3

Are Students' Perceptions of their Mathematics Teaching and Learning Related to Mathematics Performance?

This chapter first outlines the approach taken to develop an analytical framework of teaching and learning strategies, and then considers the actual effects of background factors and teaching and learning factors in PISA 2003, with separate findings for each country. Teaching and learning strategies do not take place in a vacuum. Rather, various background characteristics of students and schools create a context that can profoundly influence teaching and learning processes and outcomes. These background factors require examination alongside the teaching and learning factors, whose predictive power is the main subject of investigation in this chapter.

INTRODUCTION

The extent to which teaching and learning enable students to acquire knowledge and skills is central to the success of school systems. But can measurable features of teaching and learning activity be linked with testable student outcomes? In principle, PISA provides the tools to make such connections, both by measuring a range of characteristics of teaching and learning as reported by students and school principals and by testing student performance. However, drawing out links between the two is an imprecise science, not least because the knowledge and skills a student may have at age 15 are the product of learning over many years, both inside and outside school, whereas PISA is only able to look at conditions that 15-year-olds are experiencing in their schools at the time of the survey.

Recognising these limitations, this report uses a model designed to consider the extent to which certain features of teaching and learning can help predict performance in mathematics in the PISA assessment. This model acknowledges that teaching and learning do not take place in a vacuum. Various background characteristics of students and schools create a context that can profoundly influence the teaching and learning process and its outcomes. These characteristics include socio-economic background, student attitudes to school and mathematics, student levels of motivation, their perceptions of their own capability, and structural characteristics of schools such as school size. Such factors can be regarded as the antecedents of teaching and learning because they are not, for the most part, under the control of those who manage schools. These background factors bear examination alongside the teaching and learning factors whose predictive power is the main subject of investigation in this chapter.

The chapter outlines the approach taken in developing an analytical model of teaching and learning, and then considers the actual effects of background factors and of teaching and learning factors in PISA 2003.[1]

An analytical model of the effect of teaching and learning strategies on mathematics achievement

The discussion that follows uses an analytical model designed to determine to what extent learning strategies and teaching strategies are associated with stronger mathematics performance, after accounting for other characteristics of students and schools. Thus, mathematics achievement is the educational outcome, student learning strategies and teaching strategies are its main predictors and a wide variety of other characteristics are treated as antecedents to learning. These last characteristics are controlled for in the analytical models, so that the teaching and learning effects can be more clearly seen.

The measures of teaching and learning that are considered here can be thought of as those that contribute to the efficiency or effectiveness with which learning takes place. The measures of antecedents to learning mainly cover factors that appear in other PISA reports, and in the literature, as being significantly related to achievement. Although it is impossible to establish the causal direction of effects in analytical models built on correlational data, measures other than teaching and learning strategies are modelled here as having influences on achievement that are independent of the antecedent variables.

The analytical model is a multi-level one which looks at the performance and characteristics both of individual students and of groups of students within schools. The grouping of students within schools in the survey makes it possible to examine variations across schools as well as among students. The analytical model first provides an estimate of the proportions of variability in achievement as accounted for by school differences on the one hand and by student differences within schools on the other. Once these proportions have been established, each measure of teaching and learning can be added in turn to the analytical model and its contribution to achievement estimated when account is made for all the other variables. The report expresses this contribution as an effect (regression coefficient), which may be interpreted as the change in mathematics achievement attributable to a one-unit change in the chosen measure or predictor in the analytical model. The theoretical approach outlined in Chapter 1 and the general logic of education production functions, which treats context measures essentially as antecedents to teaching and learning and hence as factors to be accounted for in studies of teaching and learning strategies, determine the overall structure of the analytical model. Measures of context in this analysis include students' socio-economic background, students' self-beliefs as mathematics learners and students' general attitudes towards school.

In this type of analytical model, a third level of analysis could potentially be added: that at country level, in addition to student and school levels. However, the analysis of three-level models is complex, and the relatively small number of countries surveyed precludes the use of many country-level variables. In addition, there are indications that students in different countries may interpret questionnaire items differently, making it difficult to treat some of the measures as a single scale across countries. For these reasons, the report presents results for each country separately. While the report does not build cross-country comparisons into the modelling, it is useful nevertheless to examine whether the effects of particular teaching and learning strategies are universal or country-specific. This question is analysed by examining differences in the size of the model coefficients across countries.

The PISA database contains many measures that can be analysed to investigate the effects of teaching and learning strategies (see Chapter 2) The choice of variables included in the model and the choice of results presented in this chapter was guided by an in-depth exploratory analysis of a wide range of variables in the PISA 2003 database.[2] The final set of measures included in the analytical model are those judged to give the best overall predictive power of student achievement with minimal redundancy among the predictors. This exercise has led to the exclusion of several measures related to time and to school principals' perceptions of teaching strategies, as these have shown essentially no separate effects when modelled as predictors of achievement.

REPORTING THE RESULTS

To avoid undue complexity the reported results concentrate on two types of effects relating the measures of teaching and learning strategies to PISA mathematics performance. The first type is a bivariate regression coefficient representing the direct or absolute association of a particular teaching or learning strategy variable with performance, as already presented in Chapter 2. This coefficient shows how strongly each measure is associated with performance, before accounting for other factors. The second type is a multi-level, multivariate regression coefficient and shows the unique effect of a single variable, after accounting for other factors in the teaching and learning analytical model (see Box 3.1). This chapter reports on the unique effects for each factor and reminds readers

of the observed associations with performance already found for each factor. Comparing the two sets of coefficients for all countries presents a picture of the extent to which other factors included in the analytical model have mediated the effect of the factor under examination.[3]

A complete breakdown of the effects for each measure included in the analytical model for each country appears in Annex C, Multilevel Model, Table C.1, Multivariate regression coefficients and standard errors. Table C.2 presents the bivariate regression coefficients and standard errors. For those interested in a complete profile for a specific country or group of countries, the tables can be used to construct within-country figures across all of the factors analysed, similar to the across-country figures presented in this chapter.

Box 3.1 ■ **Interpreting the effects of regression coefficients**

The figures and tables in this chapter are based on regression coefficients designed to show the effect on mathematics achievement of a one-unit change in each of the independent measures or predictors included in the analytical model.

A one-unit change indicates a difference of one standard deviation in each measure. In some cases, the measure of interest is an index and a difference of one standard deviation equals an increase of one unit on the index. For each index, values are standardised so that the mean value is zero and one unit is equal to one standard deviation. For example, on an index showing the strength of the disciplinary climate as reported by students in answering a range of questions, an average-strength disciplinary climate is represented as zero. The index is constructed so that about two-thirds of students internationally report a disciplinary climate in the range +1 to -1, *i.e.* within one standard deviation of the mean. A regression coefficient of, say, 10 indicates that a one-point difference on this scale is associated with a difference of 10 score points on the PISA mathematics scale. Looked at in another way this would mean that, taking the middle two-thirds of students ranked by how strongly they rate the disciplinary climate of their schools, those with the strongest disciplinary climate would have predicted mathematics scores 20 points ahead of those with the weakest disciplinary climate (because they would be separated by two standard deviations on the disciplinary climate scale).

In most figures and tables, both a bivariate coefficient (absolute or observed effect) and a full-model coefficient (relative or unique effect) are shown for each country. The bivariate effect represents the effect on mathematics achievement of one unit change in the variable of interest when this variable is considered alone. This effect is often referred to as the observed association with performance. The full-model effect is the coefficient obtained when all measures are included in the model. Therefore, it represents the effect on mathematics achievement of a one-unit change in the measure of interest, accounting for all of the other measures included in the model. This relative or unique effect is shown for each country in graphical format, with countries ordered by the size of the effect. Statistically significant effects are shown as blue bars and non-significant effects as white outline bars. In each case, the accompanying table gives some further information to aid in interpreting the effects. A comparison of the bivariate coefficient with the full model coefficient gives a sense of the degree to which other measures included in the model exert mediating effects on the measure of interest's association with performance. In almost all cases, the full-model effect is smaller than the bivariate effect because of these mediating influences.

Box 3.1 ■ **Interpreting the effects of regression coefficients** *(continued)*

It is important to note that, although the figures have been ordered by size of effects, these figures should not be interpreted as a comparative ranking of countries, as is the case for the achievement results. Statistical significance of the effects shown refers to whether the coefficient is significantly different from zero, not whether effects in different countries are statistically significant when compared with each other. Where the strength of an effect is shown as greater in one country than another, this difference is not always statistically significant. In some cases, comments are made in the text about comparative effects: these apply mainly to countries at the extremes of the distribution or to patterns across countries with similar characteristics. All differences large enough to warrant comment are statistically significant.

Including a large number of measures in regression models makes calculations technically difficult. One problem is that the effects of occasional missing data are more significant overall than when fewer factors are considered. In the analysis conducted in this report, multiple imputation techniques were used to deal with missing data.

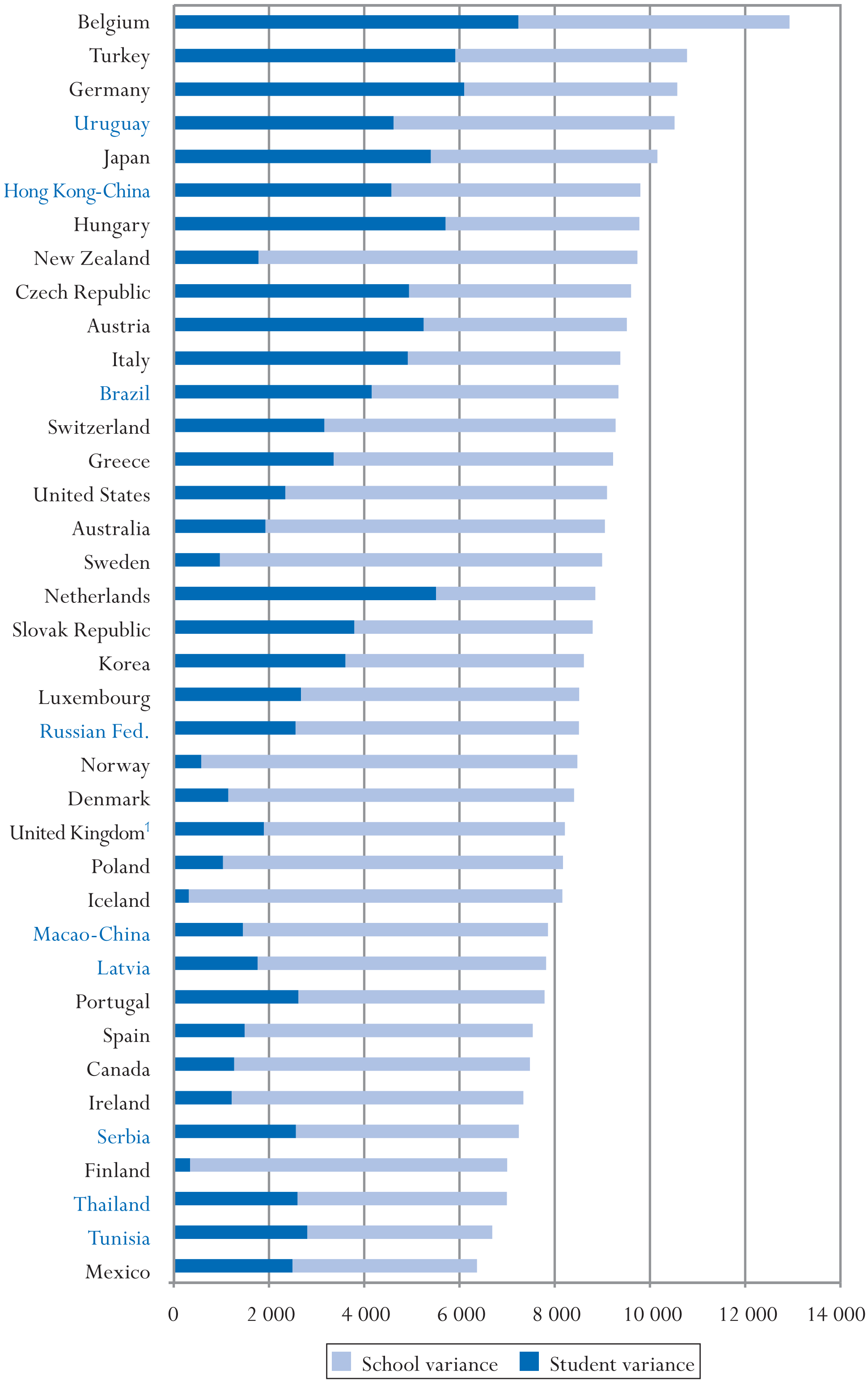
HOW MUCH PERFORMANCE VARIATION IS DUE TO SCHOOL DIFFERENCES AND HOW DO A RANGE OF FACTORS CONTRIBUTE TO THIS VARIATION?

From the results presented in Chapter 2, it is clear that the amount of variation among schools in some of the factors analysed here differs widely from one country to another. Some countries seem to have relatively homogeneous school systems, while in others schools have wide variations in a number of factors. PISA results have shown strong differences with regard to the socio-economic composition of schools: some countries have schools that are highly differentiated in terms of students' backgrounds and other countries have relatively small differences in socio-economic composition between different schools (OECD, 2004). To what extent do schools differ in teaching and learning strategies?

The analysis in this report partitions the total variation in students' performance in mathematics into between-student and between-school components. It is instructive to examine these components in terms of the impact on overall performance of differences between schools and as a precursor to the more detailed analysis of the effects of selected student and school factors on achievement.

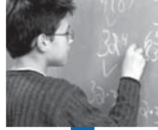
Figure 3.1 shows the total variance in mathematics performance accounted for by the teaching and learning analytical model for each country, and the amount of this variance attributable to differences between students and schools. In this graph, the total length of the bars gives the total variance, with the two segments showing how much of this variance is attributable to differences between schools (left segment) and variation within schools (right segment). Generally speaking, countries that have high total variation in achievement also tend to have high between-school variation, and vice versa. That is, highly differentiated school systems tend to be associated with high variations in achievement while relatively homogeneous school systems tend to be associated with smaller overall variations in achievement. There are notable exceptions to this, however. For example, Sweden has moderate total variation in performance but low variation between schools, while the Netherlands has similar total variation in performance to Sweden but much greater variation between schools.

Figure 3.1 ■ **Total student and school variance accounted for by the model**



1. Response rate too low to ensure comparability.

Source: OECD PISA 2003 Database.



Finland, Ireland, Canada and Spain have among the smallest total variation in performance and the smallest variation between schools. In the cases of Canada and Finland, this finding also combines with high average performance in mathematics, showing that uniformity does not necessarily come at the expense of overall performance. Conversely, some high-achieving countries, notably Japan and the partner economy Hong Kong-China, have both high variation overall and between schools.

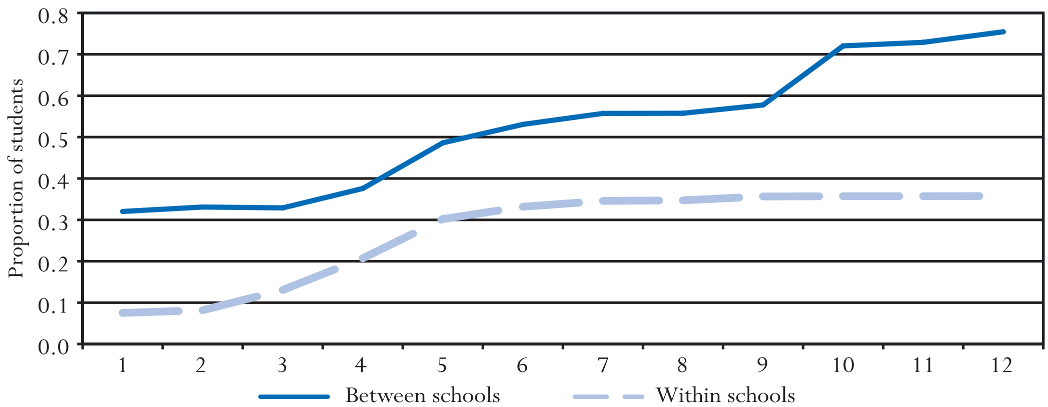
The results from the analytical model are not dependent on the order of entry of the different factors analysed; nevertheless, an important indicator of the predictive power of the model is the proportion of school and student variance accounted for as one adds additional measures or factors. When built in stages, the analytical model unfolds with one or more factors added at each stage and with the order of addition chosen on *a priori* grounds. Stable student factors or measures considered as precursors of learning strategies enter before the measures of more specific learning strategies. For example, the three measures of students' socio-economic background enter at the first stage in order to account for the effects of socio-economic background when examining learning strategies. Student attitudes towards school, students' motivation to learn mathematics and their levels of anxiety in learning mathematics, as well as students' self-beliefs as mathematics learners enter next, in that order, because these factors were judged to be predictors of students' use of learning strategies. Student learning strategies enter next, on the assumption that student factors are more stable and hence require treatment as antecedent to teaching strategies. Finally, teaching strategies enter, along with two school-level factors, school size and school level socioeconomic status, considered as related to teaching strategies.

