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Chapter 10
Understanding achievement in PIRLS and TIMSS 2011

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Introduction

The achievement results from PIRLS and TIMSS 2011 (PT 2011) (Eivers & Clerkin, 2012; Martin, Mullis, Foy, & Stanco, 2012; Mullis, Martin, Foy, & Arora, 2012; Mullis, Martin, Foy, & Drucker, 2012) show that there are large differences within countries between the scores of individual pupils, and also that performance varies across the three domains (reading, mathematics and science). In individual countries/education systems, some of these differences can be associated with school and class characteristics, while others relate to pupil characteristics.

This chapter uses multilevel analyses to explore some of the factors that may account for variation in reading, mathematics and science achievement in Ireland. An advantage of PT 2011 in some countries, including Ireland, is that the same pupils were assessed in all three domains, allowing direct comparisons to be made between them. A detailed literature review of how (and why) background characteristics are related to achievement is outside the scope of this chapter: instead, readers are referred to general reviews on/overviews of the topic. The analyses focus on achievement differences within Ireland, rather than relative to other countries.[1] As noted in Chapter 1 of this volume (Eivers & Clerkin, 2013), it should be borne in mind that causality cannot be inferred from the associations between background characteristics and achievement.

The remainder of this chapter is divided into 11 sections. First, we provide an overview of multilevel modelling: what it is, and why it is used in the present analyses. Second, we describe the school, teacher/classroom and pupil characteristics that have been selected for analysis. Third, we compare the dataset used in modelling with the larger PT 2011 sample. Fourth, we explore the manner in which variation in achievement is divided into between-school/class, and pupil levels. This gives an indication of the extent to which schools/classes differ with respect to achievement, and will be referred to when interpreting the results. Fifth, we present and compare the results of the models for reading, mathematics and science, highlighting characteristics that appear to be important in explaining achievement differences across all three domains, and others which may have domain-specific relationships with achievement.

Sixth, we explore interactions between gender and other pupil characteristics in their associations with achievement. Seventh, we examine whether or not the strength of the relationships between pupil-level characteristics and achievement are constant across classes/schools. The next three sections follow up on three specific findings in the models that merit closer examination: these are the "social context effect" (the extent to which the socioeconomic environment of the school/class is associated with achievement after accounting for pupil characteristics), the relationship between books in the home and achievement, and variation between schools in the incidences of bullying reported by

[1] In any case, detailed international comparisons were not possible, since the international databases were unavailable at the time of writing. The PIRLS and TIMSS international databases were released in early 2013, and a joint database for both will be released in late 2013 (see www.iea.nl/current_studies.html).

students. Finally, conclusions draw together findings, and offer suggestions for further research. More detailed information on the data underlying the models is provided in the appendices at the end of the chapter. Readers should note that this chapter examines only a subset of the PT 2011 data. Those who would like more general information about PT 2011 are referred to Chapter 1.

What is multilevel modelling and why do it?

Multilevel models are statistical models that describe the relationship between an outcome (in this case, achievement in PT 2011) and background characteristics that vary at more than one level. In this chapter, the multilevel models that are described can be seen as an extension of linear multiple regression models. They are particularly useful for analysing survey results where data are organised at more than one level (i.e., nested data, such as pupils in schools). Also, because multilevel models allow us to divide the variation in achievement into individual and group levels, we can describe the extent to which schools differ with respect to a given outcome, and then proceed to examine the extent to which different school and pupil characteristics take account of the variation in achievement.

There are two main reasons for using multilevel modelling for PT 2011 achievement. First, multiple regression techniques treat individuals as independent observations, which is not the case with survey data that comes from grouped or clustered data, such as pupils in schools. One consequence of ignoring nested structures is that the standard errors will be underestimated, leading to an overstatement of statistical significance. Standard errors for the group-level predictor variables (e.g., school characteristics) will be most affected by ignoring grouping. Second, the extent to which group-level characteristics are associated with achievement, over and above individual pupil-level characteristics, is of interest. A specific example of this is the social context effect, whereby the socioeconomic environment of the school may have a relationship with achievement over and above individual pupil characteristics (see, for example, Sofroniou, Archer and Weir's [2004] study on the social context effect in Irish primary and post-primary schools).

Many of the techniques that are associated with multiple linear regression also apply to the analyses presented in this chapter. Two are described here since they are important in interpreting the results that are presented. First, we want to examine the relationships between achievement and several background characteristics simultaneously. This is important, since bivariate analyses (examining relationships between achievement scores and one background variable at a time) fail to take the relationships among (covariances between) various background characteristics into account. For example, we might observe large achievement differences between pupils in urban and rural schools, but much of this difference could well be due to differences in the background characteristics of pupils that attend these schools, rather than attributable to the schools' locations, *per se*. In this chapter, we explore covariance by showing how achievement varies for some specific characteristics before and after adjusting for the other variables in the model; we also examine the amount of variation in achievement that is explained by various combinations of background characteristics. Second, we examine whether or not background characteristics interact with one another. For example, the relationship between enjoyment of reading and reading achievement might be different for boys and girls, in which case we would say that an *interaction* exists between pupil gender and enjoyment of reading with regard to achievement.

There is a specific feature of multilevel models that is examined in this chapter – that is, whether a pupil-level slope varies randomly across schools or not. This refers to whether or not the strength of the relationship between a pupil characteristic and achievement is the same across schools, or whether it is significantly stronger in some schools than others.

Inset 10.1 describes some concepts and terms that are needed to interpret the results of the models. A more detailed description of the procedures used to develop and finalise the models is in Chapter 8 of the PISA 2009 national report (Perkins, Cosgrove, Moran, & Shiel, 2012).[2]

Inset 10.1: Concepts and terms used in Chapter 10

Standard error: As noted in Chapter 1, PT 2011 results are estimates from a sample of pupils, so there is some error associated with the results. In the analyses presented in this chapter, the standard error takes account of both sampling and measurement error (the latter arising due to the fact that each pupil attempted a sub-set of the PT 2011 test items, rather than all items).

Explanatory (independent) variable: This refers to a variable or measure that may account for some of the variation in the outcome variable (i.e. achievement). This is a strictly statistical term – a variable does not 'explain' variation in achievement in a direct or causal sense.

Intercept: The intercept is the estimated achievement score of a pupil who has a value of zero on all categorical explanatory variables and a mean value on all of the continuous explanatory variables.

Dummy indicators, dummy variables, and reference groups: A dummy indicator or a dummy variable always has a value of either 0 or 1. For example, in the models presented in this chapter, gender is a dummy indicator with 0 for boy and 1 for girl. Other variables whose values fall into categories have been recoded as dummy variables, with one of the categories acting as the reference group.

In the fictitious example of job satisfaction shown below, the expected score for male employees is 490, and for female employees it is 505 (490+15). Response options to a statement regarding feeling supported by supervisor are *agree*, *don't know*, and *disagree*. *Don't know* is the reference group. Respondents who *agree* that they feel supported have an expected job satisfaction score that is 8 points higher than respondents who *don't know*, while individuals who *disagree* have an expected score that is 5 points lower than respondents who *don't know*.

Fictitious example: Extract from a multilevel model of job satisfaction

Intercept		490.0
Gender (male)	Female	15.0
Years in current position (5 to 10 years)	Less than 1 year	-45.0
	One to 4 years	-28.0
	11 years or more	32.0
	Missing years in current position	-19.0
Feels supported by supervisor (don't know)	Agree	8.0
	Disagree	-5.0

Missing indicator*:* A missing indicator is a type of dummy indicator, and is used for variables where there is some missing data. In these instances, we recode the missing values of the original variable to 0 (for categorical measures) or the mean (for continuous measures), and the missing indicator takes a value of 1 if a pupil is missing data on that measure. In the example extract, some individuals were missing years in current position. Their expected job satisfaction score is 19 points lower than respondents for whom these data exist.

Standardised variables: Standardising here refers to setting a continuous variable to have a specific mean and standard deviation. It is done to facilitate the interpretation of the parameter estimates (i.e., the estimate of change in achievement associated with each explanatory variable or each category within an explanatory variable). Continuous explanatory variables have been standardised to have a mean of 0 and a standard deviation of 1, so the parameter estimate

[2] For more detailed information on the theory and techniques associated with multilevel modelling, see Raudenbush and Bryk (2002), Raudenbush, Bryk, Cheong, and Congdon (2004), or Snijders and Bosker (2012).

equals the expected change in the pupil score associated with a one-standard deviation increase in the continuous variable. Also, as outlined in Chapter 1, pupils in Ireland did not achieve the same mean and standard deviation for reading, mathematics and science. Therefore, to facilitate comparisons across models, we have standardised the achievement scores for all three domains to have a mean of 500 and a standard deviation of 100.

Between-school/class variance: This is the proportion of total variation in achievement that is between groups (classes/schools). The higher the proportion (expressed in this chapter as a percentage), the more schools differ with respect to average achievement. In Ireland, between-group variance in achievement tends to be low relative to other countries. It is useful to compare the between-school variance associated with each of the three domains, since this can provide an indication of whether schools differ more with respect to (say) mathematics achievement than reading achievement.

Explained variance: This is the amount of achievement variation that is explained by the variables in the model. It gives an indication of the model's explanatory power. Usually, in models like the ones presented in this chapter, most of the variance in achievement is *not* explained, meaning that a majority of the achievement differences between pupils remains unaccounted for.

Variables examined

The variables included in the models are drawn from four sources described in Chapter 1; the *Learning to Read Survey* (Parent Questionnaire), the Pupil Questionnaire, the Teacher Questionnaire, and the School Questionnaire. These variables are shown in Table 10.1, and include pupil-level variables (e.g., gender), school-level variables (e.g., school size), and domain-specific variables (e.g., liking mathematics at pupil-level, and perceived shortage of science teachers at the school level).[3] These variables are described in detail in Table A1 in Appendix A.

In selecting background variables to include in the analyses described in this chapter, priority was given to those that were deemed to (i) have clear meaning, policy and research relevance, (ii) have good measurement properties, (iii) have low rates (generally less than 5%) of missing data and (iv) be sufficiently general to facilitate comparisons across reading, mathematics and science.

When interpreting the results it should be borne in mind that, in some cases, there are few pupils in sub-groups (see Tables B1 and C1 in Appendices B and C). For example, just 5% of pupils have a mother whose highest level of education is primary level, while 53% have a TV in their bedroom. This is important since characteristics that apply to a large sub-set of pupils might imply quite a different policy response to those that apply to a smaller sub-set.

The measure of bullying used in the present chapter is not the same as the international bullying scale discussed in Chapter 3 (Clerkin & Creaven, 2013). As the aim was to capture both *frequent* and *multiple forms of* bullying in our measure (see Minton, 2010),

[3] Because PIRLS and TIMSS 2011 are international studies, some variables are measured differently than they might be in national surveys of educational achievement. For example, in PT 2011, age starting school is coded as 5 years or younger/6 years and older. Just over 90% of pupils' parents in Ireland reported that they started school at 5 or younger, so it would have been desirable to have a measure that further sub-divided the "5 or younger" group.

bullying is treated here as a binary variable. Pupils were categorised as bullied if they were bullied *once a week or more* by at least two of the six types of bullying presented to pupils.

In the PT 2011 dataset used for multilevel modelling, 78.9% of pupils experienced none of the six forms of bullying at least once a week, 11.2% experienced one, 5.2% experienced two, 2.2% experienced three, and 2.6% experienced four or more; 10% were therefore classified as experiencing two or more forms of bullying at least once a week. A categorical version of this variable may have been desirable (e.g., none, low, medium, high), but as relatively few pupils experienced high levels of bullying, the binary version of the measure was used. In any case, there is high concordance between the classification using the binary measure and the international measure of bullying ($\chi^2 = 2223.41$, $df = 2$, $p < .001$).

Finally, it may be noted that the top two categories for books in the home (101-200 books, and more than 200 books) were collapsed into a single category (more than 100 books) in order to reduce the overall number of categories for this variable.

