistically significant.

In Wales, the majority of scales are also statistically significant, with exceptions being test anxiety, a sense of belonging at school and strict disciplinary climate in class. Similarly to England, a one standard deviation increase in most of the scales leads to a one to two percentage point increase in the probability of being a high-achiever. The largest effects for pupils in Wales are found in the scales for instrumental motivation in science (INSTSCIE), enjoyment of science (JOYSCIE) and motivation for achievement (MOTIVAT). This points to pupils' intrinsic interest and motivation potentially playing a larger role than classroom level factors (e.g. teaching and class climate). Nevertheless, teaching still plays a role in predicting high level achievement in science GCSEs, with teacher-directed science instruction (TDTEACH) and teachers providing greater support to pupils in class (TEACHUP) being statistically significant with an effect size of one to two percentage points.

Table 8. 'Value-added' models of the relationship between PISA pupil background questionnaire scales and the probability of being a *high-achiever* in their science GCSE.

	England		Wales	
	Effect	Sig	Effect	Sig
ADINST	1.8%	**	1.9%	**
ANXTEST	-2.1%	**	-0.1%	-
BELONG	1.0%	*	1.2%	-
DISCLISCI	1.5%	**	-0.4%	-
EMOSUPS	0.9%	**	2.1%	**
EPIST	1.4%	**	2.2%	**
IBTEACH	2.1%	**	0.9%	-
INSTSCIE	4.0%	**	4.4%	**
INTBRSCI	1.2%	**	2.3%	**
JOYSCIE	3.8%	**	3.4%	**
MOTIVAT	3.3%	**	3.0%	**
PERFEED	0.7%	-	1.7%	*
SCIEACT	1.6%	**	2.3%	**
SCIEEFF	3.8%	**	2.1%	**
TDTEACH	1.6%	**	2.0%	**
TEACHSUP	1.7%	**	1.2%	*

Notes: Controls for gender, parental education, immigrant status, PISA reading, science and maths scores, ethnicity (England only), EAL (England only), Welsh language (Wales only), Key Stage 2 science and maths scores (England only). * and ** indicate statistical significance at the five per cent and 10 per cent levels respectively. Effect refers to the increase in the probability of being a high-achiever in GCSE science, per a one standard deviation increase in the scale. Estimates produced using 16 separate regression models; only a single scale is included in the model at a time (they are *not* all entered simultaneously). High-achiever refers to a GCSE science EBacc pillar score of 7 and above in England. High-achiever in Wales refers to an A* or A in single science GCSE.

Table 9 provides analogous results, focusing on the probability of being a low-achiever in GCSE science. Interestingly, effect sizes in England and Wales are now much smaller, with only a few reaching statistical significance at the five per cent level. In England, there is some suggestion that greater levels of enjoyment, self-efficacy and interest in science may help to protect against low-achievement, though only by around one percentage point. Moreover, few of the factors associated with teachers and teaching practises are now related to low-achievement in science. In Wales, there is some suggestion that increasing emotional support and the sense of belonging at school may protect against low-achievement as well as having supportive teachers, by approximately two percentage points.

Together, Tables 8 and 9 perhaps suggest that although there are many possible levers to help young people who are already doing quite well in science in Year 11 to push on and obtain a high GCSE grade, there are fewer obvious routes to protecting against lower performance.

Table 9. 'Value-added' models of the relationship between PISA pupil background questionnaire scales and the probability of being a *low-achiever* in GCSE science.

	England		Wales	
	Effect	**Sig**	**Effect**	**Sig**
ADINST	-0.1%	-	-0.9%	-
ANXTEST	0.6%	-	0.9%	-
BELONG	-1.5%	**	-2.4%	**
DISCLISCI	-1.3%	*	-1.8%	*
EMOSUPS	-0.7%	-	-1.8%	**
EPIST	-0.2%	-	-0.7%	-
IBTEACH	0.0%	-	0.1%	-
INSTSCIE	-1.2%	**	-1.0%	-
INTBRSCI	-0.9%	-	-0.8%	-
JOYSCIE	-1.5%	**	-0.1%	-
MOTIVAT	-0.9%	-	-0.7%	-
PERFEED	0.5%	-	0.8%	-
SCIEACT	-0.9%	-	-0.2%	-
SCIEEFF	-1.4%	**	-0.3%	-
TDTEACH	0.2%	-	-1.2%	-
TEACHSUP	-0.5%	-	-1.5%	*