The analytical model examines many different student and school factors. As such, the predictive power of an individual measure is likely to be reduced due to the impact of mediating effects, as already described. While this might suggest that the effects of teaching and learning strategies are underestimated or are artefacts of the analytical model chosen, it is important to recognise that this model was established on *a priori* grounds, based on a hypothesised causal sequence. The effects of teaching and learning strategies thus appear as unique effects, accounting for all factors considered to be antecedents.[4] In any event, comparison of the bivariate and analytical model coefficients provides a sense of the impact of other factors in the model on the variables of interest.

Figure 3.2 shows the average proportions of school and student variance accounted for by the model. (A complete breakdown of these proportions by country appears in Table C.3, Variance explained by the multivariate multilevel model on teaching and learning.) As can be seen, the model is more effective in accounting for school variance than for student variance. The greatest incremental contributions to the variance accounted for occur when the measures of motivation to learn mathematics and self-belief as mathematics learners are included, and also with the inclusion of the socio-economic composition of the school. Nevertheless, there are significant contributions, especially to school variance, on entering some of the measures of student learning strategies and teaching strategies.

While the report presents this partitioning of variance in terms of gradually adding more factors to the model, in reporting the final model results each factor is considered in relation to all other factors in the model, demonstrating both the observed (bivariate) association with performance and the unique effects after taking account of other factors. The analysis looks in turn at the antecedents to learning and at the predictors. The methodology for calculating the effect of these two groups of factors is the same, but the second set are of greatest interest in this report; the first set are reported for context.

Figure 3.2 ■ **Average proportions of student and school variance accounted for by the model**



Model Stage
1 Parents' highest occupational status, parents' highest level of education, number of books in the home
2 Students' attitudes towards school and students' sense of belonging at school
3 Students' interest in and enjoyment of mathematics and students' instrumental motivation in learning mathematics
4 Students' anxiety in mathematics
5 Students' self-efficacy in mathematics and students' self-concept in mathematics
6 Hours per week of total homework, hours per week of mathematics homework, tutoring in mathematics, out-of-school classes
7 Memorisation/rehearsal strategies, elaboration strategies, control strategies
8 Preference for competitive learning situtations, preference for co-operative learning situtations
9 Teacher support, student-teacher relations
10 School average of the highest international socio-economic index of occupational status (HISEI) of both parents
11 School size
12 School average disciplinary climate

Source: OECD PISA 2003 Database.

THE MEASURED EFFECTS OF ANTECEDENTS TO LEARNING INCLUDED IN THE ANALYTICAL MODEL

Students' socio-economic background

The report uses three measures of students' socio-economic background. These measures are the highest occupational status of parents (HISEI), the highest educational level of parents (HISCED) and the number of books in the home. The report uses these measures in preference to the composite index of socio-economic background (a variable called ESCS) found in the PISA data file because they are straightforward and easily understandable variables, and because exploratory analysis reveals them to be better predictors of achievement than most other variables that make up the composite index.

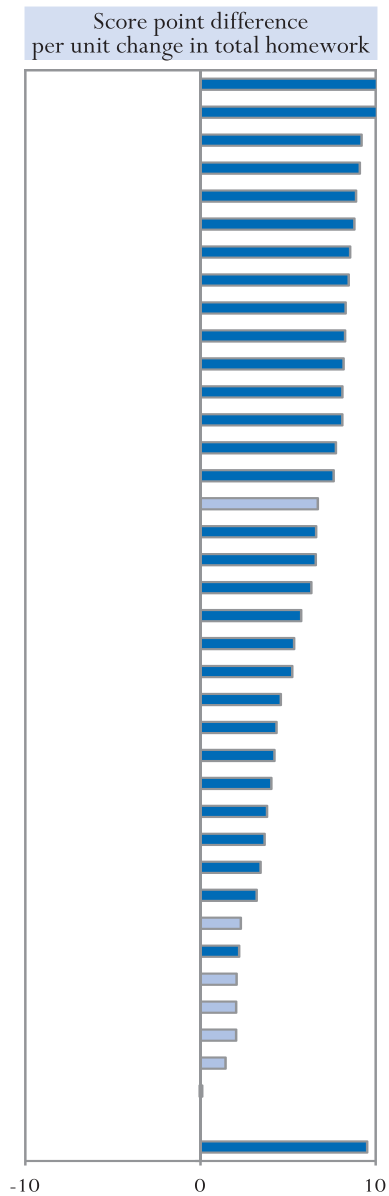
Figure 3.3 shows the effects of the highest occupational status of parents. This socio-economic measure is positively associated with mathematics performance in all countries. In Japan and in the partner economy Macao-China the relationship is non-significant. Even after accounting for other teaching and learning factors, there remains a positive association in 31 countries, although the other factors greatly reduce the effect. For example, the effect decreases by at least two-thirds in the Slovak Republic,

Spain, the Russian Federation, Norway, Poland and Sweden. In most countries, this index and the other two measures of students' socio-economic background account for substantially more of the variation between schools than between students. This finding indicates that there is a considerable school-level effect independent of variations in students' socio-economic backgrounds within schools.

The second measure of students' socio-economic background is the level of education of the parents (Figure 3.4). PISA asked students to indicate the educational level of both parents; the index used here is the highest level of either parent. This measure, like the highest occupational status of parents, shows a positive association with mathematics performance for almost all countries. The exceptions

Figure 3.3 ■ **Parents' highest occupational status (HISEI) and mathematics performance**

	Bivariate			Multivariate	
	Mean	Effect	S.E.	Effect	S.E.
Belgium	50.59	17.9	(1.13)	10.5	(1.26)
Poland	44.96	32.2	(1.74)	10.3	(1.77)
Australia	52.59	19.8	(1.30)	9.2	(1.19)
Norway	54.63	28.4	(1.75)	9.1	(1.51)
Denmark	49.26	25.4	(1.75)	8.9	(1.60)
Sweden	50.64	27.3	(1.79)	8.8	(1.47)
United States	54.55	22.2	(1.26)	8.5	(1.15)
Portugal	43.10	22.6	(1.40)	8.5	(1.57)
Switzerland	49.30	18.6	(1.54)	8.3	(1.38)
Brazil	40.12	13.1	(2.26)	8.3	(2.07)
Ireland	48.34	22.2	(1.73)	8.2	(1.42)
Finland	50.23	21.7	(1.28)	8.1	(1.07)
Canada	52.58	18.1	(1.06)	8.1	(0.96)
New Zealand	51.46	23.1	(1.44)	7.7	(1.27)
Latvia	50.28	15.6	(1.82)	7.6	(1.45)
Macao-China	39.42	6.1	(4.10)	6.7	(3.91)
Luxembourg	48.17	15.3	(1.42)	6.6	(1.69)
Tunisia	37.50	10.5	(1.39)	6.6	(1.52)
Uruguay	46.15	13.0	(1.36)	6.3	(1.59)
Thailand	36.01	9.7	(1.39)	5.7	(1.67)
Netherlands	51.26	9.5	(1.35)	5.3	(1.24)
Czech Republic	50.05	15.3	(1.59)	5.2	(1.63)
Italy	46.83	7.3	(1.11)	4.6	(1.02)
Germany	49.33	13.0	(1.52)	4.3	(1.39)
Hong Kong-China	41.13	5.7	(1.76)	4.2	(1.69)
Hungary	48.58	10.1	(1.62)	4.0	(1.57)
Russian Fed.	49.86	12.8	(1.51)	3.8	(1.49)
Serbia	48.07	11.1	(1.43)	3.7	(1.14)
Spain	44.29	15.8	(1.25)	3.4	(1.14)
Slovak Republic	48.79	14.5	(1.25)	3.2	(1.24)
Greece	46.94	12.2	(1.66)	2.3	(1.73)
Mexico	40.12	4.8	(0.96)	2.2	(0.88)
Turkey	41.57	6.4	(1.60)	2.1	(1.52)
Austria	47.06	7.0	(1.21)	2.0	(1.35)
Iceland	53.72	12.9	(1.50)	2.0	(1.46)
Korea	46.32	7.5	(1.52)	1.4	(1.25)
Japan	49.98	2.0	(1.47)	0.0	(1.28)
United Kingdom[1]	49.65	21.8	(1.38)	9.5	(1.27)



1. Response rate too low to ensure comparability.
Source: OECD PISA 2003 Database.

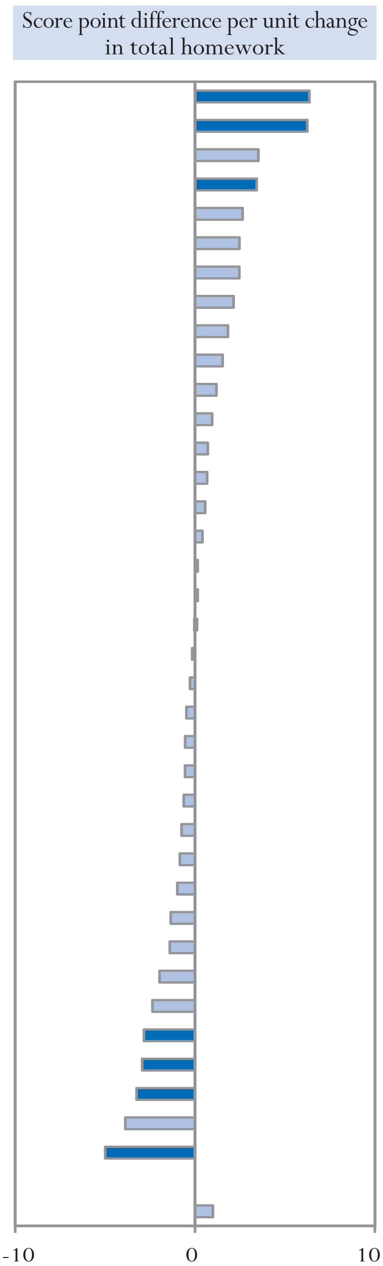
Note: Statistically significant score point differences are marked in a darker tone.

are Austria and the partner economies Brazil, Hong Kong-China, Indonesia and Macao-China. (In these countries, the relationship is non-significant). However, when included in the analytical model with all other factors, this positive association with performance remains in only Denmark, Iceland and Ireland and becomes negative in Austria, Italy and the partner countries Tunisia and Brazil.

The third measure of students' home background is the students' estimate of the number of books in the home.[5] Figure 3.5 gives the results for books in the home and – unlike for parents' education – there is

Figure 3.4 ■ **Parents' highest educational level (HISCED) and mathematics performance**

	Bivariate			Multivariate	
	Mean	Effect	S.E.	Effect	S.E.
Denmark	4.47	25.8	(2.02)	6.4	(1.76)
Iceland	4.28	20.1	(1.79)	6.2	(1.86)
Poland	4.09	35.9	(2.36)	3.5	(1.96)
Ireland	4.23	18.9	(1.59)	3.4	(1.43)
Czech Republic	4.36	17.8	(2.09)	2.6	(2.16)
Slovak Republic	4.32	18.2	(2.16)	2.5	(1.50)
New Zealand	4.25	20.9	(1.93)	2.5	(1.71)
Germany	4.05	11.4	(1.34)	2.1	(1.36)
Finland	4.80	19.4	(1.52)	1.8	(1.30)
Russian Fed.	4.86	15.8	(1.92)	1.5	(2.20)
Switzerland	3.88	13.6	(1.34)	1.2	(1.10)
Canada	4.84	18.5	(1.49)	1.0	(1.48)
Hungary	4.22	13.1	(1.66)	0.7	(1.35)
Spain	3.87	10.2	(0.86)	0.7	(0.98)
Turkey	2.84	6.1	(1.39)	0.6	(1.23)
Greece	4.12	10.8	(1.45)	0.4	(1.34)
Latvia	4.90	18.9	(3.95)	0.1	(2.25)
Mexico	3.15	2.0	(0.99)	0.0	(0.97)
United States	4.67	20.0	(1.90)	0.0	(1.60)
Korea	4.04	6.3	(1.20)	-0.2	(1.06)
Thailand	2.55	5.4	(1.21)	-0.3	(1.36)
Luxembourg	4.09	8.5	(1.08)	-0.5	(1.34)
Uruguay	3.83	7.3	(1.47)	-0.5	(1.54)
Japan	4.77	3.5	(1.64)	-0.6	(1.38)
Macao-China	2.63	2.4	(3.23)	-0.6	(2.85)
Belgium	4.64	11.0	(1.25)	-0.7	(1.15)
Australia	4.62	12.4	(1.49)	-0.8	(1.25)
Sweden	4.67	15.9	(1.75)	-1.0	(1.54)
Netherlands	4.56	4.3	(1.21)	-1.4	(1.13)
Portugal	2.70	10.4	(1.10)	-1.4	(0.95)
Serbia	4.21	7.4	(1.50)	-2.0	(1.47)
Norway	4.75	23.8	(2.30)	-2.4	(2.36)
Brazil	3.72	0.1	(1.20)	-2.8	(1.11)
Italy	3.95	3.1	(1.11)	-2.9	(1.10)
Tunisia	2.46	4.2	(1.06)	-3.3	(1.26)
Hong Kong-China	2.58	-0.7	(2.01)	-3.9	(2.01)
Austria	4.09	1.9	(1.68)	-5.0	(1.50)
United Kingdom[1]	4.22	18.5	(1.77)	1.0	(1.57)



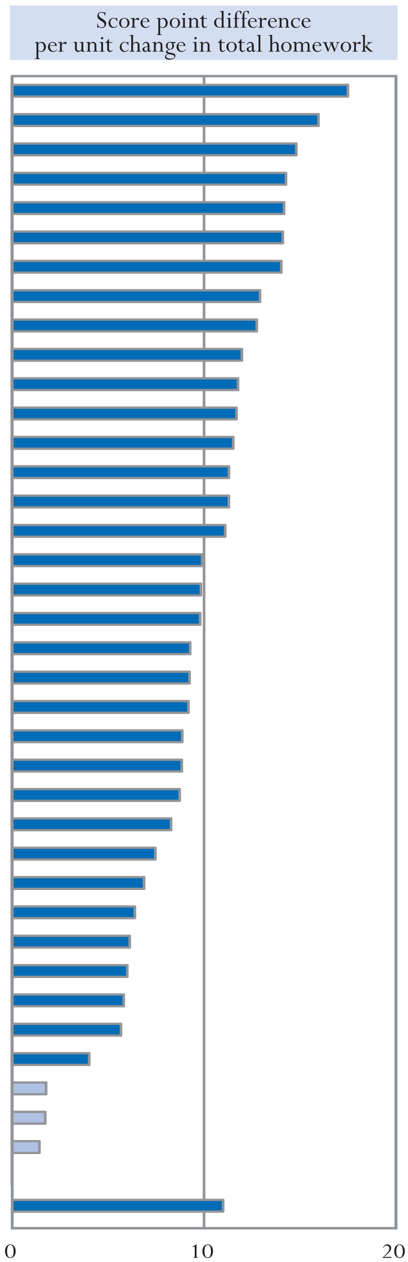
1. Response rate too low to ensure comparability.
Source: OECD PISA 2003 Database.

Note: Statistically significant score point differences are marked in a darker tone.

a positive association with mathematics performance, even when considered in the wider context of teaching and learning, in all countries except Mexico and the partner economies Macao-China and Thailand where there is no significant relationship. In 19 of the OECD countries the effect of the number of books in the home is of 10 score points or more. Clearly, this factor plays a significant role in achievement independently of the other measures of socio-economic background and of other school and student effects.