Table 10.1: Pupil and school/class characteristics used in modelling achievement in PT 2011

Pupil-level variables	**School/class-level variables**
Reading, mathematics and science achievement	School enrolment size
Gender	Urban-rural status
Age	DEIS status
Home language*	School language of instruction
Test language	Proportion of parents with third-level education
Books at home*[a]	Average number of full time equivalent jobs per household
Children's books at home	Proportion of pupils with another first language
TV in bedroom	Proportion of female pupils
Computer in bedroom	Average pupil age in years
Own iPhone	Perceived problems with absenteeism/lateness*
Parents set aside time for homework daily*	Perceived parental support*
Experiences two or more types bullying at least weekly[b]	Class size
Age starting school	School emphasis on academic success scale
Mother's education*	Safe and orderly school climate scale
Father's education*	
Number of jobs in the household*[c]	
Parent – time spent reading per week	
Parent – perceived importance of reading*	
Domain-specific pupil variables	**Domain-specific school/class variables**
Pupil frequency of reading for enjoyment*	Teacher specialisation in English*
Pupil perceived importance of reading*	Teacher specialisation in mathematics*
Pupil perceived importance of mathematics*	Teacher specialisation in science*
Pupil liking of mathematics*	Perceived shortage of reading teachers*
Pupil perceived importance of science*	Perceived shortage of mathematics teachers*
Pupil liking of science*	Perceived shortage of science teachers*
Missing indicator for Parent Questionnaire	Hours of instruction per week – English*
	Hours of instruction per week – mathematics*
	Hours of instruction per week – science*

Note: Further detail on these variables is available in Table A1, Appendix A.

*Variable has a missing indicator to preserve cases in the dataset.

[a]Books at home represents pupil-reported number of books in the home. Parent-report data on books in the home are also available, but this variable was not included in the multilevel models: it was felt that pupils' reports formed the more relevant measure here.

[b]A nationally-derived binary variable contrasting children who experience two or more (of six) types of bullying at least once a week with those who experience fewer and/or less frequent bullying behaviours.

[C]Continuous variable representing the number of full-time jobs held in the household (with part-time jobs classified as 0.5).

Schools, classes and pupils included in the analyses

Achievement scores for all three domains were available for 4348 of pupils in Ireland who took part in PT 2011. However, the analyses in the present chapter are based on 4044 pupils.[4] As shown in Table 10.2, there are no notable differences between the pupils with achievement data on all three domains, and the sub-set included in the multilevel models, indicating that the reduced dataset is unbiased and representative of the full PT 2011 sample.

Table 10.2: Complete combined PIRLS/TIMSS dataset compared with the dataset used in modelling achievement in PT 2011

Characteristic	All PIRLS/TIMSS pupils	Pupils in the multilevel model dataset
N pupils	4348*	4044
N classes	221	211
Pupil gender	%	%
Girls	49.4	49.2
Boys	50.6	50.8
School DEIS status	%	%
In DEIS Band 1 school	7.6	7.8
In DEIS Band 2 school	6.8	7.0
In DEIS Rural school	4.5	4.2
Not in DEIS school	81.0	81.0
School gender composition	%	%
Mixed school	73.4	74.0
All-boys school	9.4	9.2
All-girls school	12.2	12.5
Girls and infant boys school	5.0	4.3
School size	%	%
Small school	31.8	30.9
Medium school	26.5	27.5
Large school	41.6	41.6
School Location	%	%
City/large town	46.9	47.8
Small town/village	27.2	26.1
Rural community	25.9	26.1
School language	%	%
English medium school	92.5	92.2
Irish medium school	7.5	7.8
Reading achievement mean	552.6	554.7
Reading achievement sd	74.4	73.7
Mathematics achievement mean	528.7	530.6
Mathematics achievement sd	77.6	77.0
Science achievement mean	517.5	519.3
Science achievement sd	79.1	78.5

Note. All percentages apply to pupils. The achievement estimates in the table are not standardised, as they are in Table 10.1, and subsequent tables showing the results of the models.

*The number of pupils with an achievement score on all three of PIRLS, TIMSS mathematics and TIMSS science.

[4] In all, 94.5% of sampled pupils participated in TIMSS, and 93.8% of sampled pupils participated in PIRLS (see Table 1.5 of the national report [Eivers & Clerkin, 2012]). Of these, 4348 pupils, or 90.1% of all sampled pupils, have data for both studies. The pupils in the dataset used in multilevel modelling (4044 in all) represent 83.8% of all sampled pupils, or 93.0% of pupils in the combined PIRLS/TIMSS dataset. There are 304 fewer pupils in the multilevel dataset because these cases were missing a majority of questionnaire data.

To what extent do schools, classes, and pupils differ in achievement?

How PT 2011 sampled schools, classes and pupils is relevant to the interpretation of between-school or between-class differences in achievement. The 151 schools that participated were relatively evenly divided between those with one or two Fourth grade classes (automatically selected) and those with more than two such classes (from which two classes were randomly selected).

The sampling design introduces some complexities when deciding how best to group the data for multilevel modelling. If we use school as the cluster variable, we cannot include teacher/class variables in the model. However, if we use class as a cluster variable, we risk confounding school and class "effects". A three-level model (pupil, class, and school) is not desirable, since in schools where only one class was selected, the school level is the same as the class level. If, on the other hand, the variation in achievement is partitioned in a similar manner between classes as it is between schools, then using class as the cluster variable is the most appropriate way to analyse the data. Here, we examine the manner in which variation in achievement is partitioned between schools, classes and pupils, and compare two-level (school and pupil, class and pupil) and three-level (school, class, and pupil) models.

As shown in Table 10.3, between-cluster or between-group variance is quite low for all three domains, whether school or class is used as the cluster variable. Between-cluster variation is lowest for reading, and highest for science, with between-cluster differences for mathematics lying in between. Moreover, in a three-level model, only a very small amount of the variance lies between classes. This indicates that it is appropriate to conduct a two-level model analysis with class/school as the cluster variable, thereby allowing the inclusion of teacher/class characteristics. From here on, the two-level models refer to pupil and school levels, where "school level" is shorthand for "school/class level".

Table 10.3: Total, between- and within-school/class variation in reading, mathematics and science achievement, two versus three levels

Model/level	Reading	Mathematics	Science
Two levels – classes and schools	%	%	%
Pupils	86.6	82.5	78.2
Classes/schools	13.4	17.5	21.8
Total	100.0	100.0	100.0
Two levels – schools	%	%	%
Pupils	87.8	82.2	78.2
Schools	12.2	17.8	21.8
Total	100.0	100.0	100.0
Three levels – all schools	%	%	%
Pupils	87.4	82.1	78.0
Classes	1.5	0.5	0.9
Schools	11.1	17.3	21.1
Total	100.0	100.0	100.0
Three levels – schools with two classes	%	%	%
Pupils	83.1	83.2	79.9
Classes	4.0	2.0	3.1
Schools	12.9	14.9	16.9
Total	100.0	100.0	100.0

Results for the models of reading, mathematics and science

Table 10.4 presents a summary of the two-level models for reading, mathematics and science, and Tables D1, D2 and D3 in Appendix D show the detailed results for each domain, including the results of significance tests. Gender interactions were found in all three models. The parameter estimates for gender cannot be interpreted without also taking the parameter estimates for the interaction terms and related main effects into account; and significance tests for the main effects (e.g., gender, books in the home) should not be reported in the presence of an interaction effect. Gender interactions are explored in detail later in this chapter.

For those unfamiliar with data as presented in Table 10.4, the following examples may help:

1. Pupils flagged "Yes" for having a TV in their bedroom have an expected **reading** achievement score that is 14 points lower than pupils flagged "No".
2. Each additional full-time job in a household is associated with a **science** score increase of 8 points over the *intercept* score.

When examining the achievement differences shown in Table 10.4, readers should bear in mind that the standard deviation for reading, mathematics and science achievement is 100 points. Thus, for example, the modelled mathematics achievement difference of 41 points between pupils who experienced bullying and pupils who did not is equivalent to roughly two-fifths of a standard deviation.

Variables associated with achievement: All domains

Pupil-level variables

As shown in Table 10.4, seven variables were associated with achievement in all three domains. Having a greater number of books in general, as well as children's books in the home, was positively associated with achievement in reading, mathematics, and science. Pupils who had a TV in their bedroom had lower achievement scores than pupils who did not, and pupils who reported that they owned an iPhone also had lower achievement scores than pupils who did not own one. Frequently being bullied (in this model, experiencing two or more types of bullying at least once weekly) was associated with lower achievement in reading, mathematics, and science. In terms of socioeconomic characteristics, maternal education level was positively associated with achievement, as was the number of full-time jobs held by the pupils' parents. The results for books in the home and maternal education need also to be interpreted with reference to the gender interactions found (as will be described in a later section).

School-level variables

Only one school-level variable was significant in all three models: the average age of pupils in the school was positively associated with achievement; that is, the older the average age of pupils in the school, the higher the achievement scores of individual pupils. However, the effects of age were stronger for mathematics and science than for reading. For reading, a one-year increase in average age was associated with an achievement increase of 36 points, for mathematics, an increase of 59 points, and for science, an increase of 72 points.

Individual pupil age (rather than average pupil age at the school/class level) was not significant in any of the three models.[5]

Table 10.4: Summary of models of achievement in reading, mathematics and science

		Reading	Mathematics	Science
Intercept		466.46	496.83	464.10
Pupil-level variables (reference group)				
Gender (Boy)	Girl	-17.25	-37.42	-33.45
Books at home (26-100 books)	10 books or fewer	-51.64	-57.22	-57.14
	11 to 25 books	-20.40	-29.50	-25.33
	More than 100 books	14.94	13.21	15.89
Children's books at home (26-50 books)	10 books or fewer	**-18.05**	**-22.68**	**-26.71**
	11 to 25 books	**-6.03**	**-2.36**	**-7.53**
	51 to 100 books	**14.35**	**11.33**	**8.73**
	More than 100 books	**25.50**	**16.09**	**12.50**
TV in bedroom (No)	Yes	**-14.03**	**-13.19**	**-14.33**
Own iPhone (No)	Yes	**-31.52**	**-39.58**	**-30.36**
Parents make sure that time is made for homework daily (Less often)		**19.03**	x	**14.86**
Experiences at least 2 types of bullying behaviour at least weekly (No)		**-42.44**	**-41.14**	**-37.04**
Age starting school (5 or younger)	6 or older	23.72	x	**24.12**
Mother's education (Upper secondary, PLC or apprenticeship)	Primary	-20.93	**-16.29**	**-14.20**
	Lower secondary	-12.19	**-7.762**	**-9.67**
	Third level	4.08	**11.10**	**11.52**
Total number of full-time jobs or equivalent (Part-time=0.5)		**12.36**	**12.17**	**8.04**
Additional domain-specific variables (reference group)				
Frequency of reading for enjoyment (Weekly/monthly)	Daily	16.94	x	x
	Never	11.73	x	x
Likes maths/science (Disagree)	Agree		**20.63**	**20.43**
Interactions				
Gender and books at home	Gender*10 books or fewer	**35.26**	**28.60**	**36.44**
	Gender*11 to 25 books	**15.02**	**19.29**	**20.17**
	Gender*more than 100 books	**9.15**	**21.68**	**22.13**
Gender and mother's education	Gender*primary	**-12.22**	x	x
	Gender*lower secondary	**14.37**	x	x
	Gender*third level	**18.12**	x	x
Gender and frequency of reading for enjoyment	Gender*daily	**3.38**	x	x
	Gender*never	**-26.22**	x	x
School-level variables (reference group)		x		
School enrolment size (Medium)	Small	x	**18.51**	**23.64**
	Large	x	**1.00**	**10.85**
School language (English)	Irish	**17.69**	x	x
Average pupil age in years		**36.36**	**59.33**	**71.96**
School emphasis on academic success scale		**5.80**	x	x
Parental support (Medium)	Low	x	**-11.41**	x
	High	x	**14.20**	x

Legend

x	Not in model
	Variable is in an interaction
	Significant p ≤ .05
	Significant p ≤ .01
	Significant p ≤ .001

[5] Even though individual pupil age was not associated with achievement, secondary analyses confirmed that when pupil age *was* included in the models, average pupil age was still significantly positively associated with achievement. This confirms the presence of a contextual effect for age.

Variables associated with achievement: Domain-specific

Pupil-level variables

Although a number of variables were associated with achievement in all three domains, some domain-specific associations were also found. An older school starting age was associated with higher achievement in reading and science, but not in mathematics (even after school average age is taken into account). Pupils' age at the time of the PT 2011 assessment was not associated with achievement in any domain, even when examined on its own during the process of developing the models.