Notes: Controls for gender, parental education, immigrant status, PISA reading, science and maths scores, ethnicity (England only), EAL (England only), Welsh language (Wales only), Key Stage 2 science and maths scores (England only). * and ** indicate statistical significance at the five per cent and 10 per cent levels respectively. Effect refers to the increase in the probability of being a low-achiever in GCSE science, per a one standard deviation increase in the scale. Estimates produced using 16 separate regression models; only a single scale is included in the model at a time (they are *not* all entered simultaneously). Low-achiever refers to a GCSE science EBacc pillar score of 4 and below in England. Low-achiever in Wales refers to achieving below a C grade in science GCSE.

3.5 Limitations and further analysis required

There remain a number of limitations and caveats to the results presented above, which need to be considered before they are used in determining education policy. First, although we have sequentially accounted for an increasing number of factors within our regression models, the estimates are still associations only, and do not capture cause and effect. Further work in this area should proceed to potentially include other variables within the model (e.g. parental out-of-school investments, truancy from school etcetera) to see if the substantive results continue to hold.

Second, although the final set of models (using GCSE results) have many benefits, the limitations on time means that further work would ideally be done to check the sensitivity of these results. Ideally, the PISA population model would be re-estimated including GCSE grades. This is because it is recognised in the psychometric literature that relationships between PISA scores and data linked in from external sources can suffer from biases due to the nature of how the PISA plausible values are constructed (via multiple imputation).

Third, the fact we have included school fixed-effects in the model means we are asking quite a lot of the data (particularly when additional controls are added as well). Ideally, additional robustness tests would be conducted to investigate whether the use of school fixed-effects is leading to any strange behaviour in the reported results.

Fourth, for ease of interpretation and computational time, we have chosen to estimate linear probability models (OLS regressions with a 0/1 outcome). Yet, by looking at high- and low-achievers, our focus is very much on the tails of the achievement distribution, where non-linearities could become an issue. Ideally, additional robustness tests would be conducted, to investigate whether the key results remain unchanged when using an alternative functional form (e.g. when using a probit or logit model instead).

3.6 Conclusions

Correlations between the PISA background questionnaire items and PISA science scores are often examined by the OECD at the country level. There are a number of challenges with using such evidence to inform education policy, including limited sample size, lack of causal evidence and the possibility of encountering the ecological fallacy (i.e. relationships at the group level may not hold at the individual level as well).

In contrast, this note has examined the association between the background questionnaire scales and PISA science scores *within countries* at the pupil level. Our results indicate that a number of factors remain associated with the probability of being a high-achiever, even after extensive controls (including school fixed-effects and prior achievement) have been taken into account. Of particular note is how certain teaching styles and strategies, including teacher-directed learning and providing greater support to pupils in class, are associated with higher levels of achievement and greater progress being made during Year 11. Yet ensuring pupils are interested in and enjoy science, have self-confidence in their abilities, and do not suffer from test anxiety is also critical to young people making achievement gains. Future work should investigate the robustness of these results, before they are ready to use in developing education policy.

Addendum: Original uncorrected tables

Demographic characteristics of low-achievers		
	Low-achievers	**Non-low-achievers**
Proportion of which are…		
Girls	50%	48%
Boys	50%	52%
Low SES	37%	25%
High SES	13%	25%
FSM eligible	21%	11%
First generation immigrants	6%	5%
Second generation immigrants	2%	2%
Native born	83%	88%
Welsh medium pupils	17%	17%
English medium pupils	82%	81%

Demographic characteristics of high-achievers		
	High-achievers	**Non-high-achievers**
Proportion of which are…		
Girls	41%	49%
Boys	59%	51%
high SES	17%	28%
High SES	47%	22%
FSM eligible	10%	13%
First generation immigrants	6%	5%
Second generation immigrants	2%	2%
Native born	90%	87%
Welsh medium pupils	11%	17%
English medium pupils	82%	81%