Figure 3.5 ■ **Number of books in the home and mathematics performance**

	Bivariate			Multivariate	
	Mean	Effect	S.E.	Effect	S.E.
Sweden	3.92	34.4	(1.51)	17.5	(1.18)
Spain	3.76	28.8	(1.36)	16.0	(1.26)
Slovak Republic	3.53	26.4	(1.89)	14.8	(1.54)
Switzerland	3.37	25.3	(1.21)	14.3	(1.08)
Korea	3.57	24.0	(1.55)	14.2	(1.65)
Norway	4.00	29.7	(1.66)	14.1	(1.45)
United States	3.30	28.4	(1.18)	14.0	(1.16)
Finland	3.59	28.6	(1.47)	12.9	(1.22)
New Zealand	3.70	29.0	(1.59)	12.7	(1.32)
Austria	3.43	17.1	(1.28)	12.0	(1.20)
Poland	3.39	31.2	(1.49)	11.8	(1.18)
Czech Republic	4.11	19.8	(1.63)	11.7	(1.63)
Iceland	4.05	24.9	(1.73)	11.5	(1.47)
Ireland	3.34	24.1	(1.48)	11.3	(1.14)
Denmark	3.54	27.6	(1.77)	11.3	(1.46)
Canada	3.72	20.6	(0.98)	11.1	(0.70)
Portugal	3.04	24.9	(1.53)	9.9	(1.80)
Australia	3.87	21.4	(0.95)	9.8	(0.86)
Luxembourg	3.53	16.5	(1.30)	9.8	(1.21)
Turkey	2.55	15.3	(1.70)	9.3	(1.48)
Germany	3.67	17.8	(1.17)	9.2	(1.15)
Latvia	3.94	21.3	(2.16)	9.2	(1.51)
Netherlands	3.39	12.9	(1.34)	8.9	(1.28)
Belgium	3.36	16.8	(1.12)	8.8	(1.04)
Hungary	3.92	15.2	(1.24)	8.7	(1.18)
Hong Kong-China	2.54	12.9	(1.42)	8.3	(1.36)
Greece	3.20	17.0	(1.31)	7.5	(1.47)
Russian Fed.	3.81	18.6	(1.40)	6.9	(1.35)
Japan	3.50	10.8	(1.26)	6.4	(1.33)
Brazil	2.01	12.0	(2.27)	6.1	(2.20)
Serbia	2.65	15.3	(1.76)	6.0	(1.51)
Tunisia	2.31	11.7	(1.44)	5.8	(1.21)
Uruguay	2.71	12.9	(1.86)	5.7	(1.46)
Italy	3.51	10.7	(1.18)	4.0	(1.07)
Thailand	2.45	8.3	(1.66)	1.8	(1.43)
Macao-China	2.27	7.0	(3.70)	1.7	(3.16)
Mexico	2.12	5.2	(1.57)	1.4	(1.49)
United Kingdom[1]	3.41	26.0	(1.37)	11.0	(1.19)



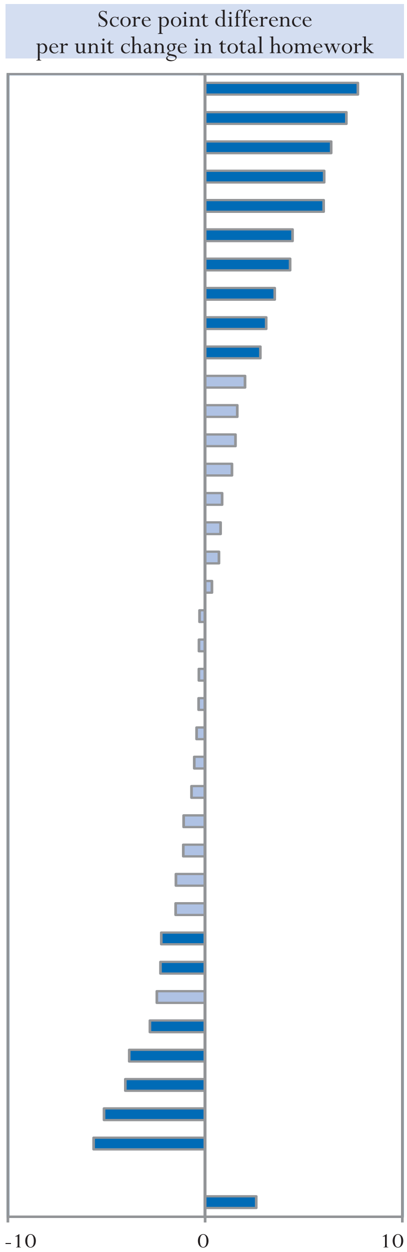
1. Response rate too low to ensure comparability.
Source: OECD PISA 2003 Database.

Note: Statistically significant score point differences are marked in a darker tone.

In summary, two of the three measures of students' socio-economic background, the highest occupational status of parents and students' estimates of the number of books in the home, remain almost universally significant contributors to achievement, even after accounting for a large number of other student and school characteristics. The size of these effects is generally diminished in the full analytical model relative to their observed association with performance, indicating that other factors can help overcome disadvantages in students' socio-economic background. While universally positively correlated with achievement, parents' educational levels do not generally exert independent effects after other factors are accounted for.

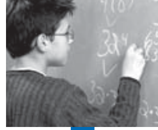
Figure 3.6 ■ **Students' attitudes towards school and mathematics performance**

	Bivariate			Multivariate	
	Mean	Effect	S.E.	Effect	S.E.
Mexico	0.42	10.5	(1.11)	7.7	(1.02)
Iceland	0.00	15.0	(1.46)	7.2	(1.51)
Latvia	0.22	8.7	(1.94)	6.4	(1.31)
Finland	0.11	12.1	(1.46)	6.0	(1.27)
New Zealand	0.10	13.4	(1.53)	6.0	(1.48)
Norway	-0.21	15.8	(1.86)	4.4	(1.76)
Sweden	0.02	13.0	(1.46)	4.3	(1.44)
Tunisia	0.72	4.8	(0.87)	3.5	(0.85)
Thailand	0.28	7.6	(1.31)	3.1	(1.26)
Australia	0.25	10.2	(1.10)	2.8	(0.96)
Brazil	0.53	1.7	(1.40)	2.0	(1.41)
Switzerland	0.03	1.4	(1.90)	1.6	(1.29)
Denmark	-0.03	5.2	(1.64)	1.5	(1.66)
Portugal	0.27	6.6	(1.31)	1.4	(1.13)
Ireland	0.13	6.1	(1.46)	0.9	(1.26)
Uruguay	0.11	2.1	(1.61)	0.8	(1.61)
Serbia	0.17	-0.8	(1.32)	0.7	(1.16)
Italy	-0.06	0.6	(1.08)	0.3	(1.36)
Macao-China	-0.37	1.2	(5.68)	-0.3	(4.13)
Russian Fed.	0.19	3.6	(1.38)	-0.3	(1.60)
Spain	0.14	5.1	(1.28)	-0.3	(1.22)
Canada	0.06	6.6	(0.87)	-0.3	(0.70)
Czech Republic	-0.01	1.3	(1.33)	-0.4	(1.18)
Austria	0.12	-2.2	(1.00)	-0.6	(1.02)
United States	0.09	6.6	(1.23)	-0.7	(1.26)
Luxembourg	-0.23	-2.5	(1.33)	-1.1	(1.23)
Poland	-0.12	-0.8	(1.72)	-1.1	(1.42)
Hong Kong-China	-0.52	6.3	(1.90)	-1.5	(1.74)
Korea	-0.37	1.2	(1.16)	-1.5	(1.10)
Germany	-0.08	-3.8	(1.25)	-2.2	(1.08)
Turkey	0.13	-1.0	(1.32)	-2.3	(1.13)
Japan	-0.50	-0.8	(1.43)	-2.4	(1.38)
Netherlands	-0.19	-1.1	(1.43)	-2.8	(1.34)
Slovak Republic	0.03	-6.4	(1.35)	-3.8	(1.20)
Greece	0.08	-5.6	(1.53)	-4.0	(1.62)
Belgium	-0.19	-3.4	(1.10)	-5.1	(1.10)
Hungary	-0.22	-7.3	(1.36)	-5.7	(1.35)
United Kingdom[1]	0.12	9.8	(1.23)	2.6	(1.24)



1. Response rate too low to ensure comparability.
Source: OECD PISA 2003 Database.

Note: Statistically significant score point differences are marked in a darker tone.



Students' general perceptions of school

Two indices in PISA 2003 represent student perceptions of school in general. These are: attitudes towards school and sense of belonging at school. Although it can be argued that attitudes should relate to achievement, an interesting question of causality arises here because it is not obvious if success in learning engenders better attitudes or if a positive attitude to school is effectively a factor in motivating students to learn.

The effects on achievement of students' attitudes towards school and sense of belonging at school appear in Figures 3.6 and 3.7. Students' attitudes towards school are only weakly correlated with achievement. The report finds statistically significant effects for about half the countries studied, but these are not in a consistent direction. Countries where positive student attitudes towards school are positively associated with mathematics performance include Norway, Iceland, New Zealand, Sweden, Finland, Mexico, as well as Australia and the partner countries Latvia, Tunisia and Thailand. Countries where a more positive attitude towards school shows a negative association with mathematics performance include Hungary, the Slovak Republic, Greece, Germany and Belgium. Therefore, there appears to be a tendency for the effect to be positive in countries with relatively homogeneous school systems and negative in a few highly differentiated school systems. For students' sense of belonging at school, other teaching and learning factors offset any positive (albeit weak) associations with student performance. In fact, in 20 of the OECD countries, a sense of belonging at school is negatively associated with performance once other teaching and learning factors are accounted for – Turkey is the only OECD country where this effect is positive.

Student motivation to learn mathematics

The literature on students' motivation to learn often makes a distinction between intrinsic and extrinsic motivation, commonly holding that intrinsic motivators are more effective than extrinsic ones in engendering engagement and performance.

PISA views interest in the subject matter as an intrinsic motivational preference which affects intensity of engagement with the subject. The report uses the index variable *interest in and enjoyment of mathematics* to represent this construct. This variable derives from a series of questionnaire items on how much students enjoy and look forward to doing mathematics. The report considers subject-matter interest to be an aspect of student learning strategies, especially if interest in the subject flows in some way out of or from the teaching. This type of positive motivation might be expected to result in increased achievement.

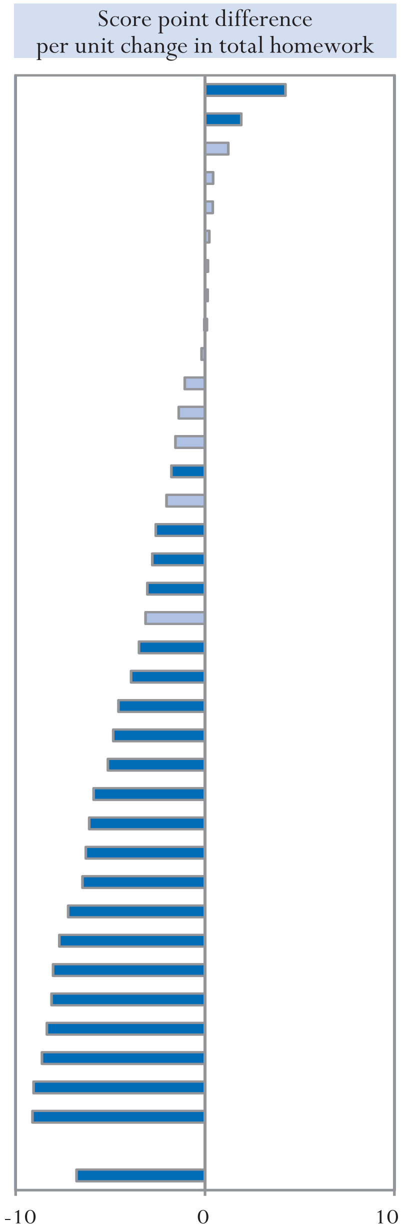
In contrast to the intrinsic nature of interest and enjoyment, students may be motivated to study mathematics by its perceived importance to future education or to careers. To analyse this possibility, the report uses the PISA *index of instrumental motivation in mathematics*, measured by a series of questionnaire items on the perceived value of studying mathematics for these external reasons.

Figures 3.8 and 3.9 give the effects of each of these measures of motivation on mathematics performance. Together, on average, the two measures of motivation to learn mathematics account for an additional 5% of performance variation among students but no additional performance variation among schools (see Table C.4, Variance explained by model changes). Students' motivation accounts for 11% of the variation in student performance in Norway, 9% in Denmark and Finland and 8% in Korea. Students' reported levels of interest in and enjoyment of mathematics show relatively strong positive association with mathematics performance. However, this changes mainly to moderate

negative effects in the full analytical model. In contrast, students' instrumental motivation to learn mathematics, which also has a strong positive observed association with performance, continues to show significant positive effects in 13 of the OECD countries in the full model. Poland displays the strongest positive effects (11 score points), followed by Norway and Spain (6 score points) and the United States, Canada and the Russian Federation (5 score points). It is interesting to note that in Poland, the United States, Canada and the Russian Federation, the effect of students' interest in and enjoyment of mathematics is negative while the effect of students' instrumental motivation to learn mathematics is positive.

Figure 3.7 ■ **Students' sense of belonging at school and mathematics performance**

	Bivariate			Multivariate	
	Mean	Effect	S.E.	Effect	S.E.
Turkey	-0.44	9.6	(1.69)	4.2	(1.46)
Tunisia	-0.09	3.6	(0.93)	1.9	(0.96)
Portugal	0.09	10.1	(1.50)	1.2	(1.50)
Mexico	0.08	3.7	(0.94)	0.4	(0.97)
Brazil	0.13	3.1	(1.12)	0.4	(1.31)
Czech Republic	-0.27	7.8	(1.72)	0.2	(1.46)
Uruguay	0.24	2.3	(1.26)	0.2	(1.32)
Russian Fed.	-0.29	7.7	(1.00)	0.1	(0.96)
Thailand	-0.29	6.9	(1.42)	0.0	(1.56)
Luxembourg	0.23	4.4	(1.33)	-0.2	(1.15)
Macao-China	-0.61	4.3	(5.21)	-1.1	(4.27)
Hungary	0.08	2.0	(1.19)	-1.4	(1.21)
Greece	0.04	2.2	(1.44)	-1.6	(1.41)
Serbia	0.03	0.2	(1.02)	-1.8	(0.90)
Poland	-0.17	7.5	(1.35)	-2.0	(1.11)
Switzerland	0.19	3.0	(1.29)	-2.6	(0.92)
Slovak Republic	-0.16	0.2	(1.30)	-2.8	(1.15)
Austria	0.44	0.1	(0.95)	-3.0	(0.89)
Latvia	-0.21	9.4	(2.10)	-3.1	(1.75)
Belgium	-0.28	-0.8	(1.31)	-3.5	(1.31)
Italy	0.05	-0.5	(1.15)	-3.9	(1.15)
Spain	0.20	0.4	(1.37)	-4.6	(1.13)
Japan	-0.53	-1.0	(1.50)	-4.8	(1.50)
Netherlands	-0.06	-2.8	(1.47)	-5.1	(1.53)
Germany	0.24	-3.4	(1.36)	-5.9	(1.39)
Korea	-0.39	1.0	(1.31)	-6.1	(1.25)
Hong Kong-China	-0.61	5.5	(1.62)	-6.3	(1.71)
Denmark	0.01	1.7	(1.69)	-6.5	(1.50)
Canada	0.02	-1.4	(0.89)	-7.2	(0.81)
Iceland	0.16	0.1	(1.45)	-7.7	(1.20)
Ireland	0.08	-4.7	(1.42)	-8.0	(1.13)
Norway	0.24	-0.2	(1.53)	-8.1	(1.21)
New Zealand	-0.01	2.5	(1.38)	-8.4	(1.32)
Australia	0.04	0.9	(1.19)	-8.6	(0.97)
Sweden	0.25	-0.4	(1.53)	-9.1	(1.26)
Finland	-0.02	-1.9	(1.23)	-9.1	(1.09)
United Kingdom[1]	0.08	0.2	(1.21)	-6.8	(1.30)



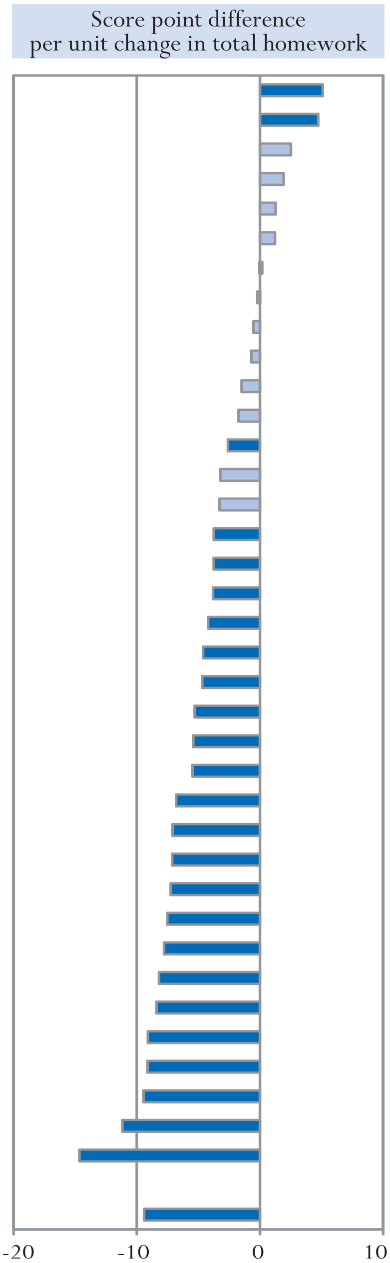
1. Response rate too low to ensure comparability.
Source: OECD PISA 2003 Database.

Note: Statistically significant score point differences are marked in a darker tone.

Positive attitudes towards school and motivation to learn may be, independently of their impact on achievement, important outcomes in their own right. The four measures of students' perceptions of school in general and their motivation to learn mathematics show positive correlations among themselves. This lack of independence among these measures no doubt accounts for the change in patterns of relationship when all of the measures enter into the same analytical model.