Parents ensuring that time was set aside for homework on a daily basis (rather than less often) was associated with higher reading and science performance, but not with mathematics performance. Frequency of reading (which interacted with pupil gender) was associated with reading achievement, while liking of mathematics was associated with mathematics achievement, and liking of science was associated with science achievement.[6]

School-level variables

Some domain-specific school-level associations with achievement were also found. School enrolment size was associated with achievement in mathematics and science. Pupils in smaller schools had a 19-point advantage in mathematics and a 24-point advantage in science compared with those in medium-sized schools. Pupils in large schools also demonstrated a slight advantage over those in medium-sized schools. For mathematics, there was only a one-point advantage for larger schools compared with medium-sized schools, with an 11-point advantage for science.

School emphasis on academic success was associated with an increase in reading achievement (specifically, a five-point increase in achievement with a one-standard deviation increase on this scale), with no effect observed for either mathematics or science. Likewise, attending an Irish-medium school was associated with an 18-point advantage in reading achievement, with no significant differences observed for mathematics or science.

Teacher-reported level of parental support for pupil achievement was associated with mathematics achievement only. Pupils in schools rated high on parental support had a 14-point advantage over pupils in schools with medium levels of parental support. Pupils in schools where parental support was rated as low scored 11 points lower than pupils did in the medium-support schools.

No school-level variables were associated uniquely with science achievement.

Gender interactions in the models

Most pupil-level variables were related to achievement in the same manner for boys and girls. However, a significant interaction between gender and books in the home was observed for reading, mathematics, and science.

No other variables interacted with gender in their associations with mathematics and science. In contrast, significant interactions between gender and two other variables were found for reading: frequency of reading for enjoyment, and maternal education. Since they are quite detailed, interactions are described in a later section.

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[6] We did not specifically test for significance of associations between these domain-specific variables *across domains* (e.g., we did not examine the association between frequency of reading and mathematics/science achievement).

Variables absent from the models

Some variables associated with achievement in other studies and tested in these models (as shown in Table 10.1), were *not* significantly associated with achievement in PT 2011. At the pupil level, father's education was significantly associated with achievement in all three domains when tested on its own, but was no longer a significant predictor when other pupil characteristics were included in the models. This confirms a stronger association between mother's education and achievement, when other characteristics are taken into account. Also, when tested on its own, the language spoken by pupils at home, if other than English or Irish, was associated with lower achievement (ranging from 19 points in mathematics to 38 points in reading), but was no longer significant in the presence of the other pupil variables. Other pupil-level characteristics that were not associated with achievement in the PT 2011 models were the presence of a computer in the pupil's bedroom, pupils' perceptions of the importance of reading, mathematics, or science, and parental perceived importance of reading.

At the school level, DEIS status was significantly associated with achievement in all three domains when tested on its own, but not when pupil characteristics were included in the models. It is also of note that other indicators of school-level socioeconomic status (e.g., the proportion of parents with a third-level education, and the average number of full-time equivalent jobs held by parents of PT 2011 pupils in the school) were not associated with achievement in the final PT 2011 models. Similarly, principals' perceived problems with pupil absenteeism or lateness was associated with lower achievement when tested on its own (with score differences ranging from 36 to 49 points, depending on the domain), but not in the presence of other variables in the final models.

For some characteristics, associations with achievement were weak or non-significant even when tested on their own. The number of teacher-reported instructional hours devoted to each subject was not associated with pupil achievement in the corresponding domain, nor was teachers' reported specialisation in English, mathematics, or science. Perceived shortage of teachers was not associated with achievement, nor was the scale measuring safe and orderly school climate. Although school size was associated with achievement in mathematics and science, class size was not associated with achievement in any domain.

How much variance in achievement is explained by the models?

Table 10.5 shows the percentage of variance explained by the models shown in Table 10.4. Across all three domains, just over one-quarter of variance is explained (ranging from 26.4% for mathematics, and 27.1% for science, to 27.6% for reading), implying that most of the variation in achievement remains unexplained.[7]

All three models explain a greater proportion of between-school than within-school variation: explained between-school variation ranges from 55.3% for science, and 58.3% for mathematics, to 73.9% for reading. The explained between-school variance is also a function of the amount of variance between schools/classes (Table 10.3), which is lower for reading than for mathematics or science. On their own, the school-level variables do not explain much of the total variation in achievement (ranging from about 4% to 8%) (Table 10.5). These co-vary to some extent with the pupil-level characteristics, as can be seen by

[7] The explained variance is calculated on the basis of the null (or empty) model *plus* missing indicators compared to the final model. That is, we include the achievement variance associated with missing data in the "error" or "unexplained" parts of the models.

comparing the complete model with the pupil-level-variables-only model, in Table 10.5. For example, the model for mathematics explains 26.4% of total variance. Pupil-level variables explain 25.2% of variance, implying that school-level variables explain just 1.2% of variation in achievement over pupil variables. Of the explained variance, a large majority is attributable to pupil gender, parent background and home environment.

Table 10.5: Percentage of variance explained by the models

Model/level	Reading	Mathematics	Science
Complete model	%	%	%
Between	73.9	58.3	55.3
Within	21.7	20.7	20.2
Total	27.6	26.4	27.1
Pupil-level variables only	%	%	%
Between	64.7	44.4	42.7
Within	21.9	21.6	20.3
Total	26.7	25.2	24.7
School-level variables only	%	%	%
Between	34.8	46.7	24.0
Within*	-0.4	-0.3	-0.1
Total	3.6	7.9	5.2
Gender, parent background[a] and home environment[b]	%	%	%
Between	63.2	41.0	37.6
Within	19.4	17.5	18.1
Total	24.3	21.1	21.9
Pupil in school[c]	%	%	%
Between	12.5	16.5	14.9
Within	3.6	5.3	5.2
Total	4.6	7.3	7.4
Pupil engagement/interest in the domain[d]	%	%	%
Between	9.7	-1.3	2.9
Within	3.0	1.1	0.8
Total	3.7	0.7	1.3

Note. Explained variance is estimated on the basis of models with fixed slopes.

*Small negative changes in explained variance associated with the inclusion of the school-level variables only should not be interpreted as a disimprovement in model fit – rather, there is some error around these estimates and these values should be interpreted as no change in model fit.

[a]Mother's education, household employment status.

[b]Books at home, children's books at home, TV in bedroom, own iPhone, parents set aside time for homework.

[c]Age starting school, experience of bullying.

[d]Frequency of reading, liking mathematics, or liking science.

Exploring gender interactions

As noted in the previous section, three pupil-level variables interacted with gender in their association with achievement; these were books at home (for all three domains), frequency of reading for enjoyment (for reading only), and mother's education (for reading only). Figures 10.1a, 10.1b and 10.1c show the expected reading scores of boys and girls for the different categories of books in the home, frequency of reading, and mother's education, respectively (while Table D4 shows the data underlying the figures).

Figure 10.1a: Interaction for reading: Gender and books in the home

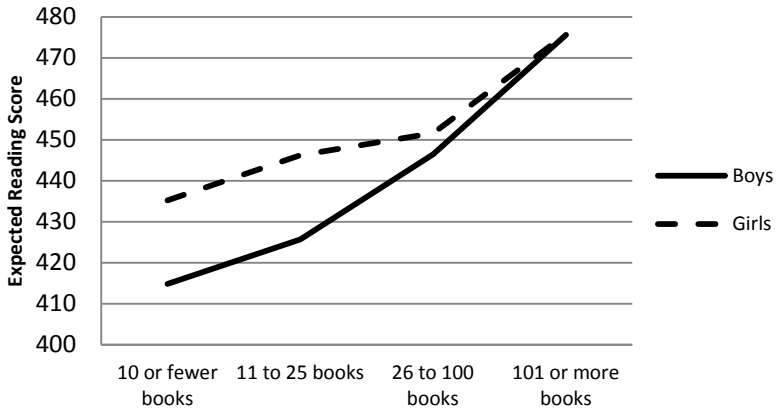


Figure 10.1b: Interaction for reading: Gender and frequency of child's reading for enjoyment

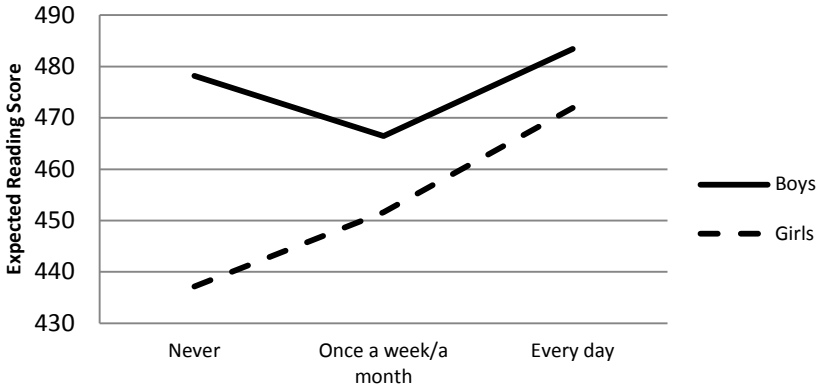


Figure 10.1c: Interaction for reading: Gender and mother's education

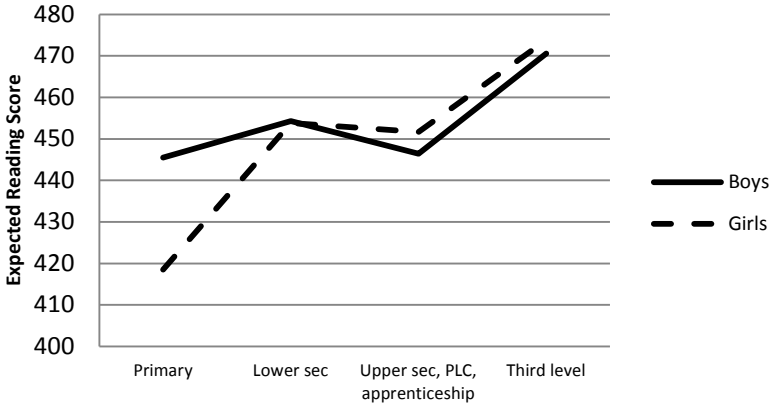


Figure 10.1a shows that there is a stronger association of books in the home with achievement for boys than for girls. Boys reporting the lowest category of books in the home had reading achievement scores that were approximately 20 points below those of girls in the same group, with the achievement gap narrowing with increasing numbers of books. Boys also reported fewer books in their home than girls, on average (Table D4).

In contrast with the stronger association with achievement for boys in relation to books in the home, the associations with reading achievement for both frequency of reading and mother's education were stronger for girls. As shown in Figure 10.1b, more frequent reading was associated with higher reading achievement for girls, with little effect of reading frequency for boys. For mother's education, both boys and girls who had mothers with the

highest level of education had higher reading achievement than those children whose mothers were in the *lowest* education category (Figure 10.1c). However, within this lowest category, girls had reading achievement scores that were more than 20 points behind those of boys, suggesting that low maternal education is associated with more of an achievement disadvantage for girls than boys.

Figures 10.2 and 10.3 show the expected mathematics and science scores of boys and girls for the different categories of books in the home (while Table D5 shows the data underlying the figure). Consistent with the findings for reading (Figure 10.1a), there are stronger associations for boys than for girls. Girls and boys with few books in the home score similarly in mathematics and science. However, at moderately high levels of books in the home, boys have higher scores than girls in both domains.

Exploratory analyses confirmed that the interactions between gender and books in the home occur independently of the other variables in the models for mathematics and science. That is, we compared the parameter estimates for a simple model that included *only* gender, books, and the gender-books interaction with the final model; parameter estimates for the simple model and the final model were almost the same for both mathematics and science. In the case of reading, secondary analysis suggests that although an interaction between books and gender in its relationship with achievement occurs independently of the other variables in the model, the size of the interaction effect increases with the inclusion of maternal education, frequency of reading, and their interaction terms. This suggests that, in the case of reading, there may be a rather complex set of two- or three-way interactions occurring, involving gender, books, frequency of reading, and maternal education. This is not explored further in the present chapter.

Figure 10.2: Interaction for mathematics: Gender and books in the home

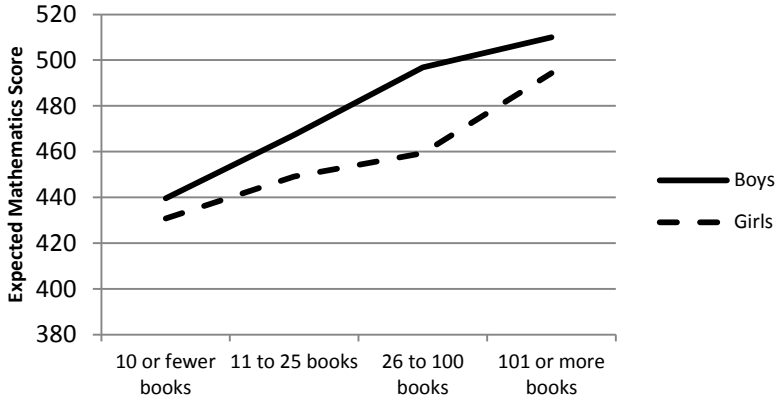
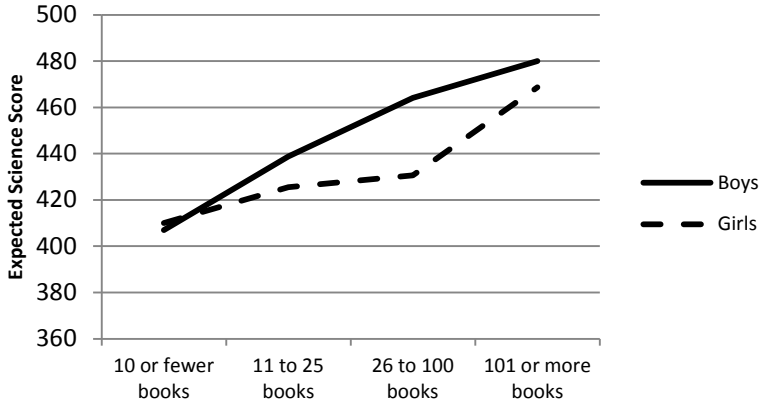


Figure 10.3: Interaction for science: Gender and books in the home



Variation in the strength of the relationship between pupil characteristics and achievement

The associations between most pupil characteristics and achievement were consistent from school to school. However, four variables did vary significantly in their associations with achievement across schools. These were age starting school (for reading only), being bullied (for mathematics and science), number of jobs per household (mathematics), and setting aside time for homework (science).

With respect to age starting school, Table 10.6 shows a strong negative correlation between the intercept and the slope, meaning that the relationship between age starting school and reading achievement is *stronger* in schools with *lower* average reading achievement. There are no significant associations between the intercepts and slopes for being bullied and achievement in mathematics and science. This indicates that, although the relationship between being bullied and achievement differs from school to school, it does not differ in a consistent manner.

The slope for number of jobs in the household has a strong positive correlation with school average mathematics achievement, meaning that the relationship is *weaker* in schools with lower average achievement. Finally, there is a strong negative correlation between setting time aside for homework (for all subjects) and achievement in science (i.e., the relationship is *stronger* in schools with lower average achievement).

Table 10.6: Pearson correlation coefficients between intercepts and slopes for pupil-level variables with significant slope variation, all domains

	Reading	Mathematics	Science
Age starting school	-.87**[a]	-	-
Bullied	-	.02#[b]	-.02#[d]
Number of jobs in household	-	.57**[c]	-
Parents set aside time for homework daily	-	-	-.74**[e]

Note: **$p < .001$, # indicates no significant correlation between intercept and slope for that variable.

[a]Based on 146 classes.
[b]Based on 163 classes.
[c]Based on 211 classes.
[d]Based on 163 classes.
[e]Based on 195 classes.

The relationships between these pupil characteristics and achievement are illustrated in Figure 10.4, in order to provide a visual representation of the information shown in Table 10.6. The graphs in Figure 10.4 were generated on the basis of a random sample of 25% of class groups, since including all 211 groups would have resulted in very over-crowded graphs.

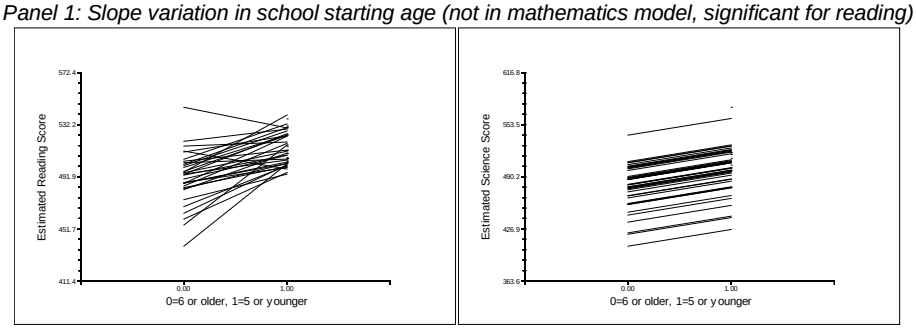
In Panel 1, a fanning-in of lines can be observed from the left to the right of the graph for reading. This implies that with higher average school reading achievement, the relationship with school starting age is weaker. The graph for school starting age and science achievement shows a series of parallel lines, which illustrates that the strength of the relationship is the same across schools, regardless of their average science achievement.

Panel 2 illustrates the slopes for frequent bullying, which vary across schools in the models for mathematics and science, but not reading. Although the lines are not parallel for mathematics and science, there is no discernible pattern (such as was evident in the graph for reading and school starting age).

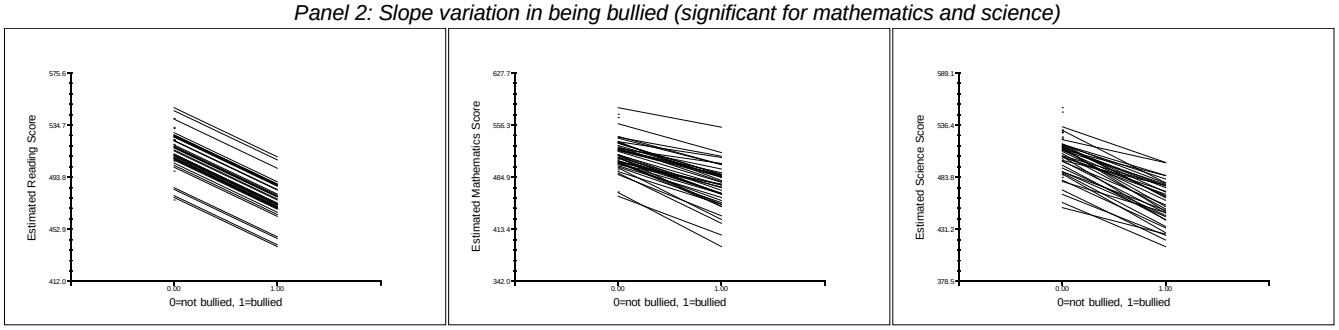
Panel 3 shows slope variation associated with the number of full-time jobs held by pupils' parents and achievement in all three domains. For reading and science, these are fixed or parallel. In contrast, they cross over for mathematics, with slightly steeper lines (implying greater variation between schools) for schools with higher average achievement.

Figure 10.4: Graphs of slope variation in pupil-level variables that are significant in one or more models

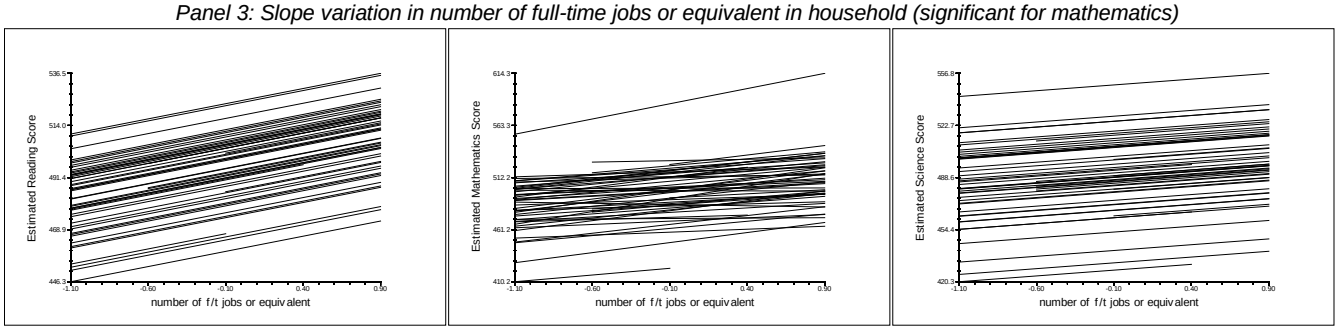
Panel 1: Slope variation in school starting age (not in mathematics model, significant for reading)



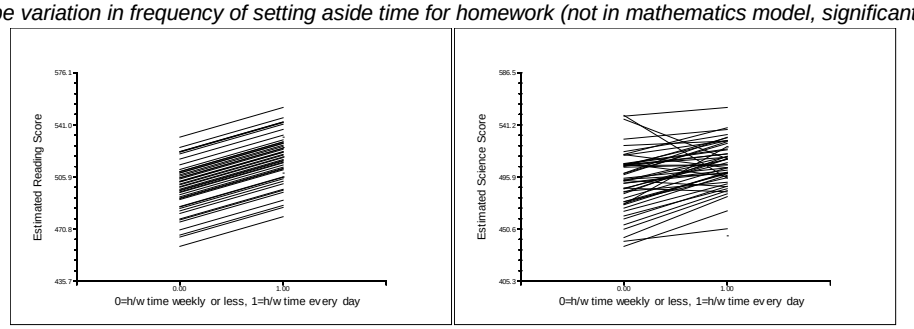
Panel 2: Slope variation in being bullied (significant for mathematics and science)



Panel 3: Slope variation in number of full-time jobs or equivalent in household (significant for mathematics)



Panel 4: Slope variation in frequency of setting aside time for homework (not in mathematics model, significant for science)



Note. Graphs are based on a random sample of 25% of classes.

Panel 4 illustrates the slopes associated with frequency of setting time aside for homework, for reading and science achievement. For reading, the lines are parallel, indicating no slope variation, but for science, a fan-pattern is evident, similar to the one for reading in Panel 1. This indicates that for higher average school science achievement, the relationship with setting aside time for homework is weaker.

Further examination of the (lack of) social context effect

Previous studies have observed a social context effect for achievement, whereby pupil achievement is adversely affected by the presence of high densities of pupils from disadvantaged backgrounds. Within multilevel analysis, a strict definition of the social context effect is the finding of a statistically significant relationship between individual-level socioeconomic characteristics *and* the cluster-level (or school-level) aggregates of these same characteristics. Our analyses emphasise DEIS as the school-level measure of socioeconomic characteristics rather than pupil-level aggregates since (i) DEIS is of wide interest and policy relevance and (ii) those school aggregates that *were* initially included (e.g., proportion of parents with university education; average number of full time equivalent jobs per household) became non-significant in the presence of the DEIS indicator. The presence of a social context effect is widely acknowledged, both in Ireland (e.g., McCoy, Quail & Smyth, 2012; Perkins et al., 2012) and internationally (e.g., Chiu & McBride-Chang, 2006; OECD, 2010). In Ireland, Sofroniou et al. (2004) found that primary school pupils' reading and mathematics scores decreased relative to the proportion of pupils in the school whose families held a medical card, even controlling for the individual pupils' own medical card possession. However, the PT 2011 results indicated that, over and above pupil characteristics, school socioeconomic characteristics are *not* significantly associated with achievement. In fact, the only variable at the school level that was consistently related to achievement was pupil average age. As this contrasts with the findings of these earlier studies, it merits further examination. We examined two possibilities: first, that a social context effect was being obscured by grouping pupils by class rather than school for the analyses, and second, that DEIS status (an important index of socioeconomic disadvantage) is associated with achievement when pupil-level disadvantage is *not* included in the models.

Possible dilution of the social context effect

It is possible that grouping pupils by class for the analyses may have "diluted" the social context effect. However, this is somewhat unlikely, given that between-class variance, overall, is quite low (Table 10.3). Nonetheless, to examine this possibility, the final models were re-analysed using school rather than class as the cluster variable.[8] The results are shown in Table E1 (Appendix E) and are very similar to those shown in Table 10.4. This suggests that using class rather than school as the cluster variable has no substantive effect on the significance of school-level socioeconomic variables for the PT 2011 models.

Table E2 (Appendix E) shows the variance explained by the models shown in Table E1, which is very similar to that explained by the models in Table 10.4 (and shown in Table 10.5). Furthermore, Table E2 indicates that the addition of schools' DEIS status explains very little additional variation in achievement – just 0.3% for reading, 0.7% for mathematics, and 1.1% for science. The results suggest that the absence of a social context effect, at least for DEIS status, is not attributable to the use of class as the cluster variable.

[8] In the case of mathematics, parental support was omitted from the model, since this was a measure derived from the Teacher Questionnaire, and as such, is a class- rather than school-level variable.