Figure 3.8 ■ Students' interest in and enjoyment of mathematics and mathematics performance

		Bivariate		Multivariate	
	Mean	Effect	S.E.	Effect	S.E.
Hong Kong-China	0.22	22.0	(1.25)	5.1	(1.83)
Japan	-0.39	15.9	(1.11)	4.7	(1.70)
Korea	-0.12	23.3	(1.03)	2.5	(1.71)
Luxembourg	-0.26	9.8	(1.18)	1.9	(1.77)
Norway	-0.17	34.0	(1.36)	1.3	(2.01)
Macao-China	0.13	19.2	(4.18)	1.2	(4.53)
Switzerland	0.12	14.5	(1.36)	0.0	(1.87)
Netherlands	-0.20	15.1	(1.47)	-0.2	(1.71)
Belgium	-0.17	15.1	(1.18)	-0.5	(1.46)
Uruguay	0.36	15.9	(1.62)	-0.7	(2.42)
Hungary	-0.21	10.8	(1.52)	-1.5	(1.80)
Greece	0.10	19.8	(1.30)	-1.7	(2.14)
Germany	0.04	14.3	(1.09)	-2.6	(1.31)
Turkey	0.55	12.9	(1.64)	-3.2	(2.10)
Spain	-0.07	20.6	(1.24)	-3.3	(1.93)
Ireland	-0.05	17.1	(1.52)	-3.8	(1.72)
Czech Republic	-0.19	18.4	(1.52)	-3.8	(1.81)
Italy	0.07	14.1	(1.15)	-3.8	(1.74)
Iceland	-0.11	24.7	(1.45)	-4.2	(1.68)
Finland	-0.24	30.2	(1.61)	-4.6	(1.79)
Sweden	0.09	27.2	(1.63)	-4.7	(1.76)
Austria	-0.28	10.2	(1.22)	-5.3	(1.48)
Slovak Republic	0.03	15.4	(1.67)	-5.4	(1.90)
Tunisia	0.94	8.4	(1.17)	-5.5	(1.76)
Russian Fed.	0.25	11.5	(1.70)	-6.8	(2.36)
Canada	-0.01	19.9	(0.94)	-7.1	(1.29)
Denmark	0.41	28.1	(1.56)	-7.1	(2.23)
Thailand	0.71	6.4	(1.79)	-7.2	(2.52)
United States	0.04	12.9	(1.18)	-7.5	(1.33)
Australia	0.01	17.2	(1.07)	-7.8	(1.57)
Mexico	0.58	7.9	(1.52)	-8.2	(2.03)
Portugal	0.16	15.6	(1.75)	-8.4	(2.35)
Brazil	0.54	5.3	(2.07)	-9.1	(2.54)
New Zealand	0.12	15.9	(1.62)	-9.1	(2.07)
Serbia	-0.06	1.7	(1.57)	-9.5	(1.86)
Poland	0.11	17.7	(1.37)	-11.2	(1.85)
Latvia	0.05	16.5	(2.43)	-14.7	(2.52)
United Kingdom[1]	0.00	13.8	(1.30)	-9.4	(1.73)



1. Response rate too low to ensure comparability.

Source: OECD PISA 2003 Database.

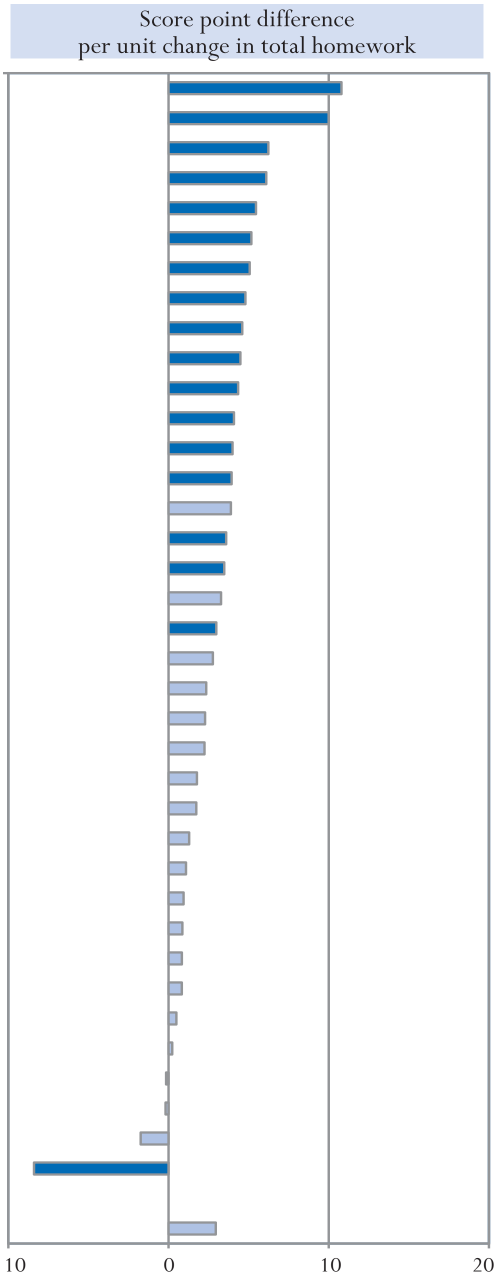
Note: Statistically significant score point differences are marked in a darker tone.

Student perceptions of their mathematics capability

PISA assesses student perceptions of their capabilities in mathematics using three indices. One of these, the *index of anxiety in mathematics*, effectively represents an emotional reaction to mathematics. High anxiety is measured by agreement with items having to do with worrying about obtaining good marks or feeling helpless or nervous when doing mathematics problems. A second measure, the *index of self-efficacy in mathematics*, is more cognitive than affective in nature and derives from

Figure 3.9 ■ **Students' instrumental motivation in mathematics and mathematics performance**

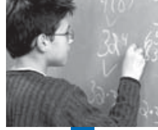
	Mean	Bivariate Effect	Bivariate S.E.	Multivariate Effect	Multivariate S.E.
Poland	0.04	18.8	(1.63)	10.8	(1.65)
Latvia	0.07	19.2	(1.61)	10.0	(1.58)
Norway	0.15	27.9	(1.55)	6.2	(1.55)
Spain	-0.05	19.2	(1.04)	6.1	(1.60)
United States	0.17	16.8	(1.23)	5.5	(1.28)
Canada	0.23	19.0	(0.86)	5.2	(0.94)
Russian Fed.	0.00	10.1	(1.54)	5.1	(1.54)
Portugal	0.27	15.0	(1.59)	4.8	(1.74)
Belgium	-0.32	11.6	(1.20)	4.6	(1.26)
Slovak Republic	-0.05	11.8	(1.36)	4.5	(1.66)
Sweden	0.02	22.9	(1.83)	4.3	(1.51)
Serbia	-0.20	2.1	(1.32)	4.1	(1.58)
New Zealand	0.29	16.3	(1.72)	4.0	(1.44)
Italy	-0.15	9.9	(1.29)	3.9	(1.67)
Thailand	0.49	9.0	(1.69)	3.9	(2.19)
Finland	0.06	26.6	(1.71)	3.6	(1.46)
Tunisia	0.52	9.9	(1.18)	3.5	(1.48)
Greece	-0.05	13.2	(1.33)	3.3	(1.86)
Czech Republic	0.01	14.1	(1.38)	3.0	(1.20)
Korea	-0.44	19.0	(1.15)	2.8	(1.43)
Iceland	0.31	18.0	(1.68)	2.4	(1.68)
Hungary	-0.11	8.1	(1.34)	2.3	(1.30)
Uruguay	0.27	10.0	(1.31)	2.2	(1.41)
Germany	-0.04	9.7	(1.29)	1.8	(1.23)
Australia	0.23	15.6	(0.94)	1.7	(1.41)
Hong Kong-China	-0.12	15.7	(1.50)	1.3	(1.67)
Turkey	0.23	9.3	(1.47)	1.1	(1.75)
Mexico	0.58	5.7	(1.32)	0.9	(1.82)
Ireland	0.10	8.3	(1.40)	0.9	(1.32)
Netherlands	-0.26	10.5	(1.29)	0.8	(1.20)
Japan	-0.66	11.5	(1.15)	0.8	(1.57)
Brazil	0.40	0.5	(1.72)	0.5	(1.95)
Luxembourg	-0.41	4.7	(1.19)	0.2	(1.56)
Denmark	0.37	21.0	(1.48)	-0.2	(1.87)
Switzerland	-0.04	8.4	(1.54)	-0.2	(1.28)
Austria	-0.49	3.1	(1.15)	-1.7	(1.37)
Macao-China	-0.03	4.5	(3.79)	-8.4	(4.25)
United Kingdom[1]	0.12	11.6	(1.45)	2.9	(1.54)



1. Response rate too low to ensure comparability.

Source: OECD PISA 2003 Database.

Note: Statistically significant score point differences are marked in a darker tone.



responses to questions about student confidence in their ability to solve specific kinds of mathematics problems. The third measure, the *index of self-concept in mathematics*, represents responses to items on student perceptions of how good they are at mathematics in general. These three measures are not mutually independent. There is a strong positive correlation between self-concept in mathematics and self-efficacy in mathematics and strong negative correlations between both of these and anxiety in mathematics; the correlation between anxiety in mathematics and self-concept in mathematics is particularly pronounced (-0.80 on average in OECD countries; see Table B.1.).

As Figure 3.10 shows, anxiety in mathematics has a significant negative association with performance for most countries and, furthermore, the pattern remains the same even when taking other contextual and teaching and learning factors into consideration, with only Korea showing a significant positive effect. Among the OECD countries where anxiety in mathematics shows the largest negative effects Mexico (-13 score points) has above-average reported levels of anxiety, Denmark (-12 score points) and New Zealand (-11 score points) have below-average reported levels of anxiety and Poland (-15 score points) has average reported levels of anxiety. As noted earlier, these patterns may relate to country or cultural differences in the interpretation by students of the questions making up the anxiety scale. This potential source of bias needs to be investigated further.

The association between students' self-efficacy in mathematics and mathematics performance is positive and strong in all countries (Figure 3.11). Indeed, self-efficacy in mathematics shows the strongest overall effects of any factor in the teaching and learning analytical model in 12 OECD countries and 3 partner countries. The strength of this relationship is perhaps not surprising, as the items used to measure self-efficacy in mathematics to some extent resemble the actual test items, although the assessment items are more generic. The important difference between them is that the self-efficacy items indicate students' perceptions of their ability to perform the task rather than their actual performance. Nevertheless, it can be argued that self-efficacy in mathematics, if not a proxy for achievement, is closer to achievement as a construct than any other factor analysed in the model.

Figure 3.12 demonstrates that self-concept in mathematics has a similar relationship with performance both before and after other contextual and teaching and learning factors are considered: there is a strong and positive association with mathematics performance, although the strength of the association varies more among countries. These results are consistent with the high observed correlations of self-concept in mathematics with achievement. Self-concept in mathematics shows a positive effect of 30 score points in Finland, and between 20 and 25 score points in Denmark, Iceland, Australia, the Slovak Republic, New Zealand, Norway, Poland and the partner country Latvia. In Denmark, Finland and Iceland self-concept in mathematics shows the strongest overall positive effects of any of the factors analysed in the teaching and learning model. Students in Denmark report above-average levels of self-concept in mathematics.

It is interesting to note that, although these three measures of student perceptions of capability are intercorrelated, all three exert independent effects on achievement when included together in the model.[6] This indicates that the analysis has measured relatively independent constructs. It also indicates that all of these factors are powerful predictors of achievement. However, PISA data do not show the direction of causation. The argument that students have a positive self-concept or self-efficacy in mathematics because they are good at mathematics is just as plausible as the argument that being more confident in learning mathematics will lead to better performance. In fact, these

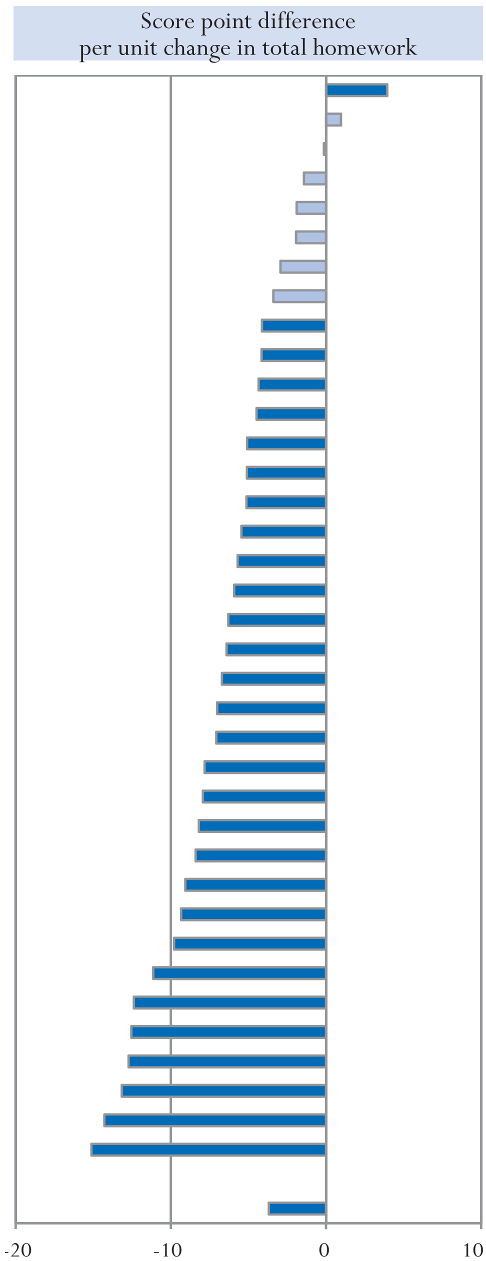
results indicate that high levels of confidence and high performance are mutually reinforcing. The same is true for high levels of anxiety in learning mathematics and low performance. The report addresses the policy implications of this finding in Chapter 4.

School size

Two school-level measures, school size and socio-economic composition of the school, are used in the teaching and learning analytical model. School size was chosen because of its observed high

Figure 3.10 ■ **Anxiety in mathematics and mathematics performance**

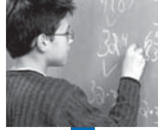
	Bivariate			Multivariate	
	Mean	Effect	S.E.	Effect	S.E.
Korea	0.41	-18.3	(1.38)	3.9	(1.87)
Iceland	-0.20	-33.1	(1.34)	1.0	(1.54)
Hong Kong-China	0.23	-20.3	(1.72)	-0.1	(2.24)
Japan	0.44	-14.4	(1.18)	-1.4	(1.83)
Tunisia	0.62	-10.0	(1.33)	-1.9	(1.34)
Netherlands	-0.38	-20.4	(1.43)	-1.9	(1.65)
Macao-China	0.24	-26.4	(3.71)	-2.9	(4.23)
Spain	0.28	-22.6	(1.74)	-3.4	(1.73)
Thailand	0.49	-14.9	(1.58)	-4.1	(1.75)
Portugal	0.15	-27.7	(1.40)	-4.2	(1.82)
Australia	-0.05	-34.2	(1.25)	-4.3	(1.40)
Austria	-0.27	-20.9	(1.03)	-4.5	(1.49)
Belgium	0.09	-23.0	(1.09)	-5.1	(1.34)
United States	-0.10	-30.1	(1.17)	-5.1	(1.46)
Germany	-0.25	-22.2	(0.87)	-5.1	(1.37)
Switzerland	-0.29	-26.1	(1.04)	-5.5	(1.36)
Canada	-0.04	-30.6	(0.79)	-5.7	(1.11)
Czech Republic	-0.05	-32.0	(1.35)	-5.9	(1.65)
Finland	-0.31	-41.7	(1.51)	-6.3	(1.88)
Luxembourg	-0.01	-20.8	(1.17)	-6.4	(1.65)
Uruguay	0.30	-28.2	(1.71)	-6.7	(1.99)
Ireland	0.07	-30.0	(1.53)	-7.0	(2.24)
Turkey	0.34	-19.3	(1.52)	-7.1	(1.63)
Norway	-0.05	-41.3	(1.33)	-7.8	(1.65)
Sweden	-0.49	-41.2	(1.56)	-7.9	(1.61)
Italy	0.29	-25.5	(1.29)	-8.2	(1.45)
Hungary	-0.01	-23.6	(1.23)	-8.4	(1.72)
Serbia	0.28	-23.6	(1.23)	-9.1	(1.74)
Greece	0.16	-28.6	(1.42)	-9.3	(1.60)
Slovak Republic	0.04	-37.0	(1.03)	-9.8	(1.37)
New Zealand	-0.10	-44.4	(1.35)	-11.1	(1.92)
Denmark	-0.45	-42.8	(1.40)	-12.4	(1.81)
Latvia	0.12	-42.1	(1.99)	-12.5	(1.95)
Mexico	0.47	-26.0	(1.19)	-12.7	(1.15)
Brazil	0.57	-27.4	(2.24)	-13.2	(2.72)
Russian Fed.	0.14	-37.3	(1.68)	-14.3	(2.25)
Poland	0.04	-44.8	(1.34)	-15.1	(1.65)
United Kingdom[1]	-0.08	-29.9	(1.20)	-3.7	(1.84)



1. Response rate too low to ensure comparability.

Source: OECD PISA 2003 Database.