DEIS status and achievement, with and without accounting for pupil characteristics

An alternative explanation is that more detailed pupil-level model specification (in comparison with some previous studies) results in a diminished effect for school-level socioeconomic characteristics (in this case, school DEIS status). The present study includes a wide range of pupil characteristics. In comparison, the study by Sofroniou et al. (2004), for example, included only gender and medical card possession at the pupil level. It is possible therefore that the present study represents a more detailed understanding of how the social context effect may operate at the individual pupil level. To investigate this, we examined the associations between DEIS and achievement, with and without accounting for (i) pupils' gender and socioeconomic characteristics and (ii) pupils' home environments. Four models were estimated and compared as follows, for each of the three domains:

Model 1: School DEIS status only.

Model 2: School DEIS status with pupil gender and socioeconomic background (i.e., mother's education, and number of full-time jobs in the household).

Model 3: School DEIS status with pupil home environment (i.e., books in the home, children's books in the home, having a TV in the pupil's bedroom, pupil owning an iPhone, and parents ensuring that time is set aside for homework on a daily basis).

Model 4: School DEIS status, pupil gender and socioeconomic background, and pupil home environment (i.e., Models 2 and 3 combined).

Table 10.7 shows the parameter estimates associated with DEIS status when considered on its own, and in conjunction with pupil gender and socioeconomic characteristics, and their home environments.

Table 10.7: Parameter estimates for school DEIS status, with and without adjustments for pupils' gender and socioeconomic characteristics, and pupils' home environments

	Reading		Mathematics		Science	
DEIS on its own (Model 1)	Estimate	SE	Estimate	SE	Estimate	SE
DEIS Urban 1	-70.62	12.69	-81.47	13.55	-81.24	14.60
DEIS Urban 2	-67.47	8.80	-77.78	15.42	-90.34	17.94
DEIS Rural	-0.90	9.54	-18.63	17.73	-15.44	18.08
DEIS with gender and socioeconomic background (Model 2)	Estimate	SE	Estimate	SE	Estimate	SE
DEIS Urban 1	-39.92	9.281	-55.90	11.980	-57.852	13.360
DEIS Urban 2	-43.70	9.336	-63.17	16.160	-76.134	18.519
DEIS Rural	5.584	8.269	-9.23	14.517	-7.155	14.656
DEIS with home environment (Model 3)	Estimate	SE	Estimate	SE	Estimate	SE
DEIS Urban 1	-21.63	9.991	-36.02	12.376	-35.48	12.733
DEIS Urban 2	-37.17	10.408	-47.66	17.536	-60.96	19.036
DEIS Rural	11.83	8.599	-6.29	17.369	-2.61	17.568
Model 4 (Model 2 + Model 3)	Estimate	SE	Estimate	SE	Estimate	SE
DEIS Urban 1	-14.76	8.862	-26.72	11.214	-28.02	12.208
DEIS Urban 2	-33.12	10.280	-45.95	16.356	-59.33	18.452
DEIS Rural	13.52	7.764	-0.41	14.542	2.21	14.757

Model 1 suggests that there are substantial differences between DEIS Urban Band 1 and Band 2 schools and non-DEIS schools in average achievement. Pupils in Band 1 schools have an expected reading score that is 71 points or over two-thirds of a standard deviation lower than that of pupils in non-DEIS schools; similarly, pupils in Urban Band 2 schools have an expected score that is 67 points lower. In contrast, there is no difference in the expected reading achievement of pupils in rural DEIS schools and pupils in non-DEIS schools (with an estimate of just -0.9 points). That is, pupils in DEIS Band 1 and Band 2 schools have significantly lower achievement than those in non-DEIS schools, with no significant difference between rural DEIS and non-DEIS pupils.

Comparing these results with the estimates for DEIS when pupil characteristics are taken into account, it can be seen that the achievement differences for the latter models are considerably smaller. Taking mathematics as an example, the unadjusted achievement difference between pupils in non-DEIS schools and pupils in Band 1 Urban schools is -81 points. This decreases to -56 points when pupil gender and socioeconomic background are taken into account, and to -36 points when home environment is taken into account. It decreases further to -27 points when gender, socioeconomic background, *and* home environment are taken into account. A comparison of Models 2 and 3 shows that pupils' home environments are at least as important as their socioeconomic backgrounds in explaining achievement differences between DEIS and non-DEIS schools. Model 4 suggests that there is a good deal of covariance between Models 2 and 3, that is, more socioeconomic disadvantage tends to be associated with less positive home environments. It can be inferred from the results presented here and in Table 10.4 that the achievement differences that still remain between urban DEIS and non-DEIS schools are due largely to pupils' reports of being bullied and differences in engagement in reading, and enjoyment of mathematics and science. Table 10.7 also indicates that disadvantage operates differently in rural and non-rural DEIS schools in terms of its associations with achievement, both with and without taking account of pupils' characteristics.

Table E3 (Appendix E) shows that over and above pupil gender, socioeconomic background and home environment, school DEIS status explains just 0.9% of additional variation in reading achievement, 1.5% in the case of mathematics, and 2.2% in the case of science. Over and above gender and socioeconomic background *only*, school DEIS status explains 3.6% of variation in reading achievement, 3.7% in mathematics achievement, and 4.6% in science achievement. Therefore, the size of the social context effect is dependent upon which pupil-level characteristics are included in the models, and appears larger when gender and socioeconomic background, but not home environment, are taken into account. This latter finding provides support to the hypothesis that the inclusion of a wider range of pupil characteristics results in a reduction in the social context effect.

Further examination of books in the home: Pupils' and parents' reports

This section provides more detail on the association between books in the home and achievement. It should be noted that self-reports are subjective measures – that is, we do not have information on the *actual* number of books in the pupils' homes. PT 2011 collected estimates from both pupils and parents on the number of books in their home, but only the pupil-reported data were used in the multilevel models.[9] The pupil- and parent-reports were

[9] Analyses using the *parent*-reported books in the home variable indicated that it was not associated with achievement in any domain. This suggests that the association between books in the home and achievement may be contingent on the pupils' perception of the books, or that the method by which pupils were asked the

only moderately inter-correlated ($r = +.50$, $p < .001$), indicating that pupils and parents did not always agree on the number of books in their home.

The distribution of pupil- and parent-reported books in the home, overall and by gender, is shown in Table 10.8, while the cross-tabulation of pupil- and parent-reported books in the home is shown in Table 10.9. To examine agreement between pupil- and parent-reported books in the home, a difference score was computed (i.e., a score indicating the difference between pupil- and parent-reported books in the home).

Overall, less than 40% of pupil-parent reports were in agreement on the number of books in the home. Pupil-parent reports were in agreement for girls more often than for boys (Table 10.10). The parents of boys were more likely to report greater number of books in the home relative to their children, compared to the parents of girls. Chi-square analyses confirm that these discrepancies between pupil- and parent-reported books in the home differed significantly for boys and for girls ($\chi^2 = 65.48$, $df = 8$, $p < .001$). One interpretation of the results is that girls are more likely to perceive the books that are in their home, which is why they are more likely to agree with their parents on the quantity of books. Conversely, it is possible that boys are not engaging with the reading material in their homes, and this is why parents report greater number of books in the home relative to their sons.

Table 10.8: Frequencies of categories of books in the home: Pupil and parent reports

Overall (%)	0-10		11-25		26-100		101-200		200+	
Books in the home (pupil)	9.9		22.4		34.2		18.5		14.9	
Books in the home (parent)	9.8		16.9		33.4		18.3		21.6	
By gender (%)	Girls	Boys	Girls	Boys	Girls	Boys	Girls	Boys	Girls	Boys
Books in the home (pupil)	6.3	13.5	19.0	25.6	36.5	32.0	21.5	15.6	16.7	13.2
Books in the home (parent)	9.3	10.2	16.6	17.3	33.1	33.7	18.5	18.1	22.5	20.8

Table 10.9: Cross-tabulation of books in the home (pupil by parent reports)

Books in the home (pupil)	Books in the home (parent)					Total %
	0-10	11-25	26-100	101-200	200+	
None or few (0-10)	3.0	2.6	2.4	0.9	0.3	9.1
One shelf (11-25)	3.4	6.4	8.4	2.2	1.6	21.9
One bookcase (26-100)	2.1	5.8	15.4	6.4	5.1	34.7
Two bookcases (101-200)	0.8	1.7	5.0	5.4	5.9	18.9
Three+ bookcases (200+)	0.4	0.5	2.0	3.4	8.9	15.3
Total %	9.7	17.0	33.3	18.2	21.8	100.0

Note. The percentages shown include only cases with responses for both parents' and pupils' reports of books. As such, they differ slightly from those in Table 10.8.

Table 10.10: Pupil-parent agreement on books in the home

	Pupils report more books	Agreement	Parents report more books
Overall (%)	25.2	39.2	35.6
Girls	27.8	41.6	30.6
Boys	22.6	36.8	40.7

question generated more accurate responses (children were given schematic images of books on shelves to help them estimate the number, while parents were not).

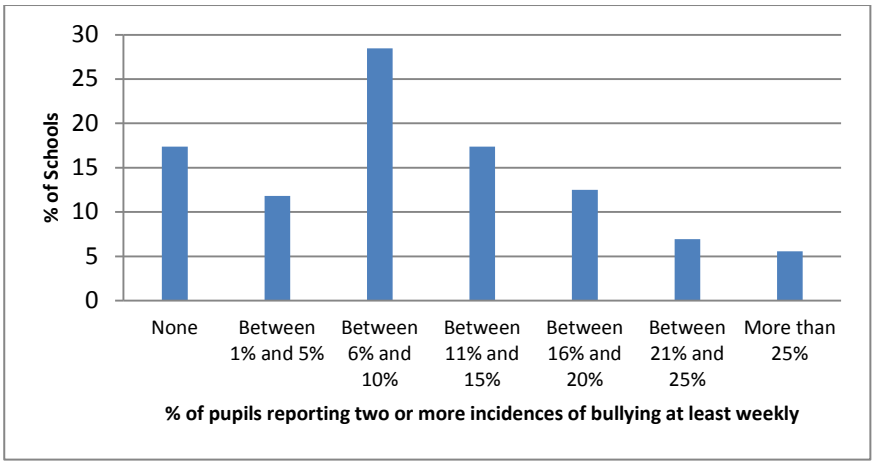
Between-school variation in bullying

Bullying has consistently been shown to have adverse effects on the social, emotional, physical and educational well-being of children (e.g., Harel-Fisch et al., 2011). The incidence of bullying (as measured by the PT 2011 *Students Bullied at School Scale*) was low in Ireland relative to other countries who took part in PT 2011. Pupils' reports of bullying emerged as being significantly associated with lower achievement in all three domains, in Ireland and internationally (Martin et al., 2012; Mullis, Martin, Foy, & Arora, 2012; Mullis, Martin, Foy, & Drucker, 2012). Chapter 3 in this volume (Clerkin & Creaven, 2013), provides further information on this scale, and highlights some variation in the frequencies of different types of bullying behaviours between pupils in Ireland.

In this chapter, as noted earlier, a modified, dichotomous version of the scale was used, with emphases on frequent and multiple forms of bullying. The present results confirm that bullying is an issue in relation to achievement. Pupils' reports of frequent bullying emerged as being significantly associated with achievement in all three domains. Pupils who reported that they had been bullied scored around two-fifths of a standard deviation lower than pupils who did not report this, after taking other variables in the models into account. The strength of the relationship between bullying and achievement also varied across schools for mathematics and science, but not for reading.

Analysis of the distribution of pupils' reports of bullying across schools indicates wide variation. For example, in 25 schools (17.4% of schools included in the analyses) *no* pupils reported two or more incidences of bullying at least weekly, while these rates exceeded 20% in 19 schools (12.5% of the sample) (Figure 10.5). This finding may be relevant to the interpretation of the random slopes for bullying for mathematics and science shown in Figure 10.4. That is, it may be the case that the relationship between bullying and achievement is stronger in schools where incidences of bullying are higher; however, this issue is not explored further here.

Figure 10.5: Percentages of schools with varying incidences of pupils reporting two or more incidences of bullying at least weekly



Summary and conclusions

This chapter examined the achievements of Fourth class pupils in PT 2011 through three multilevel models, one for each of reading, mathematics and science. The analyses grouped the data into two levels – school and class combined, and pupil. The objectives of the analyses were to identify those combinations of background characteristics that best explained variation in achievement, and to describe commonalities and differences in the variables associated with achievement in reading, mathematics and science.

An initial examination of between-school/class variance indicated that schools/classes in the Irish PT 2011 sample do not differ much with respect to achievement. About 13% of the variation in reading achievement was between schools or classes, and this was slightly higher for mathematics (18%) and science (22%). International comparative data on between-school differences were not available at the time of writing.

A wide range of background characteristics from the PT 2011 Irish database was examined (Table 10.2 in this chapter lists all of the characteristics considered). At the pupil level, these included gender, age starting primary school, home language, books and children's books at home, having a TV and computer in the bedroom, owning an iPhone, experiencing bullying in school on a frequent basis, parental education, and number of parental full-time jobs. At the cluster level, some of the measures (DEIS status, average parental education and employment status, and proportion of pupils with a first language other than English or Irish) were included specifically to test for the presence of a social context effect. Variables that are domain-specific were also included at both pupil and cluster levels (e.g., pupils' perceived importance of reading, mathematics and science; class hours of instruction per week in English, mathematics and science).

Results indicated that several pupil-level variables were associated with achievement in all three domains: these were books and children's books at home, maternal (but not paternal) education, number of full-time jobs in pupils' households (all positively associated), and having a TV in the bedroom, owning an iPhone, and experiencing bullying on a "frequent" basis (all negatively related to achievement). Just one school-level variable was significantly associated with achievement in all three domains – school average age (the older the average age, the higher the expected achievement scores).

Some characteristics showed statistically significant associations with achievement in one or two, but not all three of the domains. Overall, results suggest that the models for reading and science achievement are similar to one another but somewhat different to the model for mathematics. Parents setting time aside for homework and school starting age were both positively associated with achievement in reading and science (but not mathematics). Engaging in frequent reading for enjoyment was positively associated with reading achievement, while liking mathematics and science were positively associated with achievement in the two corresponding domains. In the case of mathematics and science, pupils in smaller schools had higher achievement scores, relative to medium and large schools. Also, pupils in Irish-medium schools had significantly higher reading scores than pupils in English-medium schools, but there was no difference between these two school types for mathematics and science achievement. The scale measuring school emphasis on academic success had a small positive association with achievement in reading only, while level of parental support was weakly, though significantly, associated with mathematics achievement only.

It is noteworthy that most of the school- or class-level characteristics were not significantly associated with achievement in any domain, once account was taken of the pupil demographic and socioeconomic characteristics, as well as to bullying and engagement with the domain in question. Significant school-level variables explained only very small and

substantively trivial amounts of variation in achievement over and above pupil characteristics, though it should be recalled that schools do not differ greatly to one another in average achievement in the first place. None of the measures relating to the socioeconomic context (DEIS status, average parental education, average employment status, EAL status of pupils) retained a significant association with achievement, over and above the pupil characteristics in the model.

This contrasts quite strongly with previous research on the social context effect (e.g. McCoy et al., 2012; Perkins et al., 2012). Earlier, we contrasted these results with those conducted by Sofroniou et al. (2004) who analysed the social context effect using data from the 1998 National Assessments of Mathematics and the 1999 National Assessments of English at primary level. Aside from the differences in the survey designs and contents between PT 2011 and the National Assessments, it is possible that the inclusion of a range of pupil characteristics in the models described here account for some of the observed social context effect, since the analyses in Sofroniou et al. included only gender and medical card status at the pupil level. It is also possible that a "real" reduction in the social context effect (and hence socioeconomic inequity) has occurred in the intervening period between the collection of the data used by Sofroniou et al. (1998/1999) and PT 2011. To address these two possibilities, the Educational Research Centre will be exploring the National Assessments datasets further, initially by replicating the analyses conducted by Sofroniou et al. on the 1998/1999 data with the 2004 and 2009 National Assessments datasets.

Specific to DEIS, though, it is worth noting that the nature of educational disadvantage and its relationship to achievement in rural DEIS schools has been examined by Weir, Archer and Millar (2009), who have found that the relationship between socioeconomic characteristics and achievement in reading and mathematics in rural and urban schools is different, both quantitatively and qualitatively. Results presented here are consistent with Weir et al. (2009) in that they show that, once adjustments are made for pupil background, children in rural DEIS schools do slightly better on reading than their non-DEIS counterparts. Rural disadvantage is an area of current and ongoing investigation by the Educational Research Centre.

It should be borne in mind also that the DEIS measures of socioeconomic disadvantage were based on data collected in 2005. Hence, there is a possibility that these measures are now becoming outdated, at least in some schools, which may have experienced changes in their pupils' intake characteristics due, for example, to changes in the socio-demographic characteristics of the schools' local communities.

Perhaps more important than the up-to-dateness of the socioeconomic measures associated with DEIS is the fact that this classification is both an indicator of socioeconomic disadvantage *and* a means whereby schools (and pupils) receive specific, targeted supports. That we failed to find a significant association between school DEIS status and achievement in our final models could in part be due to improvements in the achievements of children in DEIS schools as the interventions and supports begin to take effect. Indeed, Weir, Archer, Flaherty and Gilleece (2011) found significant improvements in the reading and mathematics test scores of pupils in DEIS primary schools in comparisons of standardised test results administered in 2007 and 2010.

Interactions between gender and books in the home in their relationships with achievement make the interpretation of gender differences in achievement difficult. These gender interactions occur largely independently of the other variables in the models; that is, the stronger association between books in the home and achievement for boys than for girls is not contingent upon the other variables in the models. In the case of reading, the issue is complicated by the presence of two further gender interactions with frequency of reading for

enjoyment and maternal education. Preliminary secondary analyses also suggest that more complex two- or three-way interactions may underlie the results for reading. Further examination of the gender interactions for reading is therefore warranted.

With respect to the measure of books in the home more generally, we noted that boys, on average, reported fewer books in their homes than girls. Comparisons with parents' reports of the numbers of books in the home indicates that girls' reports of books agreed with parents' reports more frequently than did boys' reports. Thus, it may be the case that it is the *perception* of the numbers of books in the home that is underpinning the gender-books interactions, or there could be a gender bias in the reporting of books in the home that is arising for some other reason. In either case, we recommend further examination of the relationships between books in the home and the achievement of boys and girls. One possible useful source is the comparative data from the PT 2011 international dataset, since this would provide information on the extent to which the findings may or may not be considered unique to Ireland. This is of potential importance, given the widespread use and interpretation of high numbers of books in the home as an indicator of an educationally-supportive home climate in both national and international surveys of pupil achievement, in the absence, in our view, of a sufficient reflection on what the indicator is actually capturing. An example of this is the results of a comparative study of books in the home (Evans, Kelley, Sikora, & Treiman, 2010), whose results were widely cited in the media on their publication. Their abstract (p. 171) states:

> Children growing up in homes with many books get 3 years more schooling than children from bookless homes, independent of their parents' education, occupation, and [social] class. This is as great an advantage as having university educated rather than unschooled parents, and twice the advantage of having a professional rather than an unskilled father. It holds equally in rich nations and in poor; in the past and in the present; under Communism, capitalism, and Apartheid; and most strongly in China. Data are from representative national samples in 27 nations…

The PISA 2009 dataset could also be explored further with the books in the home issue in mind, since an interaction similar to that found in the present study was observed in multilevel analyses of PISA 2009 reading (Perkins et al., 2012). Finally, it should be noted that the measure of books in the home does not take electronic reading resources (such as e-books or e-readers) into account; nor does it take account of how patterns of reading may have changed alongside developments in digital communications technology (see, for example, OECD [2013]), indicating a clear need to develop and enhance indicators of educationally-supportive home environments for use in future educational surveys.

Related to this, we found substantively important negative associations with pupils having a TV in their bedroom (consistent with Eivers et al., 2010 and Gilleece, Shiel, Clerkin, & Millar, 2012) and owning an iPhone. Moreover, we noted that 53% of pupils had a TV in their bedroom, and 12% reported owning an iPhone, indicating that the issue is quite widespread. This underlines the need for further and ongoing research that keeps abreast of technological developments and changes in children's leisure activities in order to help inform parents about practices that may benefit their children's education.

We found that Irish-medium schools out-performed their English-medium counterparts in reading (but not mathematics or science) by about one-sixth of a standard deviation, after adjusting for the other variables in the model. This is largely consistent with findings from the National Assessment of Irish Reading and Mathematics in Irish-Medium Schools (Gilleece et al., 2012), where pupils in scoileanna lán-Ghaeilge outperformed the NA 2009 pupils in reading by 17 points (or one-third of a standard deviation), and pupils in

Gaeltacht schools outperformed NA 2009 pupils by 3 points (just under one-tenth of a standard deviation) (achievement differences not adjusted for any background characteristics; reading achievement in scoileanna lán-Gaeilge was about what would be expected based on SES, and below what would be expected for mathematics). In mathematics, achievement differences were in the order of one-sixth of a standard deviation. The PT 2011 sample was not explicitly designed to facilitate detailed comparisons of achievement by language of instruction; however, it may be the case that bilingualism, a common feature of many pupils in Irish-medium schools, provides an advantage in reading. For a review of some previous research on this issue, see Chapter 1 of Gilleece et al. (2012).

The detection of random slopes for some of the pupil-level variables in the models has potential policy implications, but these findings would need to be corroborated with other data sources to help interpretation. That the relationship between bullying and achievement varies across schools (as does the incidence of bullying) implies that some schools are highly successful in promoting a safe and respectful environment, while others may struggle to do so, and that in some schools, there is a stronger negative association between bullying and achievement than in others. These may be for reasons relating to the characteristics of pupils in the school, or factors outside of the school (see also Clerkin & Creaven's [2013] analyses in Chapter 3, describing variation in bullying across sub-groups of pupils). In any case, the association between bullying and achievement was found to be substantial in the present study in all three domains, and it is recommended that further research be carried out in this area, drawing on other datasets, including data from the Growing Up in Ireland study (which collected both quantitative and qualitative information) and PISA (which collected quantitative information on bullying from 15-year-old students in 2006 and 2009). It would seem important to include explicit measures of cyber bullying in any analyses or review of this issue, since the PT 2011 bullying measure did not include it as an explicit component of the scale.

Random slopes for school starting age were also found in the case of reading and science whereby the lower the school average achievement, the stronger the (positive) association between age and achievement. This finding should be interpreted with respect to the fact that school average age was also positively associated with achievement in all three domains (individual pupil age was not). In a broad sense, these findings suggest that school policies on enrolment age merit review, particularly in light of the national Early Childhood Care and Education scheme, which has been available since 2010. As part of this, a review of research on those characteristics that are relevant to differences in school readiness between children would be useful, in order to guide policy and practice.

Overall, the models explain only a little over one-quarter of the variation in achievement in reading, mathematics and science, meaning that a majority of the achievement differences between pupils remains unaccounted for. This is important, since it implies that quantitative analysis techniques based on cross-sectional designs may only go so far in addressing questions as to what makes a difference with respect to pupils' achievement. Longitudinal data, where a cohort of children is tracked over time, and whose achievement is measured at at least two time-points, offers a better way to address this question, but at present, there is a dearth of Irish longitudinal educational survey data. However, the availability of the second wave of the GUI data has the potential to add to our general understanding of changes in achievement over time, since 9-year-olds, assessed in September 2007-June 2008, were again assessed in August 2011-March 2012 (see www.growingup.ie).

It is also relevant to note that cross-sectional survey data cannot adequately or fully capture the more complex and subtle aspects relating to school and class climate, and the processes underlying teaching and learning in classrooms. This indicates a need to supplement quantitative findings with high-quality observational or interview data to inform

policy and practice in these areas. In other words, that the models failed to find significant associations with measures relating to school climate, teacher or class characteristics does not suggest that they are unimportant; rather that multilevel modelling can only go so far in informing us about these issues. Finally, one can always expect some tension between the aims and design of an international survey and its correspondence to characteristics of national education systems. Some of the teacher measures, in particular teacher specialisation in reading, mathematics or science, are of less relevance in the Irish context than may be the case in other countries that took part in TIMSS and PIRLS and which do have specialist teacher education programmes for primary level teaching.

Additional references

This section does not repeat the core references already listed in Chapter 1. These include the three international reports on PT 2011 and the Irish national report and those related to other key studies such as National Assessments and PISA.