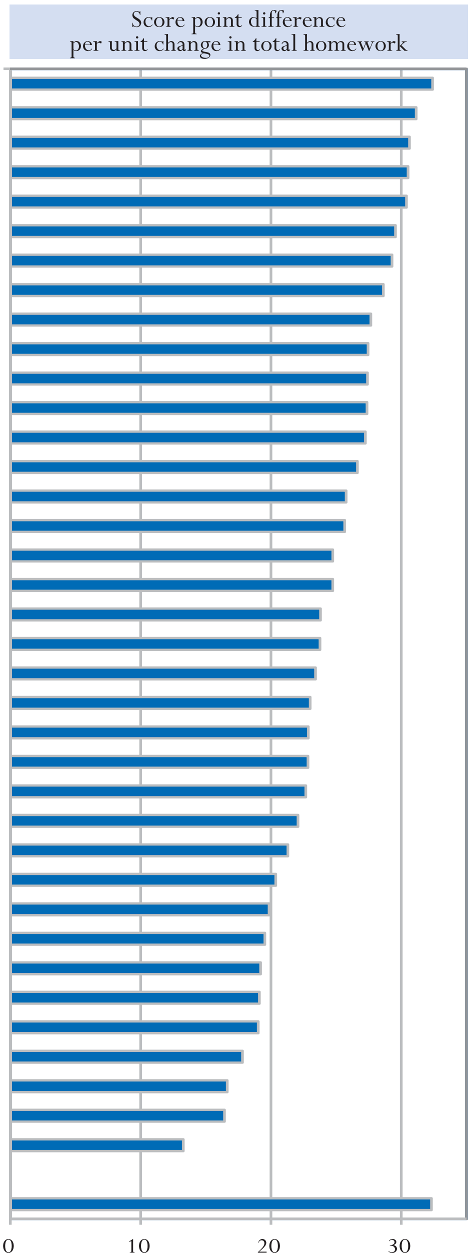
Note: Statistically significant score point differences are marked in a darker tone.



correlation with achievement in many countries, and because teaching strategies are treated here as characteristics of schools and hence might be expected to be related to school size. School size is most notable for its variability both within and between countries (see Figure 3.13). A mean school size of more than 1 000 students is found in Luxembourg and the partner economy Macao-China. Both of these countries also show large variations in school size. However, Korea and the United Kingdom, and the partner economy Hong Kong-China, have mean school sizes in the range of 900 to 1 000 students, but with a much more homogeneous distribution. Countries with the smallest average school sizes also tend to show the smallest variation in school sizes. With some exceptions,

Figure 3.11 ■ **Self-efficacy in mathematics and mathematics performance**

		Bivariate		Multivariate	
	Mean	Effect	S.E.	Effect	S.E.
Ireland	-0.03	44.0	(1.35)	32.4	(1.82)
New Zealand	0.01	48.8	(1.36)	31.1	(1.71)
Sweden	0.03	51.8	(1.61)	30.6	(1.66)
Australia	0.10	43.4	(0.88)	30.5	(1.35)
Switzerland	0.32	40.0	(1.47)	30.4	(2.41)
United States	0.27	41.4	(1.17)	29.6	(1.37)
Latvia	-0.11	47.0	(2.61)	29.3	(2.21)
Poland	0.05	50.7	(1.93)	28.6	(2.03)
Macao-China	0.08	38.2	(3.90)	27.7	(4.04)
Hong Kong-China	0.11	34.8	(1.61)	27.5	(1.82)
Canada	0.25	39.7	(0.83)	27.4	(0.93)
Russian Fed.	-0.08	38.0	(1.97)	27.4	(2.25)
Portugal	-0.06	43.2	(1.88)	27.2	(1.97)
Luxembourg	0.10	31.8	(1.18)	26.6	(1.31)
Japan	-0.53	30.4	(1.34)	25.8	(1.76)
Italy	-0.11	34.4	(1.38)	25.7	(1.33)
Slovak Republic	0.39	39.4	(1.49)	24.7	(1.71)
Belgium	-0.04	33.0	(1.50)	24.7	(1.29)
Czech Republic	0.16	38.3	(1.19)	23.8	(1.27)
Iceland	0.04	40.1	(1.27)	23.8	(1.63)
Denmark	-0.07	48.7	(1.78)	23.4	(1.93)
Germany	0.15	32.6	(1.23)	23.0	(1.62)
Norway	-0.04	46.4	(1.52)	22.9	(1.74)
Hungary	0.36	29.9	(1.21)	22.8	(1.25)
Korea	-0.42	35.6	(1.36)	22.7	(1.56)
Spain	-0.04	36.5	(1.38)	22.1	(1.26)
Finland	-0.15	45.5	(1.40)	21.3	(1.69)
Austria	0.16	27.8	(1.18)	20.4	(1.22)
Greece	-0.26	33.1	(1.93)	19.9	(2.07)
Thailand	-0.52	23.6	(1.73)	19.5	(1.69)
Uruguay	0.02	28.5	(1.60)	19.2	(1.51)
Netherlands	-0.09	27.3	(1.25)	19.1	(1.56)
Turkey	-0.18	24.8	(1.59)	19.0	(1.45)
Serbia	-0.02	22.0	(1.83)	17.8	(1.75)
Mexico	-0.22	20.1	(1.27)	16.6	(1.46)
Brazil	-0.38	19.8	(1.84)	16.4	(2.00)
Tunisia	-0.29	18.2	(1.32)	13.3	(1.36)
United Kingdom[1]	-0.11	44.4	(1.29)	32.3	(1.49)



1. Response rate too low to ensure comparability.

Source: OECD PISA 2003 Database.

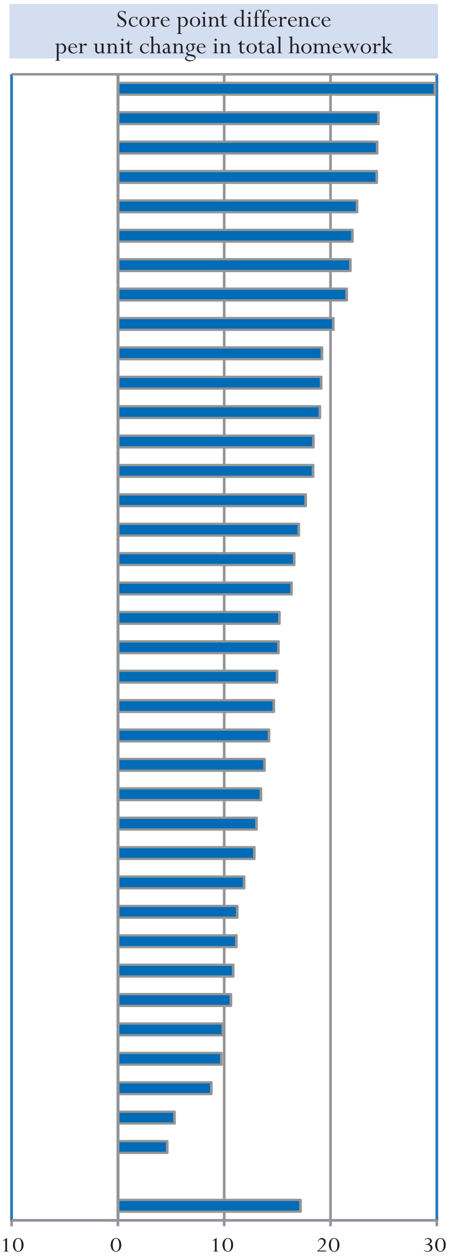
Note: Statistically significant score point differences are marked in a darker tone.

such as Greece, New Zealand and Poland, most countries with small mean school sizes are more sparsely populated. Whether the school is located in an urban of rural setting may therefore be an important variable. This issue could not be examined here but may be of interest for secondary analysis within some countries.

In general, Figure 3.14 shows that the simple observed relationship between school size and mathematics performance is: the bigger the school, the better the performance. However, the strength of this association varies considerably and it is not significant in Greece, Iceland, Norway, Poland, the

Figure 3.12 ■ **Self-concept in mathematics and mathematics performance**

	Bivariate			Multivariate	
	Mean	Effect	S.E.	Effect	S.E.
Finland	0.01	44.9	(1.19)	29.8	(1.94)
Denmark	0.24	45.4	(1.28)	24.5	(2.56)
Iceland	0.03	39.6	(1.14)	24.4	(1.88)
Australia	0.13	39.4	(1.10)	24.4	(1.31)
Slovak Republic	-0.05	39.9	(1.44)	22.5	(2.22)
New Zealand	0.15	44.2	(1.32)	22.1	(2.41)
Norway	-0.18	45.7	(1.23)	21.9	(2.13)
Latvia	-0.11	41.8	(1.93)	21.5	(2.12)
Poland	0.03	44.8	(1.39)	20.3	(2.17)
Greece	0.11	34.1	(1.56)	19.2	(2.41)
Serbia	0.02	23.3	(1.48)	19.1	(1.90)
Sweden	0.13	46.2	(1.56)	19.0	(1.81)
Canada	0.19	34.1	(0.66)	18.4	(1.56)
Portugal	-0.18	30.9	(1.18)	18.4	(1.72)
Korea	-0.35	32.1	(1.26)	17.7	(2.55)
Czech Republic	-0.09	32.8	(1.27)	17.0	(1.75)
Spain	-0.19	30.5	(1.13)	16.6	(1.95)
Mexico	0.17	22.9	(0.99)	16.3	(1.21)
Macao-China	-0.20	30.6	(3.69)	15.2	(4.07)
United States	0.25	32.2	(1.19)	15.1	(1.92)
Austria	0.07	23.5	(1.12)	15.0	(1.68)
Uruguay	0.02	27.5	(1.40)	14.7	(2.35)
Russian Fed.	0.13	34.1	(1.63)	14.2	(2.40)
Brazil	0.04	22.3	(1.57)	13.8	(2.22)
Italy	0.00	23.6	(1.06)	13.5	(1.77)
Belgium	-0.03	24.7	(1.19)	13.0	(1.35)
Hong Kong-China	-0.26	27.1	(1.56)	12.8	(2.58)
Thailand	-0.09	16.9	(1.71)	11.9	(2.09)
Ireland	-0.03	32.4	(1.55)	11.2	(2.64)
Turkey	0.02	22.2	(1.56)	11.1	(1.83)
Tunisia	0.15	13.9	(0.96)	10.8	(1.41)
Netherlands	0.00	22.4	(1.44)	10.6	(1.72)
Switzerland	0.13	25.3	(1.15)	9.9	(1.77)
Hungary	-0.15	23.7	(1.25)	9.7	(1.66)
Germany	0.15	23.1	(0.97)	8.8	(1.50)
Japan	-0.53	18.2	(1.10)	5.3	(2.17)
Luxembourg	0.07	19.1	(1.14)	4.6	(1.66)
United Kingdom[1]	0.11	34.5	(1.43)	17.2	(2.26)



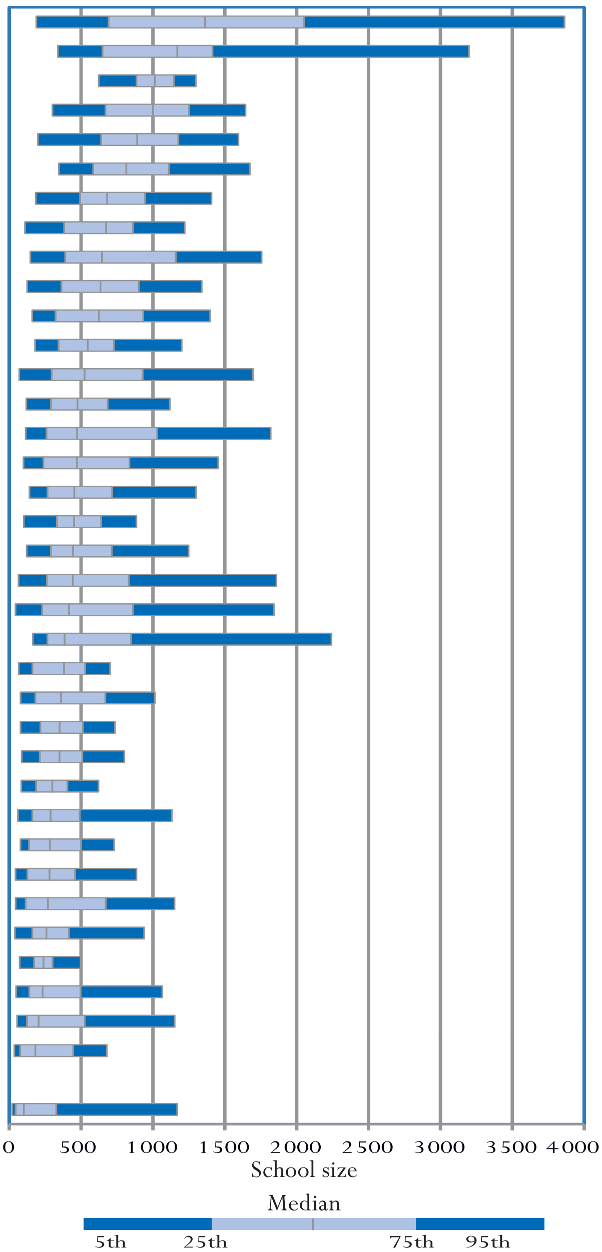
1. Response rate too low to ensure comparability.
Source: OECD PISA 2003 Database.

Note: Statistically significant score point differences are marked in a darker tone.

United States, the Slovak Republic, Germany, Luxembourg, the Czech Republic, Turkey, Spain, Italy, Switzerland, and the partner economies Brazil, Macao-China and the Russian Federation. This effect remains significant for most countries when considering other contextual and teaching and learning factors in the analytical model, but is much reduced (only 10 score points or more in 11 countries). These results do not indicate that the high correlations commonly observed between school size and achievement are likely to be products of what takes place in schools, or of student ability or other characteristics of schools or their students. Although it is interesting that the partner economy Hong Kong-China has the largest school effects in Figure 3.14, caution is required in interpreting the results as the number of schools in the sample is relatively small compared to other countries.

Figure 3.13 ■ **School size**

	Mean	Standard deviation
Macao-China	1591	1151
Luxembourg	1210	703
Hong Kong-China	986	228
Korea	993	397
United Kingdom	901	411
Tunisia	877	424
Portugal	732	397
Japan	670	396
Netherlands	800	524
Australia	653	385
Serbia	684	411
Spain	600	355
New Zealand	671	510
Belgium	520	310
Brazil	704	593
Canada	591	446
Germany	559	461
Ireland	484	241
Sweden	534	355
Turkey	670	631
United States	610	614
Thailand	702	742
Denmark	374	228
Italy	448	323
Czech Republic	380	215
Slovak Republic	385	221
Finland	313	167
Austria	385	340
Hungary	343	231
Uruguay	361	391
Russian Fed.	427	377
Poland	335	256
Greece	254	125
Switzerland	384	455
Latvia	369	338
Norway	218	139
Iceland	261	214
Mexico	279	409



Source: OECD PISA 2003 Database.

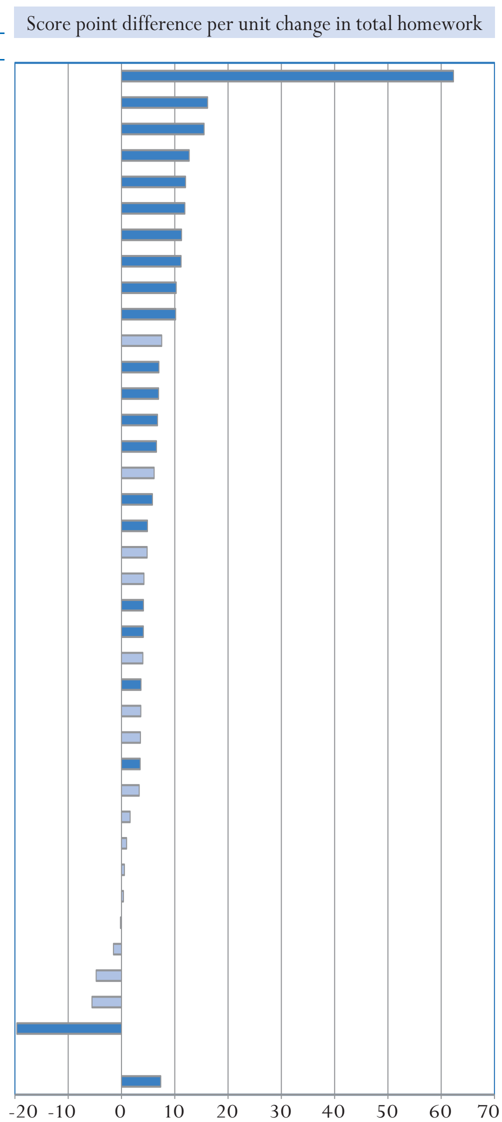
Socio-economic composition of the school

Because of the way many schools cluster within communities, parent choice of school, the existence of public and private schools, and other factors, schools within a country may differ substantially in the socio-economic background of their student bodies. Figure 3.15 shows that in most countries there is considerable variation among schools in the average socioeconomic backgrounds of their students. It is therefore appropriate to include in the model a measure of the socio-economic composition of the school. The index chosen for this purpose was the average of the highest parental occupation for students in the school, entered as a school-level predictor in the analytical model.