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Appendix A

Table A1. Pupil and school/class characteristics used in modelling achievement in PT 2011

Name	Source	Type	Description
Pupil-level variables			
Reading, mathematics and science achievement	Test	Continuous	Each domain with five imputed scores/plausible values, standardised to have a combined mean of 500 and sd of 100
Gender	Pupil Tracking Form	Categorical	0=boy, 1=girl
Age	Pupil Tracking Form	Continuous	Mean=10.35, SD=0.41
Home language*	Pupil & Parent Questionnaires	Categorical	0=Other, 1=English, with Irish coded as missing (due to small numbers of pupils in this group)
Test language	Test	Categorical	0=English, 1=Irish (does not apply to PIRLS)
Books at home*	Pupil Questionnaire	Categorical, dummy variables	10 books or fewer, 11-25 books, 26-100 books, More than 100 books, with 26-100 books as the reference group
Children's books at home	Parent Questionnaire	Categorical, dummy variables	10 books or fewer, 11-25 books, 26-50 books, 50-100 books, more than 100 books, with 26-50 books as the reference group
TV in bedroom	Pupil Questionnaire	Categorical	0=no, 1=yes
Computer in bedroom	Pupil Questionnaire	Categorical	0=no, 1=yes
Own iPhone	Pupil Questionnaire	Categorical	0=no, 1=yes
Parents set aside time for homework*	Pupil Questionnaire	Categorical	0=less than daily basis, 1=on daily basis
Experiences bullying	Pupil Questionnaire	Categorical	0=no, 1=yes, based on experiencing two or more of six forms of bullying at least weekly
Age started school	Parent Questionnaire	Categorical	0=6 or older, 1=5 or younger
Mother's education*	Parent Questionnaire	Categorical, dummy variables	Primary, lower secondary, upper secondary or PLC/apprenticeship, third level, with upper secondary or PLC/apprenticeship as the reference group
Father's education*	Parent Questionnaire	Categorical, dummy variables	Primary, lower secondary, upper secondary or PLC/apprenticeship, third level, with upper secondary or PLC/apprenticeship as the reference group
Number of jobs in household*	Parent Questionnaire	Continuous	Mean=1.13, SD=0.66; part-time employment status coded as 0.5
Parents - time spent reading per week	Parent Questionnaire	Categorical, dummy variables	Less than one hour a week, 1-10 hours a week, more than 10 hours a week, with 1-10 hours a week as the reference group
Parents - perceived importance of reading*	Parent Questionnaire	Categorical	0=disagree/strongly disagree that reading is important, 1=agree/strongly agree that reading is important

Table A1: Pupil and school/class characteristics used in modelling achievement in PT 2011 (continued)

Domain-specific pupil variables			
Pupil - frequency of reading for enjoyment*	Pupil Questionnaire	Categorical, dummy variables	Never, once a week or once a month, every day, with once a week or once a month as the reference group
Pupil - perceived importance of reading*	Pupil Questionnaire	Categorical	0=disagree/strongly disagree that reading is important, 1=agree/strongly agree that reading is important
Pupil - perceived importance of mathematics*	Pupil Questionnaire	Categorical	0=disagree/strongly disagree that mathematics is important, 1=agree/strongly agree that mathematics is important
Pupil - liking of mathematics*	Pupil Questionnaire	Categorical	0=disagree/strongly disagree that they like mathematics, 1=agree/strongly agree that they like mathematics
Pupil - perceived importance of science*	Pupil Questionnaire	Categorical	0=disagree/strongly disagree that science is important, 1=agree/strongly agree that science is important
Pupil - liking of mathematics*	Pupil Questionnaire	Categorical	0=disagree/strongly disagree that they like science 1=agree/strongly agree that they like science
Missing indicator for parent questionnaire	N/A	Categorical	0=not returned, 1=returned
School/class-level variables			
School size	PT 2011 Sampling Datafile	Categorical, dummy variables	Twenty or fewer eligible pupils, 21 to 34 eligible pupils, 35 or more eligible pupils, with 21 to 34 eligible pupils as the reference group.
Urban-rural status	PT 2011 Sampling Datafile	Categorical, dummy variables	City or large town (population 10,000 or more), small town or village (population 1,000 up to 10,000), rural community (population less than 1,000), with small town or village as the reference group
DEIS status	PT 2011 Sampling Datafile	Categorical, dummy variables	DEIS band 1, DEIS band 2, DEIS rural, not under DEIS, with not under DEIS as the reference group
School language of instruction	PT 2011 Sampling Datafile	Categorical, dummy variables	0=English, 1=Irish
Proportion of parents with university education	Parent Questionnaire	Continuous	Mean=0.32, SD=0.19
Average number of full time equivalent jobs per household	Parent Questionnaire	Continuous	Mean=1.09, SD=0.25
Proportion of pupils with another first language	Pupil and Parent Questionnaires	Continuous	Mean=0.06, SD=0.08
Proportion of female pupils	Pupil Questionnaire	Continuous	Mean=0.48, SD=0.29
Average pupil age in years	Pupil Questionnaire	Continuous	Mean=10.35, SD=0.14

*Variable has a missing indicator to preserve cases in the dataset.

Table A1: Pupil and school/class characteristics used in modelling achievement in PT 2011 (continued)

School/class-level variables (continued)			
Absenteeism/Lateness*	School Questionnaire	Categorical	0=absenteeism/lateness not perceived to be a problem, 1=absenteeism/lateness is perceived to be a problem
Parental support*	Teacher Questionnaire	Categorical, dummy variables	Low, medium, high, with medium as the reference group
Class size	Teacher Questionnaire	Categorical, dummy variables	10 or fewer pupils, 11 to 20 pupils, 21 to 30 pupils, 31 to 35 pupils, with 21 to 30 pupils as the reference group
School emphasis on academic success scale	Teacher Questionnaire	Continuous	Mean=0.00, SD=1.000
Safe and orderly school climate scale	Teacher Questionnaire	Continuous	Mean=0.00, SD=1.000
Domain-specific school/class variables			
Teacher specialisation in English*	Teacher Questionnaire	Categorical	0=no, 1=yes
Teacher specialisation in mathematics*	Teacher Questionnaire	Categorical	0=no, 1=yes
Teacher specialisation in science*	Teacher Questionnaire	Categorical	0=no, 1=yes
Perceived shortage of reading teachers*	School Questionnaire	Categorical	0=no, 1=yes
Perceived shortage of mathematics teachers*	School Questionnaire	Categorical	0=no, 1=yes
Perceived shortage of science teachers*	School Questionnaire	Categorical	0=no, 1=yes
Hours of instruction per week – English*	Teacher Questionnaire	Categorical, dummy variables	Up to four hours, four to six hours, more than six hours, with four to six hours as the reference group
Hours of instruction per week – mathematics*	Teacher Questionnaire	Categorical, dummy variables	Up to three hours, three to four hours, more than four hours, with three to four hours as the reference group
Hours of instruction per week – science*	Teacher Questionnaire	Categorical, dummy variables	Up to one hour, one hour to 90 minutes, more than 90 minutes, with one hour to 90 minutes as the reference group

*Variable has a missing indicator to preserve cases in the dataset.

Appendix B

Table B1: Distributions (percentages) for binary categorical variables used in modelling achievement in PT 2011

Level/variable	Percent coded "0"	Percent coded "1"
Pupil-level variables		
Gender	50.8	49.2
Home language*	94.3	5.7
Test language (TIMSS only)	96.1	3.9
TV in bedroom	47.3	52.7
Computer in bedroom	81.0	19.0
Own iPhone	87.7	12.3
Parents set aside time for homework*	17.8	82.2
Experiences bullying	89.7	10.3
Age started school	9.1	90.9
Parents - perceived importance of reading*	14.3	85.7
Pupil - perceived importance of reading*	7.3	92.7
Pupil - perceived importance of mathematics*	4.1	95.9
Pupil - liking of mathematics*	23.9	76.1
Pupil - perceived importance of science*	11.2	88.8
Pupil - liking of science*	13.4	86.6
Missing indicator for parent questionnaire	95.6	4.4
School/class-level variables		
School language of instruction	92.2	7.8
Absenteeism/lateness*	91.1	8.9
Teacher specialisation in English*	83.8	16.2
Teacher specialisation in mathematics*	94.6	5.4
Teacher specialisation in science*	94.1	5.9
Perceived shortage of reading teachers*	93.0	7.0
Perceived shortage of mathematics teachers*	94.0	6.0
Perceived shortage of science teachers*	82.9	17.1

*Variable has a missing indicator to preserve cases in the dataset.

Appendix C

Table C1: Distributions (percentages) across non-binary categorical variables used in modelling achievement in PT 2011

Level/variable	Categories			
Pupil level				
	10 or fewer	11 to 25	26 to 100	More than 100
Books at home*	9.9	22.4	34.3	33.4
	10 or fewer	11 to 25	26 to 50	More than 50
Children's books at home	5.9	14.5	30.4	49.2
	Primary	Lower secondary	Upper secondary, PLC or apprenticeship	Third level
Mother's education*	5.0	12.0	32.9	50.1
	Primary	Lower secondary	Upper secondary, PLC or apprenticeship	Third level
Father's education*	9.6	19.4	30.9	40.1
	Less than 1 hour	1-10 hours	More than 10 hours	
Parents - time spent reading per week	11.5	68.4	20.1	
	Never	Once a week to once a month	Every day	
Pupil - frequency of reading*	42.3	47.6	10.1	
School level				
	DEIS band 1	DEIS band 2	DEIS rural	Not under DEIS
DEIS status	8.5	7.1	3.8	80.6
	10 or fewer	11 to 20	21 to 30	31 to 35
Class size	13.3	20.4	57.3	9.0
	Small	Medium	Large	
School size	20.9	20.8	58.3	
	City or large town	Small town or village	Rural community	
Urban/rural location	55.5	25.1	19.4	
	Low	Medium	High	
Parental support	6.7	33.5	59.8	
	Up to 4 hours	4-6 hours	More than 6 hours	
Hours of instruction per week - English*	35.1	42.0	22.9	
	Up to 3 hours	3-4 hours	More than 4 hours	
Hours of instruction per week – mathematics*	17.6	41.4	41.0	
	Up to 1 hour	1 hour-90 minutes	More than 90 minutes	
Hours of instruction per week - science*	77.7	10.5	11.8	

*Variable has a missing indicator to preserve cases in the dataset.

Appendix D

Table D1: Model of reading achievement

	Parameter estimate	*SE*	*Test statistic**	*df*	*p*
Intercept	466.46	13.43	34.75	207	<.001
Pupil-level variables					
Missing parent questionnaire	-17.25	14.20	-1.22	166	.226
Gender (Boy-Girl)	-14.83	8.19			
Books at home					
10 books or fewer-26 to 100 books	-51.64	8.19			
11 to 25 books-26 to 100 books	-20.40	7.86			
101 or more books-26 to 100 books	14.94	7.35			
Missing books at home	-46.90	14.44			
Children's books at home					
10 books or fewer-26 to 50 books	-18.05	7.78	67.79	4	<.001
11 to 25 books-26 to 50 books	-6.03	7.57			
51 to 100 books-26 to 50 books	14.35	7.25			
More than 100 books-26 to 50 books	25.50	7.03			
TV in bedroom (No-Yes)	-14.03	3.91	-3.59	93	.001
Own iPhone (No-Yes)	-31.52	5.12	-6.15	2218	<.001
Parents make sure that time is made for homework					
Weekly or less often-Every day	19.03	4.39	41.93	2	<.001
Missing make time for homework	-25.62	14.24			
Experiences 2 or more types of bullying behaviour at least weekly (No-Yes)	-42.44	6.25	-6.80	89	<.001
Age starting school (6 or older-5 or younger)**	23.72	9.85	2.41	182	.017
Mother's education					
Primary-Upper secondary, PLC or apprenticeship	-20.93	14.50			
Lower secondary-Upper secondary, PLC or apprenticeship	-12.19	7.85			
Third level-Upper secondary, PLC or apprenticeship	4.08	7.09			
Missing mother's education	5.84	11.78			
Household employment status					
Total number of full-time jobs or equivalent (Part-time=0.5)	12.36	3.71	44.94	2	<.001
Missing household employment status	-14.72	9.95			
Additional domain-specific variables					
Frequency of reading for enjoyment					
Daily-weekly/monthly	16.94	5.61			
Never-weekly/monthly	11.73	8.30			
Missing reading for enjoyment	-34.12	17.89			
Interactions					
Gender and Books at home					
Gender*10 books or fewer	35.26	10.65	14.00	3	.003
Gender*11 to 25 books	15.02	8.80			
Gender*more than 100 books	9.15	8.88			
Gender and mother's education					
Gender*primary	-12.22	18.32	14.00	3	.003
Gender*lower secondary	14.37	11.05			
Gender*third level	18.12	10.53			
Gender and frequency of reading for enjoyment					
Gender*daily	3.38	7.12	9.22	2	.010
Gender*never	-26.22	12.71			
School-level variables					
School language (English-Irish)	17.69	5.99	2.95	207	.004
Average pupil age in years	36.36	13.44	2.71	207	.008
School emphasis on academic success scale	5.80	2.07	2.80	207	.006

Note. Significance tests are not included for variables that are included in interactions.