There is a strong positive association between the school average of students' socio-economic background and mathematics performance. Figure 3.16 shows this in a standardised form that allows

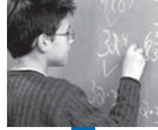
Figure 3.14 ■ **School size and mathematics performance**

	Bivariate			Multivariate	
	Mean	Effect	S.E.	Effect	S.E.
Hong Kong-China	986	116.4	(7.65)	62.3	(4.50)
Uruguay	361	40.0	(1.61)	16.2	(1.26)
Latvia	369	30.3	(2.65)	15.5	(2.12)
Belgium	520	29.3	(6.08)	12.7	(2.39)
Denmark	374	33.0	(6.47)	12.0	(4.09)
Finland	313	22.4	(2.84)	11.9	(3.22)
Netherlands	800	18.5	(2.84)	11.3	(3.08)
Austria	385	15.7	(5.19)	11.2	(2.88)
Korea	993	28.0	(4.64)	10.3	(1.40)
Portugal	732	28.2	(3.85)	10.2	(0.81)
Hungary	343	22.4	(11.44)	7.5	(4.66)
Sweden	534	16.6	(3.30)	7.0	(2.89)
Canada	591	11.4	(1.43)	7.0	(0.94)
Tunisia	877	12.6	(4.48)	6.8	(2.06)
Ireland	484	17.3	(5.15)	6.6	(3.15)
Switzerland	384	10.1	(5.15)	6.1	(4.51)
Japan	670	25.3	(1.03)	5.8	(1.06)
Australia	653	24.9	(1.34)	4.9	(1.17)
Russian Fed.	427	14.8	(4.91)	4.8	(3.25)
Italy	448	11.5	(5.59)	4.2	(3.52)
Serbia	684	8.8	(1.52)	4.1	(0.97)
Thailand	702	13.9	(0.29)	4.1	(0.43)
Spain	600	9.6	(4.11)	4.0	(2.29)
Mexico	279	5.3	(1.87)	3.7	(1.33)
Turkey	670	3.1	(3.16)	3.6	(2.93)
Macao-China	1591	4.5	(2.82)	3.6	(1.87)
New Zealand	671	15.2	(0.94)	3.5	(1.01)
Czech Republic	380	8.6	(9.01)	3.3	(3.97)
Brazil	704	2.7	(2.19)	1.6	(0.98)
Luxembourg	1210	4.5	(1.12)	1.0	(0.78)
Germany	559	8.2	(4.25)	0.6	(2.46)
Slovak Republic	385	14.1	(7.64)	0.4	(2.67)
United States	610	1.1	(2.27)	-0.2	(1.26)
Poland	335	18.3	(2.70)	-1.5	(2.65)
Norway	218	8.8	(7.99)	-4.8	(7.55)
Iceland	261	5.1	(4.93)	-5.5	(4.36)
Greece	254	-2.3	(16.24)	-19.6	(7.27)
United Kingdom[1]	901	11.0	(4.71)	7.4	(1.87)



1. Response rate too low to ensure comparability.
Source: OECD PISA 2003 Database.

Note: Statistically significant score point differences are marked in a darker tone.

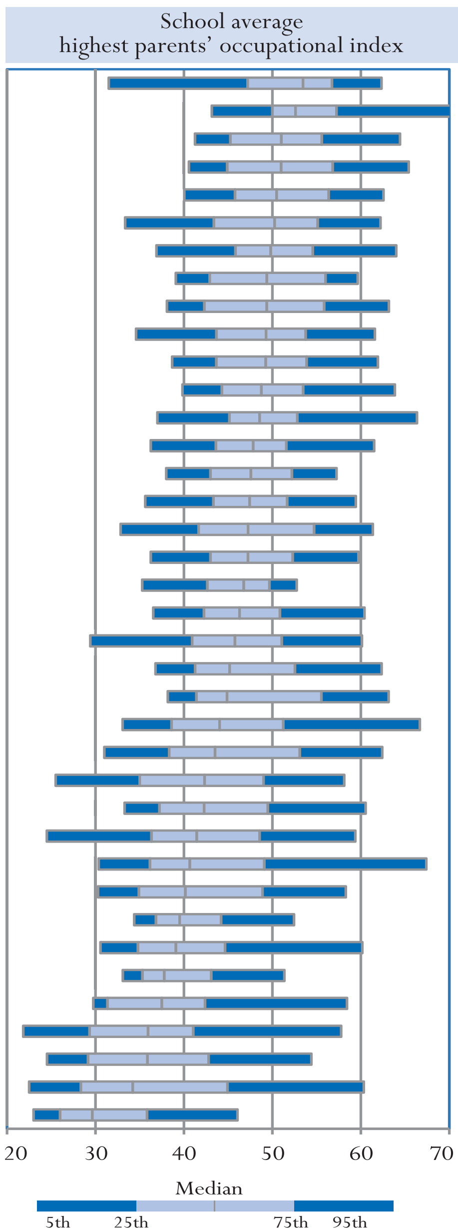


comparison with the school-level effects of other measures included in the analytical model. Even when considering other factors, one standard deviation increase in the school average of parents' occupational status is associated with a positive effect of at least 20 score points in 20 countries. It is associated with a positive effect of at least 30 score points in Japan, the Netherlands, Italy, Hungary, Germany and the Czech Republic. Conversely, in Finland, Norway, Sweden, Denmark and Iceland this association is relatively weak or even negative (8 score points or less).

It is interesting to note that although associations at the school level are comparatively weak in Denmark, Finland, Norway and Sweden, there are comparatively strong associations at the student level (8 or 9 score points; the maximum effect among countries is 10 score points). In other

Figure 3.15 ■ **School average highest parents' occupational status**

	Mean	Standard deviation
United States	51.72	8.14
Norway	54.53	8.26
Sweden	51.35	7.40
Australia	51.23	7.53
Netherlands	51.13	6.96
Iceland	49.28	8.56
Canada	50.24	7.70
United Kingdom	50.65	8.34
Serbia	49.15	8.14
Finland	48.81	7.44
New Zealand	49.47	7.54
Czech Republic	49.55	7.27
Denmark	49.60	8.16
Latvia	48.06	7.53
Japan	47.65	6.08
Russian Fed.	47.46	7.02
Belgium	47.86	9.02
Switzerland	47.67	7.18
Korea	45.84	5.70
Ireland	46.66	7.25
Slovak Republic	45.86	8.41
Germany	47.33	8.21
Luxembourg	48.12	8.12
Poland	45.63	9.94
Austria	45.79	10.21
Hungary	41.96	9.75
Spain	44.11	8.83
Italy	42.20	9.97
Uruguay	43.25	10.38
Greece	41.99	9.00
Hong Kong-China	41.13	5.94
Portugal	40.53	8.16
Macao-China	40.10	6.29
Turkey	38.54	9.07
Brazil	36.61	10.20
Tunisia	37.12	9.72
Mexico	37.17	12.16
Thailand	31.65	7.56

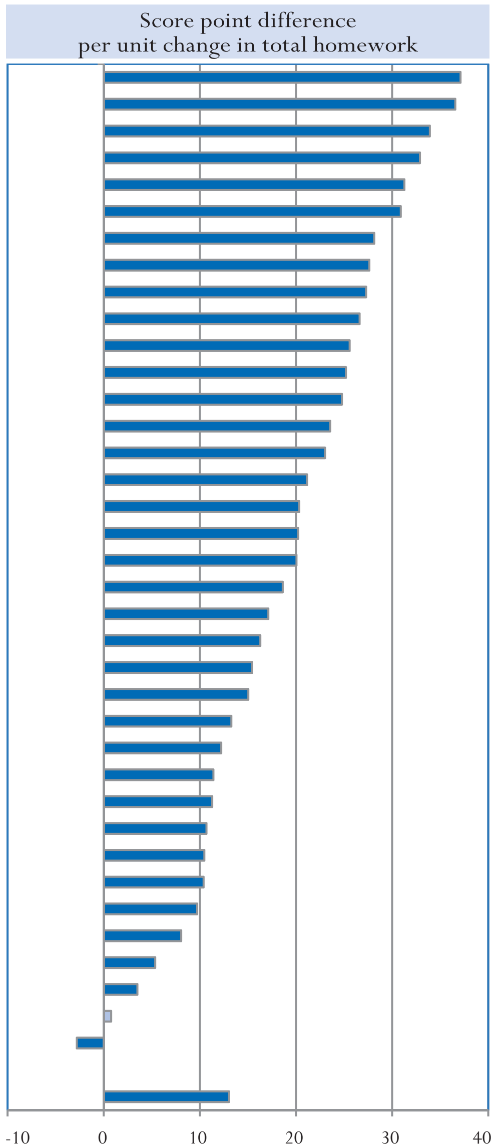


Source: OECD PISA 2003 Database.

countries, the school average effects of parents' occupational status are independent of and substantially larger than student-level effects, indicating that in most countries students attending a school in which most students are from relatively advantaged socio-economic backgrounds are at an academic advantage. This result is most striking in Japan and Korea, where at the student level there is no association, but one standard deviation improvement in the school average of parents' occupational status shows a positive effect of 37 score points (Japan) and 26 score points (Korea). Finland and Japan demonstrate two different situations where both countries achieve high mean performance, but Finland has a relatively homogenous distribution of school-level parents' occupational status, while this is not the case in Japan.

Figure 3.16 ■ **School average of the highest international socio-economic index of occupational status (HISEI) of both parents and mathematics performance**

		Bivariate		Multivariate	
	Mean	Effect	S.E.	Effect	S.E.
Japan	47.65	77.8	(0.83)	37.1	(1.63)
Netherlands	51.13	52.1	(3.46)	36.6	(2.53)
Italy	42.20	49.1	(0.68)	33.9	(1.11)
Hungary	41.96	56.2	(1.28)	32.9	(1.69)
Germany	47.33	50.6	(3.37)	31.3	(2.05)
Czech Republic	49.55	53.9	(4.60)	30.9	(3.07)
Luxembourg	48.12	53.5	(1.16)	28.1	(1.82)
Turkey	38.54	50.0	(0.94)	27.6	(1.63)
Belgium	47.86	53.0	(2.46)	27.3	(1.83)
Austria	45.79	47.1	(1.28)	26.6	(1.79)
Korea	45.84	58.3	(1.08)	25.6	(1.35)
Slovak Republic	45.86	46.7	(0.63)	25.2	(0.93)
Greece	41.99	40.2	(1.07)	24.8	(1.56)
Brazil	36.61	40.2	(1.74)	23.6	(1.34)
Uruguay	43.25	44.4	(0.76)	23.0	(1.14)
Serbia	49.15	41.2	(0.66)	21.2	(1.02)
Tunisia	37.12	31.9	(0.32)	20.3	(0.91)
Hong Kong-China	41.13	48.7	(1.24)	20.2	(1.79)
Thailand	31.65	36.4	(0.82)	20.1	(1.25)
Switzerland	47.67	39.5	(0.90)	18.6	(1.49)
Mexico	37.17	25.9	(0.32)	17.1	(0.76)
Australia	51.23	39.8	(3.37)	16.3	(2.24)
Macao-China	40.10	23.8	(3.52)	15.4	(3.95)
United States	51.72	41.1	(0.91)	15.0	(1.37)
New Zealand	49.47	36.0	(1.76)	13.3	(1.64)
Ireland	46.66	34.6	(1.69)	12.2	(1.90)
Russian Fed.	47.46	30.4	(1.18)	11.4	(1.63)
Latvia	48.06	26.6	(1.37)	11.3	(1.57)
Portugal	40.53	35.5	(0.98)	10.7	(1.27)
Canada	50.24	25.8	(0.78)	10.5	(0.73)
Spain	44.11	26.4	(0.59)	10.4	(1.09)
Poland	45.63	29.7	(1.36)	9.7	(1.63)
Denmark	49.60	29.5	(1.85)	8.1	(1.93)
Sweden	51.35	25.0	(1.62)	5.4	(1.66)
Norway	54.53	19.2	(1.71)	3.5	(1.55)
Iceland	49.28	8.0	(1.87)	0.8	(1.66)
Finland	48.81	9.7	(0.99)	-2.8	(1.10)
United Kingdom[1]	50.65	37.3	(2.87)	13.0	(1.22)



1. Response rate too low to ensure comparability.

Source: OECD PISA 2003 Database.

Note: Statistically significant score point differences are marked in a darker tone.

THE MEASURED EFFECTS OF TEACHING AND LEARNING IN THE ANALYTICAL MODEL

Homework time

The time students spend on homework is widely considered an important element of both teaching and learning strategies. Teachers vary in the amount and type of homework they assign and students obviously differ in the amount of time spent on homework. This last point is of direct interest here as time spent on homework may be an important element of student learning strategies. It is also possible that school policy, or policies developed by local or state authorities, influences homework assignment. From the perspective of the Carroll model discussed in Chapter 2, homework is one of the few ways of increasing the time spent learning in school systems where the total learning time in school is fixed.

A full analysis of homework should examine both the amount of homework assigned and the amount of time actually spent on homework, as well as the nature of the homework, its supervision and monitoring. Unfortunately, PISA does not provide measures of all of these elements. However, PISA 2003 does collect two measures of students' reports on how much time they spend on homework: hours per week of total homework and hours per week of mathematics homework. Figures 3.17 and 3.18 give the effects for these two measures of homework. Note that, again, the effect is shown in standardised form, as the performance change associated with a rise of one standard deviation in homework time, which averages more than 300 minutes per week for total homework and 160 minutes for mathematics homework across the OECD countries. There is a high degree of variability in the amount of homework reported by students, suggesting that this measure may not reflect very accurately the prescribed amount of homework, but that different students report spending more or less time doing homework.

For most countries, the number of hours students spend each week on homework in total is positively associated with mathematics performance, while the number of hours spent each week solely on mathematics homework is negatively associated with mathematics performance. Of course these two measures are not independent: mathematics homework forms a significant component of the total amount of homework reported by students in OECD countries, averaging 53% across all OECD countries and ranging from 33% in Hungary, Italy, the Netherlands and Sweden to 55% in Mexico. When looking at both these measures in the context of other factors, one might therefore expect that the effects of total homework would suppress the effects of mathematics homework. However, this is not the case, as shown by the observed negative association between mathematics homework and mathematics performance in 19 of the countries studied (Figure 3.18).

While a negative relationship between homework and achievement may seem counter-intuitive, it is conceivable that assigning extra homework to weaker students along with the likelihood that stronger students finish standard homework in less time could produce this relationship. However, such a relationship is also inconsistent with the literature on homework. As in earlier work, a new synthesis of homework research across studies employing a variety of correlational and quasi-experimental methods (Cooper *et al.*, 2006) reports positive homework effects in languages, arts and mathematics. Unfortunately, this synthesis covers only studies conducted in the United States, but the observed association between mathematics homework and mathematics performance in the United States is consistent with Cooper's work, although the relationship is weak (5 score points).

To what extent are homework effects characteristic of particular countries? In particular, to what extent are they characteristic of the way in which various countries treat homework? It is notable

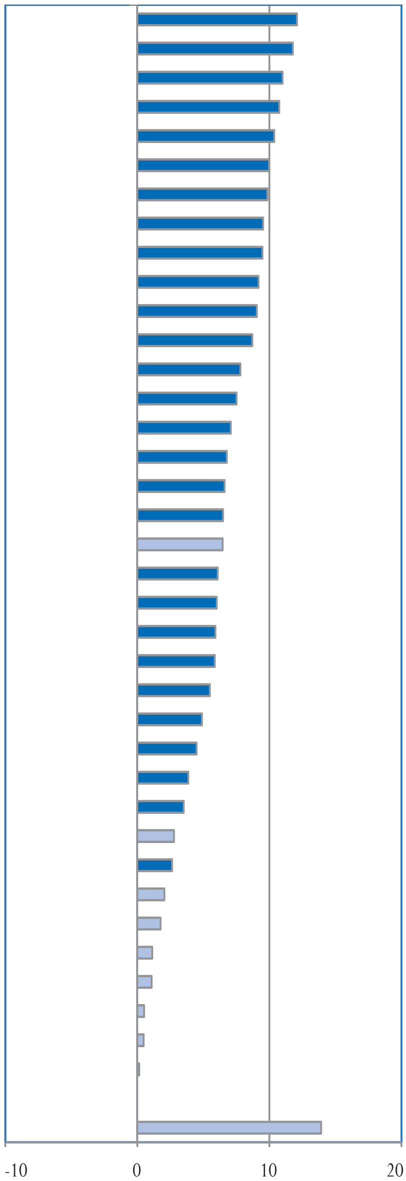
that the strongest negative effects for mathematics homework in the teaching and learning analytical model are seen in Finland, Sweden, Norway, Switzerland and Iceland, which is also the case for the observed associations with performance.

Another noteworthy finding concerns the performance within each country of students reporting no mathematics homework compared to that for students reporting some homework. In most

Figure 3.17 ■ **Hours per week of total homework and mathematics performance**

	Mean number of hours per week	Change in mathematics score		Change in mathematics score when accounting for other background, teaching and learning characteristics	
New Zealand	4.5	18.5	(2.65)	12.1	(2.19)
Korea	3.5	15.4	(2.38)	11.8	(2.74)
Thailand	6.9	16.9	(1.31)	11.0	(1.61)
Spain	7.4	15.0	(1.87)	10.7	(1.92)
Poland	8.1	8.4	(1.18)	10.4	(1.32)
Iceland	4.6	8.5	(2.81)	10.0	(2.98)
Hong Kong-China	6.8	11.7	(1.17)	9.8	(1.92)
Ireland	7.7	14.9	(1.38)	9.5	(1.32)
Norway	4.8	8.0	(2.26)	9.5	(2.43)
United States	5.7	18.1	(1.89)	9.2	(2.04)
Brazil	4.9	7.8	(1.58)	9.0	(2.08)
Japan	3.8	10.0	(2.06)	8.7	(2.70)
Mexico	5.8	13.0	(1.07)	7.8	(1.57)
Belgium	6.2	5.5	(1.48)	7.5	(1.61)
Netherlands	5.7	2.4	(1.43)	7.1	(1.49)
Luxembourg	6.1	-1.0	(2.03)	6.8	(2.19)
Canada	5.6	9.4	(1.20)	6.6	(1.06)
Australia	5.7	14.7	(1.38)	6.5	(1.53)
Macao-China	7.8	13.0	(3.27)	6.5	(4.26)
Switzerland	4.6	-6.3	(2.49)	6.1	(2.97)
Portugal	4.9	7.7	(2.02)	6.0	(2.15)
Finland	3.7	-4.2	(2.44)	5.9	(2.91)
Greece	8.3	9.0	(1.29)	5.9	(1.04)
Turkey	5.9	5.1	(1.46)	5.5	(2.07)
Sweden	3.9	4.6	(2.71)	4.9	(2.44)
Hungary	10.0	0.4	(0.94)	4.5	(1.12)
Czech Republic	3.8	-2.3	(1.80)	3.9	(1.84)
Latvia	9.4	1.4	(1.30)	3.5	(1.35)
Uruguay	6.8	5.4	(1.50)	2.8	(1.87)
Russian Fed.	12.7	3.5	(1.00)	2.6	(0.88)
Germany	6.3	-4.5	(1.76)	2.0	(2.02)
Austria	4.0	-6.9	(2.23)	1.8	(3.02)
Tunisia	4.9	6.8	(1.68)	1.1	(2.05)
Serbia	5.3	3.1	(1.49)	1.1	(1.64)
Italy	10.5	0.5	(0.77)	0.5	(0.92)
Slovak Republic	8.4	-1.9	(1.52)	0.5	(1.35)
Denmark	5.4	-2.9	(2.83)	0.0	(2.91)
United Kingdom[1]	6.0	19.6	(1.72)	13.9	(1.70)

Score point difference per unit change in total homework



1. Response rate too low to ensure comparability.
Source: OECD PISA 2003 Database.

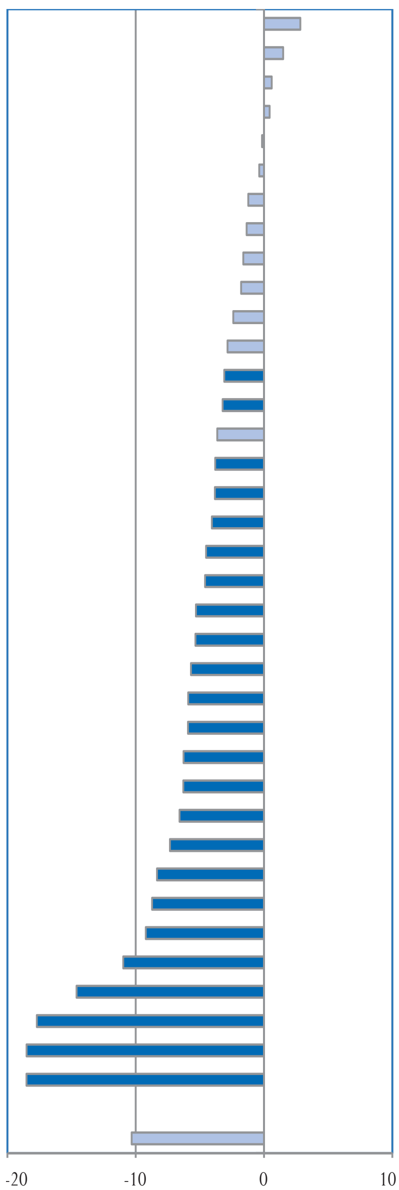
Note: Statistically significant score point differences are marked in a darker tone.

cases, the proportions of students reporting no mathematics homework were small. In virtually all countries, however, those reporting no homework performed at significantly higher levels than those reporting some homework. This result indicates that a small number of students can maintain high achievement in mathematics with no homework in that subject. Whether this is a matter of underlying ability or the influence of favourable school characteristics or instructional organisation is not clear.

Figure 3.18 ■ **Hours per week of mathematics homework and mathematics performance**

	Mean number of hours per week	Change in mathematics score		Change in mathematics score when accounting for other background, teaching and learning characteristics	
Macao-China	4.34	5.3	(2.07)	2.8	(3.27)
Tunisia	2.76	5.2	(1.33)	1.5	(1.59)
Serbia	2.43	0.5	(1.23)	0.6	(1.55)
Thailand	4.02	10.0	(0.93)	0.4	(1.17)
Mexico	3.20	7.3	(0.74)	-0.2	(1.26)
Greece	3.31	5.3	(1.24)	-0.4	(1.19)
Uruguay	2.83	0.7	(1.42)	-1.2	(1.57)
Russian Fed.	5.03	-1.8	(0.86)	-1.4	(0.73)
Slovak Republic	3.16	-5.5	(1.15)	-1.6	(1.06)
Australia	2.34	8.3	(1.42)	-1.8	(1.26)
Japan	1.98	4.9	(1.45)	-2.4	(1.80)
Hong Kong-China	3.08	7.2	(1.19)	-2.8	(1.70)
Italy	3.49	-2.7	(1.22)	-3.1	(1.13)
United States	2.77	4.6	(1.19)	-3.2	(1.20)
Korea	1.76	8.0	(2.05)	-3.6	(2.81)
Turkey	2.85	2.1	(1.35)	-3.8	(1.85)
Canada	2.81	1.2	(1.00)	-3.8	(0.92)
Latvia	3.68	-6.0	(1.58)	-4.1	(1.67)
Belgium	2.23	-2.3	(1.42)	-4.5	(1.52)
Hungary	3.29	-6.1	(1.15)	-4.6	(1.21)
Austria	1.75	-15.8	(2.35)	-5.3	(2.60)
Ireland	2.84	3.0	(1.64)	-5.3	(1.61)
Brazil	2.37	0.2	(1.52)	-5.7	(1.87)
Portugal	2.03	1.3	(1.77)	-5.9	(2.09)
Spain	2.94	3.0	(1.65)	-5.9	(1.84)
Denmark	2.59	-10.3	(1.89)	-6.3	(2.10)
Germany	2.59	-12.1	(1.49)	-6.3	(1.78)
Netherlands	1.87	-8.4	(1.62)	-6.6	(1.78)
Czech Republic	1.67	-11.9	(1.72)	-7.3	(1.76)
Poland	4.10	-6.4	(0.92)	-8.3	(0.97)
New Zealand	1.73	1.2	(2.32)	-8.7	(1.97)
Luxembourg	2.34	-12.5	(1.71)	-9.2	(1.74)
Iceland	2.27	-8.4	(2.28)	-11.0	(2.31)
Switzerland	1.85	-19.9	(2.38)	-14.6	(2.49)
Norway	1.83	-9.8	(1.91)	-17.7	(2.69)
Finland	1.46	-18.5	(2.37)	-18.5	(2.42)
Sweden	1.28	-25.8	(2.94)	-18.5	(2.46)
United Kingdom[1]	2.04	-3.1	(1.54)	-10.3	(1.55)

Score point difference per unit change in mathematics homework



1. Response rate too low to ensure comparability.

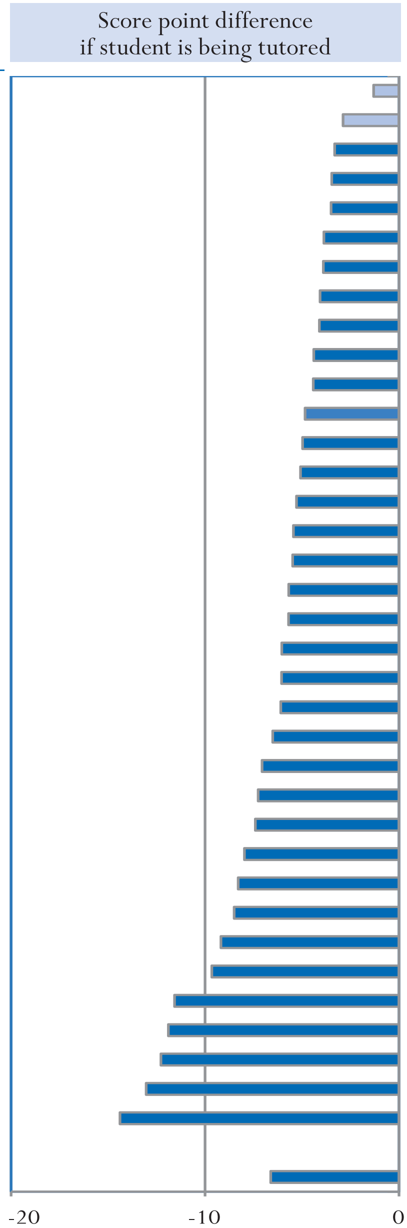
Source: OECD PISA 2003 Database.

Note: Statistically significant score point differences are marked in a darker tone.

This finding, of course, does not account for the generally positive effects for total homework. Very few students reported doing no weekly homework and for those that did the achievement results were the opposite of those of students doing no mathematics homework. To the extent that these results replicate across virtually all countries, it indicates a fundamental but complex pattern in which higher-performing students do more homework generally but do less mathematics homework. This result may relate to the earlier point about mathematics being fundamentally a school subject. It is possible that the most able students learn their mathematics mainly in school and hence

Figure 3.19 ■ **Students being tutored in mathematics and mathematics performance**

	Percentage of students being tutored	Change in mathematics score		Change in mathematics score when accounting for other background, teaching and learning characteristics	
Slovak Republic	7	-2.0	(1.26)	-1.3	(1.09)
Mexico	90	-4.2	(2.47)	-2.9	(2.35)
Serbia	21	-6.3	(1.04)	-3.3	(0.98)
Luxembourg	16	-9.4	(1.15)	-3.5	(1.15)
Korea	21	-2.8	(0.88)	-3.5	(0.87)
Thailand	14	-4.9	(1.01)	-3.9	(0.94)
Australia	13	-6.5	(1.03)	-3.9	(0.92)
Portugal	26	-3.6	(0.85)	-4.1	(0.81)
Poland	11	-10.0	(1.22)	-4.1	(0.92)
Latvia	12	-9.9	(1.19)	-4.4	(0.94)
Hong Kong-China	16	-6.4	(1.04)	-4.4	(0.88)
Hungary	14	-9.2	(0.97)	-4.8	(1.08)
Germany	15	-12.2	(0.85)	-5.0	(0.86)
Spain	23	-7.2	(0.88)	-5.1	(0.81)
Canada	9	-11.5	(0.87)	-5.3	(0.76)
Netherlands	5	-10.0	(1.55)	-5.4	(1.23)
Czech Republic	6	-9.3	(1.22)	-5.5	(1.21)
Austria	7	-13.8	(1.28)	-5.7	(1.11)
Belgium	4	-11.0	(1.63)	-5.7	(1.51)
Italy	13	-10.5	(1.02)	-6.0	(0.87)
Switzerland	8	-12.9	(1.71)	-6.1	(1.40)
Russian Fed.	15	-9.2	(1.23)	-6.1	(1.04)
Greece	29	-6.0	(1.04)	-6.5	(0.92)
Turkey	43	-6.4	(1.68)	-7.1	(1.60)
United States	9	-14.6	(1.16)	-7.3	(1.10)
Iceland	11	-16.4	(1.55)	-7.4	(1.31)
Ireland	16	-10.4	(1.42)	-8.0	(1.17)
Uruguay	20	-14.2	(1.57)	-8.3	(1.43)
New Zealand	10	-14.5	(1.76)	-8.5	(1.65)
Denmark	2	-18.7	(3.62)	-9.2	(3.26)
Japan	4	-9.4	(1.53)	-9.7	(1.40)
Macao-China	10	-15.3	(2.83)	-11.6	(2.59)
Finland	1	-22.0	(3.84)	-11.9	(3.29)
Brazil	21	-15.7	(1.25)	-12.3	(1.35)
Sweden	4	-22.2	(2.56)	-13.0	(1.73)
Norway	3	-25.8	(2.49)	-14.4	(2.38)
United Kingdom[1]	8	-8.3	(1.43)	-6.6	(1.15)



1. Response rate too low to ensure comparability.

Source: OECD PISA 2003 Database.

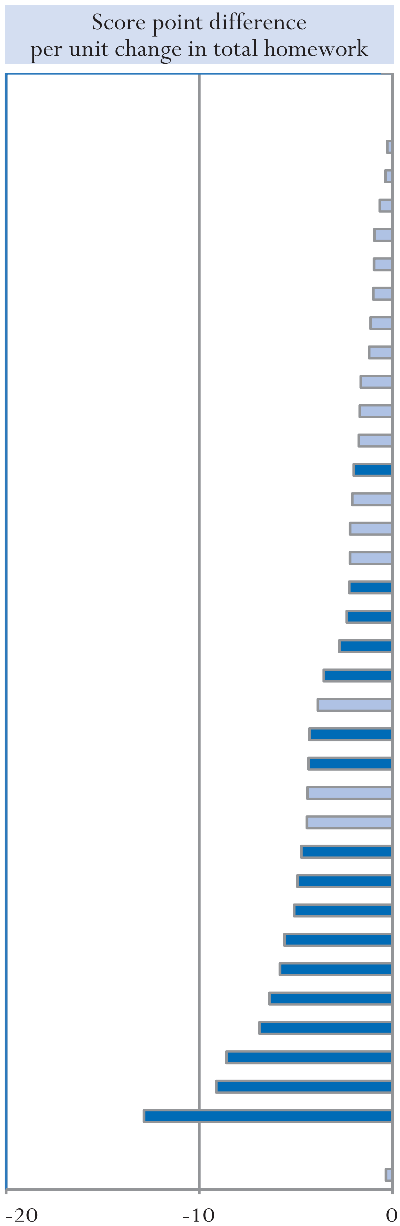
Note: Statistically significant score point differences are marked in a darker tone.

have no need for homework, while less-well-performing students struggle more with mathematics, generating a need for mathematics homework. This and other aspects of the cumulative nature of mathematics learning would best be investigated using longitudinal studies, which follow student learning behaviours and performance over several years.