*The test statistic is a *t*-test for variables measured using a single item, and is a deviance difference test (Chi-square test) for variables measured by more than one item.

**This pupil-level measure varies randomly across schools in its relationship to achievement.

Table D2: Model of mathematics achievement

	Parameter estimate	*SE*	*Test statistic**	*df*	*p*
Intercept	496.84	8.47	58.65	204	<.001
Pupil-level variables					
Missing parent questionnaire	-32.74	10.15	-3.23	248	<.001
Gender (Boy-Girl)	-37.42	6.45			
Books at home					
10 books or fewer-26 to 100 books	-57.22	8.10			
11 to 25 books-26 to 100 books	-29.50	6.60			
101 or more books-26 to 100 books	13.21	6.65			
Missing books at home	-69.39	14.39			
Children's books at home					
10 books or fewer-26 to 50 books	-22.68	8.36	42.33	4	<.001
11 to 25 books-26 to 50 books	-2.361	5.87			
51 to 100 books-26 to 50 books	11.33	5.28			
More than 100 books-26 to 50 books	16.09	5.10			
TV in bedroom (No-Yes)	-13.19	3.91	-3.38	415	.001
Own iPhone (No-Yes)	-39.58	4.60	-8.60	4013	<.001
Experiences 2 or more types of bullying behaviour at least weekly (No-Yes)*	-41.14	6.35	-6.48	58	<.001
Mother's education					
Primary-Upper secondary, PLC or apprenticeship	-16.28	9.64	32.37	4	<.001
Lower secondary-Upper secondary, PLC or apprenticeship	-7.76	5.48			
Third level-Upper secondary, PLC or apprenticeship	11.10	4.34			
Missing mother's education	-4.48	12.32			
Household employment status**					
Total number of full-time jobs or equivalent (Part-time=0.5)	12.17	2.86	38.13	2	< .001
Missing household employment status	-8.32	8.80			
Additional domain-specific variables					
Liking mathematics					
Disagree-agree	20.63	4.12	55.13	2	<.001
Missing liking mathematics	-11.07	12.57			
Interactions					
Gender and books at home					
Gender*10 books or fewer	28.60	12.36	17.90	3	.005
Gender*11 to 25 books	19.29	8.39			
Gender*More than 100 books	21.68	8.65			
School-level variables					
School enrolment size					
Small-Medium	18.51	8.30	10.61	2	.005
Large-Medium	10.00	5.95			
Average pupil age in years	59.33	21.014	2.82	204	.006
Parental support					
Low parental support	-11.41	11.52	12.12	3	.007
High parental support	14.20	6.42			
Missing parental support	-6.94	21.77			

Note. Significance tests are not included for variables that are included in interactions**.**

*The test statistic is a *t*-test for variables measured using a single item, and is a deviance difference test (Chi-square test) for variables measured by more than one item.

**This pupil-level measure varies randomly across schools in its relationship to achievement.

Table D3: Model of science achievement

	Parameter estimate	*SE*	*Test statistic**	*df*	*p*
Intercept	464.11	14.54	31.92	24	<.001
Pupil-level variables					
Missing parent questionnaire	-18.31	13.73	-1.33	45	.189
Gender (Boy-Girl)	-33.45	8.357			
Books at home					
10 books or fewer-26 to 100 books	-57.14	8.37			
11 to 25 books-26 to 100 books	-25.33	7.05			
101 or more books-26 to 100 books	15.89	6.80			
Missing books at home	-61.07	14.19			
Children's books at home					
10 books or fewer-26 to 50 books	-26.71	7.68	44.43	4	<.001
11 to 25 books-26 to 50 books	-7.53	5.25			
51 to 100 books-26 to 50 books	8.73	5.42			
More than 100 books-26 to 50 books	12.50	5.37			
TV in bedroom (No-Yes)	-14.33	4.33	-3.31	51	.002
Own iPhone (No-Yes)	-30.36	5.06	-6.01	99	<.001
Parents make sure that time is made for homework**					
Weekly or less often-Daily	14.86	5.39	39.13	2	<.001
Missing make time for homework	-39.37	13.72			
Experiences bullying behaviour at least once a week (No-Yes)*	-37.04	5.47	-6.77	370	<.001
Age starting school (6 or older-5 or younger)	24.12	10.07	2.40	27	.024
Mother's education					
Primary-Upper secondary, PLC or apprenticeship	-14.20	9.27	40.28	4	<.001
Lower secondary-Upper secondary, PLC or apprenticeship	-9.67	5.48			
Third level-Upper secondary, PLC or apprenticeship	11.52	4.47			
Missing mother's education	-12.71	9.63			
Household employment status					
Total number of full-time jobs or equivalent (Part-time=0.5)	8.04	3.62	26.13	2	<.001
Missing household employment status	-8.90	9.08			
Additional domain-specific variables					
Liking science					
Disagree-agree	20.43	4.84	65.36	2	<.001
Missing liking science	-46.28	12.74			
Interactions					
Gender and books at home					
Gender*10 books or fewer	36.44	12.18	23.73	3	<.001
Gender*11 to 25 books	20.17	9.53			
Gender*More than 100 books	22.13	8.61			
School-level variables					
School enrolment size					
Small-medium	23.64	9.59	15.25	2	<.001
Large-medium	10.85	7.15			
Average pupil age in years	71.96	22.37	3.22	207	.002

Note. Significance tests are not included for variables that are included in interactions.

*The test statistic is a *t*-test for variables measured using a single item, and is a deviance difference test (Chi-square test) for variables measured by more than one item.

**This pupil-level measure varies randomly across schools in its relationship to achievement.

Table D4: Gender interactions for reading

	Boys		Girls	
Number of books	% in group	Score estimate	% in group	Score estimate
10 books or fewer	13.5	414.8	6.3	435.3
11 to 25 books	25.6	425.7	19.0	446.3
26 to 100 books	45.3	446.5	53.2	451.6
101 or more books	15.6	475.6	21.5	475.7
Mother's education	% in group	Score estimate	% in group	Score estimate
Primary	4.4	445.5	5.2	418.5
Lower secondary	11.8	454.3	11.0	453.8
Upper secondary, PLC, or apprenticeship	37.4	446.5	34.6	451.6
Third level	46.4	470.5	49.2	473.8
Frequency of reading	% in group	Score estimate	% in group	Score estimate
Never	14.4	478.2	5.6	437.1
Once a week or once a month	49.1	466.5	46.1	451.6
Every day	36.5	483.4	48.3	472.0

Note. Score estimates are based on the intercept plus the relevant parameters in Table D1.

Table D5: Gender interactions for mathematics and science

	Mathematics				Science			
	Boys		Girls		Boys		Girls	
Number of books	% in group	Score estimate	% in group	Score estimate	% in group	Score estimate	% in group	Score estimate
10 books or fewer	13.5	439.62	6.3	430.79	13.5	406.97	6.3	409.96
11 to 25 books	25.6	467.33	19.0	449.21	25.6	438.78	19.0	425.49
26 to 100 books	45.3	496.84	53.2	459.41	45.3	464.11	53.2	430.66
101 or more books	15.6	510.05	21.5	494.31	15.6	479.99	21.5	468.67

Note. Score estimates are based on the intercept plus the relevant parameters in Tables D2 and D3.

Appendix E

Table E1: Summary of models of achievement in reading, mathematics and science, with school as the cluster variable

		Reading	*Maths*	*Science*
Intercept		466.963	504.17	464.35
Pupil-level variables				
Gender (Boy)	Girl	-14.71	-37.59	-34.01
Books at home (26 to 100 books)	10 books or fewer	-51.20	-58.19	-57.41
	11 to 25 books	-20.28	-29.00	-25.06
	101 or more books	14.95	12.96	15.73
Children's books at home (26 to 50 books)	10 books or fewer	-17.83	-22.09	-25.17
	11 to 25 books	-5.91	-2.04	-7.19
	51 to 100 books	14.15	10.75	8.31
	More than 100 books	25.21	16.46	12.63
TV in bedroom (No)	Yes	-14.04	-13.67	-14.02
Own iPhone (No)	Yes	-32.10	-39.44	-30.54
Parents make sure that time is made for homework (Weekly/less often)		19.17		14.58
Experiences bullying behaviour at least once a week (No-yes)		-42.81	-41.32	-36.67
Age starting school (6 or older-5 or younger)		22.85		23.30
Mother's education Upper secondary, PLC or apprenticeship	Primary	-22.01	-17.76	-15.01
	Lower secondary	-11.89	-8.62	-10.03
	Third level	4.32	11.31	11.66
Total number of full-time jobs or equivalent (part-time=0.5)		12.40	12.02	7.87
Additional domain-specific variables				
Frequency of reading for enjoyment-Weekly/monthly	Daily	16.94		
	Never	12.12		
Likes maths/science (Agree)	Disagree		20.49	20.48
Interactions				
Gender and books at home	Gender*10 books or fewer	35.59	30.19	38.21
	Gender*11 to 25 books	14.53	17.74	19.22
	Gender*more than 100	9.21	21.60	22.09
Gender and mother's education	Gender*primary	-10.67		
	Gender*lower secondary	13.61		
	Gender*third level	17.82		
Gender and frequency of reading for enjoyment	Gender*daily	3.09		
	Gender*never	-26.56		
School-level variables				
School enrolment size (Medium)	Small		21.28	23.61
	Large		9.24	10.97
School language (English)	Gaeilge	17.06		
Average pupil age in years		24.84	57.12	62.81
School emphasis on academic success scale		5.28		

Note. Parental support is not included in the model for mathematics as it is a teacher-level variable. Parameter estimates can be compared with those in Table 10.4.

Table E2: Percentages of variance explained in final models of reading, mathematics and science, using school as the cluster variable, and with and without school DEIS status

Model/level	*Reading*	*Mathematics*	*Science*
Model (shown in Table D1)	%	%	%
Between	77.7	51.3	53.4
Within	21.7	20.6	20.1
Total	27.4	25.5	26.6
Model with DEIS status	%	%	%
Between	81.1	56.0	58.8
Within	21.7	20.6	20.0
Total	27.7	26.2	27.7

Table E3: Percentages of variance explained by models with DEIS status only, DEIS with pupil gender and socioeconomic background, DEIS with pupil home environment, and DEIS with pupil gender and socioeconomic background *and* pupil home environment

Model/level	*Reading*	*Mathematics*	*Science*
DEIS only (Model 1)	%	%	%
Between	43.8	37.7	34.8
Within*	-0.2	-0.1	-0.1
Total	5.1	6.6	7.5
School DEIS status with pupil gender and socioeconomic background (Model 2)	%	%	%
Between	65.1	46.3	42.9
Within	10.2	8.2	7.5
Total	16.9	15.0	15.2
School DEIS status with pupil home environment (Model 3)	%	%	%
Between	77.4	54.2	52.4
Within	20.5	18.6	19.3
Total	27.4	25.0	26.5
School DEIS status, pupil gender and socioeconomic background, and pupil home environment (Model 4)	%	%	%
Between	79.8	56.9	54.5
Within	22.5	21.7	21.6
Total	29.5	27.9	28.8
Variance explained by DEIS over pupil gender and socioeconomic background	%	%	%
Between	22.5	21.1	21.4
Within*	1.0	-0.1	-0.1
Total	3.6	3.7	4.6
Variance explained by DEIS over pupil home environment	%	%	%
Between	11.3	10.9	12.0
Within*	-0.2	-0.1	-0.1
Total	1.2	1.9	2.6
Variance explained by DEIS over pupil gender and socioeconomic background, *and* pupil home environment	%	%	%
Between	8.7	8.8	10.5
Within*	-0.2	-0.1	-0.1
Total	0.9	1.5	2.2

*Small negative changes in explained variance associated with the inclusion of the school-level variables only should not be interpreted as a disimprovement in model fit – rather, there is some error around these estimates and these values should be interpreted as no change in model fit.