It is interesting to note that in the majority of OECD countries there is very little correlation between mathematics homework and self-efficacy in mathematics, although there are moderate

Figure 3.20 ■ Out-of-school classes and mathematics performance

	Percentage of students taking out-of-school classes	Change in mathematics score		Change in mathematics score when accounting for other background, teaching and learning characteristics	
Turkey	59	3.0	(0.98)	0.6	(0.90)
Korea	37	3.7	(0.66)	0.3	(0.61)
Thailand	20	-0.6	(0.96)	-0.3	(0.82)
Tunisia	35	0.7	(0.58)	-0.4	(0.47)
Russian Fed.	15	-0.6	(1.07)	-0.6	(0.99)
Spain	20	-3.9	(0.95)	-0.9	(0.85)
Greece	42	-0.3	(0.71)	-1.0	(0.57)
Hong Kong-China	13	-0.6	(0.88)	-1.0	(0.84)
Brazil	26	-3.9	(0.98)	-1.1	(0.95)
Czech Republic	4	-5.5	(1.97)	-1.2	(1.59)
Ireland	8	-1.0	(1.92)	-1.6	(1.43)
Mexico	89	-5.1	(0.97)	-1.7	(0.95)
Latvia	9	-2.9	(1.84)	-1.7	(1.35)
Portugal	9	-3.4	(1.27)	-2.0	(1.01)
Canada	3	-7.3	(1.68)	-2.1	(1.24)
Macao-China	9	-7.8	(2.23)	-2.2	(1.99)
Uruguay	12	-7.4	(1.50)	-2.2	(1.33)
Japan	13	-2.2	(1.17)	-2.2	(1.02)
Hungary	16	-6.7	(0.73)	-2.4	(0.87)
Slovak Republic	6	-3.7	(1.58)	-2.7	(1.10)
Belgium	3	-10.6	(1.63)	-3.6	(1.59)
Denmark	4	-12.7	(2.45)	-3.9	(2.16)
Iceland	6	-10.1	(2.26)	-4.3	(1.62)
Poland	9	-5.9	(1.32)	-4.3	(1.09)
Norway	2	-10.4	(2.81)	-4.4	(2.29)
Sweden	1	-12.4	(4.22)	-4.4	(3.08)
Luxembourg	6	-9.0	(1.88)	-4.7	(1.78)
Serbia	4	-9.3	(2.02)	-4.9	(1.77)
Switzerland	3	-8.3	(3.37)	-5.1	(2.19)
Italy	2	-9.3	(1.90)	-5.6	(1.61)
Australia	3	-9.2	(1.89)	-5.8	(1.49)
United States	4	-13.3	(2.49)	-6.4	(2.07)
Germany	2	-13.5	(2.67)	-6.9	(1.99)
New Zealand	5	-17.3	(1.66)	-8.6	(1.56)
Austria	1	-13.4	(3.24)	-9.1	(3.09)
Finland	1	-13.8	(5.35)	-12.9	(4.05)
United Kingdom[1]	9	0.7	(1.44)	-0.3	(1.23)



1. Response rate too low to ensure comparability.
Source: OECD PISA 2003 Database.

Note: Statistically significant score point differences are marked in a darker tone.

positive correlations in Japan (0.25), Korea (0.20) and Australia (0.18). Similarly, there is no correlation between mathematics homework and the number of books students have at home (which is used as a proxy for students' socio-economic background): on average across OECD countries the correlation is 0.02. The presence or absence of these control variables in the model does not change the overall pattern of mathematics homework effects.

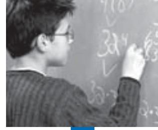
Tutoring and out-of-school lessons

Students reported the number of hours they spend per week taking mathematics lessons outside school and having tutoring in mathematics. In most countries, only a relatively small proportion of students spend any time at all at either of these activities, so these variables are dichotomised to distinguish between those exposed to these activities and those not exposed. The dichotomised variables are summarised as the percentage of students in each country taking part in these activities. Results for the two variables appear in Figures 3.19 and 3.20. In almost all cases, the effects are negative. In some countries, the effects of having tutoring or taking part in out-of-class lessons are strongly negative.

Tutoring and other forms of out-of-school learning are similar to homework in that they are ways to increase time spent in learning. All things being equal, the Carroll model would predict that these activities should contribute to increased learning. While the results presented here seem to run counter to the theoretical prediction, there are nevertheless two competing interpretations of these results.

First, it is possible that those taking part in tutoring or out-of-school lessons tend to be low-achieving students and that this characteristic outweighs the extent to which extra learning converts low achievement into high achievement for participating individuals. However, this is not to say that the activities do not convey individual benefit – PISA simply did not measure this. Another possibility is that the students taking part in these activities tend to be students whose parents have the means to pay for extra tuition. More specifically, it might be argued that participants in tutoring and out-of-school lessons are more likely to be low-achieving students of such parents. This finding raises the issue of the mediating effects of students' socio-economic background. However, on average across the OECD countries there is no correlation between the measures of students' socio-economic background and students' participation in tutoring and out-of-school lessons.[7] Having said this, in Greece, Korea and Portugal there are weak positive correlations between the student socio-economic background measures and students' participation in tutoring (between 0.11 and 0.21) and this is also the case for out-of-school lessons in Japan, Korea, Mexico and Turkey (between 0.11 and 0.21). These findings indicate that in these countries students coming from more advantaged socio-economic backgrounds are more likely to take part in these activities.

In general, the OECD countries with lower average achievement tend to have greater proportions of students participating in tutoring or out-of-school lessons: there is a strong negative cross-country correlation between these measures and overall performance. (The one clear exception to this finding is Korea, where performance is well above the OECD average and where 21% of students participate in tutoring and 37% of students participate in out-of-school lessons). Combined with the negative within-country correlations between these two measures and student performance, this suggests that additional learning beyond regular school instruction is a way to compensate for the limited quantity of schooling in some countries. The strong negative correlation across countries between number of instructional hours per year and use of extra tuition supports this suggestion.



There is no way to tell from these results if these activities have a marginal effect, which cannot be detected from the overall picture presented here, or if the effects of tutoring and out-of-school lessons are more positive for outcomes directly related to the curriculum than for more general outcomes such as those measured by PISA. Indeed, it can plausibly be argued that these activities are likely to specifically target narrower outcomes, such as school grades, than broader ones, such as building students' competencies and self-confidence. More comprehensive studies of these phenomena are clearly needed. However, some caution is required in interpreting these results, as it is not possible to dismiss the possibility of students in some countries giving socially desirable responses or interpreting the questions differently from the intended meaning.

Learning strategies

Learning strategies (sometimes referred to as meta-cognitive strategies) are generic approaches that students use to address a learning task. In the Carroll model, such strategies are at least loosely identified with ability to learn in the sense that it might be expected that students with effective learning strategies would learn more quickly than other students. The Wang *et al.* (1993) synthesis identifies learning strategies as among the proximate factors that contribute to higher achievement. However, this research is silent on whether some of these strategies are more effective than other types of strategies. The three indices used in PISA to measure students' use of learning strategies are memorisation/rehearsal strategies, elaboration strategies and control strategies (see Chapter 2).

The effects for students' use of memorisation/rehearsal strategies appear in Figure 3.21. These effects are almost universally negative, suggesting that memorisation is an ineffective strategy for learning mathematics and/or that weaker students have a greater tendency to use this strategy. It is interesting to note, however, that the observed effects are only slightly more negative across countries and have a wider overall range than the teaching and learning model effects. In general across the OECD, countries with the largest positive observed effects have close to zero effects in the analytical model and those with the largest negative observed effects tend to have the most negative effects in the analytical model.[8] Nevertheless, some countries, notably Norway, Sweden, Denmark, Australia, Japan, Korea, Spain, Finland, Canada and the partner economy Tunisia show a substantial shift in the size of the effect. This result implies that other measures analysed in the model mediate the effects that the use of memorisation/rehearsal strategies has on performance in these countries. Interestingly, however, there is no relationship between the size of the effect and achievement at the country level.

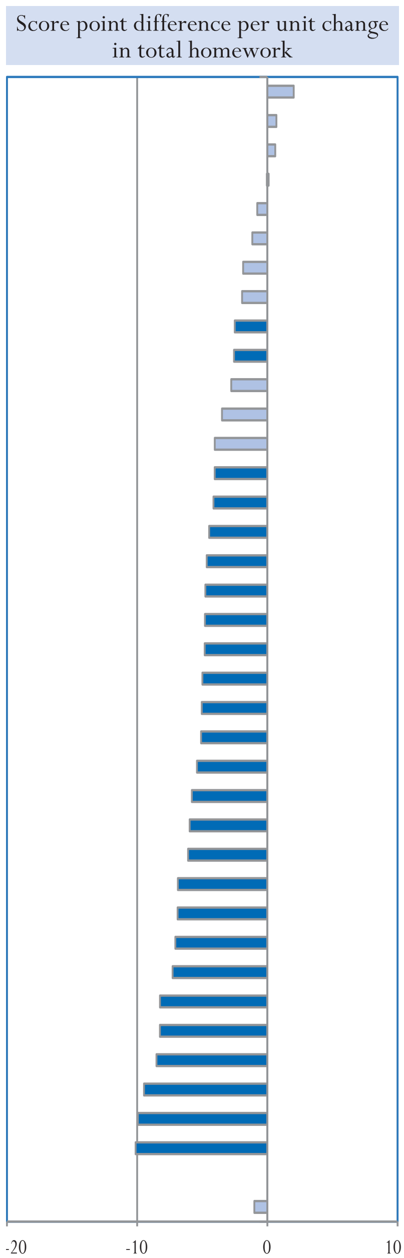
One might argue that the negative effects for the use of memorisation/rehearsal strategies are intuitively plausible and consistent with other research. However, much of the available research speaks not to the negative effects of memorisation/rehearsal strategies but to the greater positive effects of such techniques as developing and using problem-solving skills. Elaboration relates to problem solving and to the more general idea of attempting to establish meaning in the material one is attempting to learn. While it is common to interpret these strategies as more effective than memorisation for learning mathematics (Grouws and Cebulla, 2000), the research covered in this review refers to the teaching of meaning as a teaching strategy rather than as a student learning strategy.

The effects for students' use of elaboration strategies appear in Figure 3.22. In the teaching and learning analytical model the effects for elaboration strategies are mainly negative or near zero. The strongest negative effects appear in New Zealand, Australia and Norway, where there are no observed associations between the use of elaboration strategies and mathematics performance. The

positive observed association between students' use of elaboration strategies and mathematics performance in 26 countries, combined with the absence of countries where this strategy has a positive effect in the teaching and learning analytical model, raises the question of whether other research, particularly that based on less comprehensive models, is incorrect, or if other factors in the current analytical model account for the shift.

Figure 3.21 ■ **Memorisation/rehearsal strategies and mathematics performance**

	Mean index	Change in mathematics score		Change in mathematics score when accounting for other background, teaching and learning characteristics	
Netherlands	-0.16	5.2	(1.61)	2.0	(1.25)
Sweden	-0.08	14.4	(1.82)	0.7	(1.48)
Norway	-0.12	21.8	(1.55)	0.6	(1.75)
Tunisia	0.43	5.9	(0.92)	0.0	(1.21)
Uruguay	0.16	-1.6	(1.49)	-0.8	(1.57)
Turkey	0.10	3.2	(1.47)	-1.2	(1.76)
Japan	-0.56	7.2	(1.29)	-1.9	(1.37)
Belgium	-0.09	-6.7	(1.35)	-1.9	(1.17)
Luxembourg	-0.05	-7.6	(1.24)	-2.5	(1.26)
Spain	0.07	6.8	(1.23)	-2.6	(1.28)
Ireland	0.11	4.7	(1.65)	-2.8	(1.75)
Latvia	-0.14	-1.3	(3.09)	-3.5	(2.30)
Brazil	0.48	-7.3	(1.91)	-4.0	(2.28)
Canada	0.16	6.5	(0.97)	-4.0	(1.07)
New Zealand	0.13	5.7	(1.48)	-4.1	(1.56)
Russian Fed.	-0.04	-0.6	(1.27)	-4.5	(1.62)
Denmark	-0.27	9.5	(1.80)	-4.7	(1.63)
Mexico	0.56	1.4	(0.96)	-4.8	(1.06)
Poland	0.15	-3.7	(1.87)	-4.8	(1.58)
Finland	-0.19	6.6	(1.48)	-4.8	(1.27)
United States	0.31	3.1	(1.31)	-5.0	(1.47)
Australia	0.17	7.9	(1.17)	-5.0	(1.32)
Iceland	-0.03	-0.5	(1.47)	-5.1	(1.64)
Hungary	0.16	-6.2	(0.94)	-5.4	(1.19)
Slovak Republic	0.13	-6.7	(1.47)	-5.8	(1.33)
Portugal	-0.11	-2.3	(1.71)	-6.0	(1.72)
Italy	0.03	-5.5	(1.23)	-6.1	(1.34)
Germany	-0.06	-9.1	(1.16)	-6.9	(1.12)
Czech Republic	-0.05	-5.7	(1.52)	-6.9	(1.27)
Switzerland	-0.19	-11.1	(1.38)	-7.1	(1.02)
Greece	0.20	-1.7	(1.91)	-7.3	(1.91)
Austria	0.06	-11.3	(0.97)	-8.2	(1.07)
Serbia	-0.05	-12.4	(1.53)	-8.3	(1.62)
Hong Kong-China	-0.15	3.7	(1.51)	-8.5	(1.58)
Korea	-0.35	7.1	(1.24)	-9.5	(1.64)
Thailand	0.47	-0.3	(1.66)	-9.9	(2.57)
Macao-China	-0.03	-12.1	(4.12)	-10.1	(3.76)
United Kingdom[1]	0.11	10.3	(1.64)	-1.0	(1.56)



1. Response rate too low to ensure comparability.

Source: OECD PISA 2003 Database.

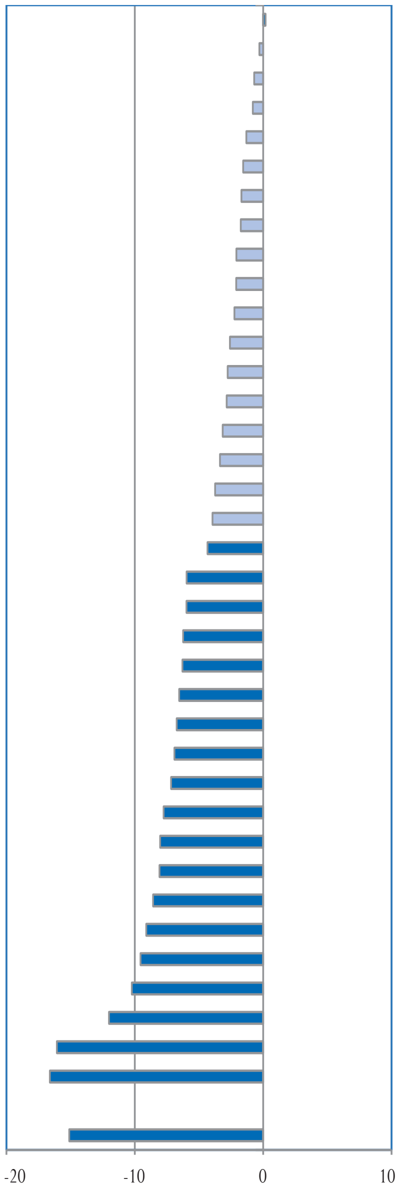
Note: Statistically significant score point differences are marked in a darker tone.

Before examining this point further, it is necessary to look at the results for students' use of control strategies to learn mathematics. While the use of elaboration strategies may be identified with effectiveness in learning, the use of control strategies may be thought of as indicators of efficiency, in the sense that the items used to measure this factor are linked to finding ways to focus on what it is important to learn.

Figure 3.22 ■ Elaboration strategies and mathematics performance

	Mean index	Change in mathematics score		Change in mathematics score when accounting for other background, teaching and learning characteristics	
Tunisia	0.94	7.8	(0.91)	0.2	(1.48)
Germany	-0.31	4.6	(1.26)	-0.3	(1.03)
Austria	-0.27	3.1	(1.08)	-0.7	(1.05)
Czech Republic	0.13	12.6	(1.37)	-0.8	(1.41)
Thailand	0.62	5.1	(1.55)	-1.3	(2.00)
Latvia	0.13	6.3	(3.34)	-1.6	(2.86)
Mexico	0.85	2.4	(1.02)	-1.7	(1.42)
Uruguay	0.36	3.7	(1.45)	-1.7	(2.34)
Serbia	0.41	-2.5	(1.49)	-2.1	(1.72)
Hungary	-0.10	3.1	(1.16)	-2.1	(1.14)
Macao-China	0.04	14.6	(3.92)	-2.2	(3.74)
Japan	-0.75	9.1	(1.07)	-2.6	(1.35)
Netherlands	-0.25	5.9	(1.43)	-2.8	(1.46)
Hong Kong-China	0.00	14.8	(1.45)	-2.8	(1.96)
Brazil	0.76	-1.0	(1.38)	-3.2	(1.95)
Slovak Republic	0.38	4.5	(1.58)	-3.4	(1.81)
Italy	0.04	5.7	(1.21)	-3.7	(1.29)
Korea	-0.39	17.7	(1.12)	-3.9	(1.46)
Spain	0.09	11.4	(1.06)	-4.3	(1.26)
Greece	0.33	8.4	(1.32)	-6.0	(1.65)
Sweden	-0.02	9.9	(2.03)	-6.0	(1.67)
Finland	-0.14	16.8	(1.34)	-6.2	(1.39)
Portugal	0.16	10.6	(1.61)	-6.3	(1.86)
Poland	0.25	7.4	(1.84)	-6.5	(1.75)
Russian Fed.	0.14	4.1	(1.65)	-6.7	(2.03)
Switzerland	-0.06	-0.1	(1.44)	-6.9	(1.53)
Denmark	0.07	10.7	(2.00)	-7.2	(2.22)
Belgium	-0.17	1.2	(1.36)	-7.8	(1.36)
Turkey	0.44	4.3	(1.17)	-8.0	(1.50)
Canada	0.08	7.5	(1.01)	-8.1	(1.00)
Luxembourg	-0.25	-2.5	(1.14)	-8.6	(1.35)
United States	0.18	-1.0	(1.25)	-9.1	(1.57)
Ireland	-0.14	-0.5	(1.73)	-9.6	(1.47)
Iceland	-0.06	0.4	(1.58)	-10.2	(1.83)
Norway	-0.16	8.0	(1.47)	-12.0	(1.70)
Australia	0.06	0.0	(0.99)	-16.1	(1.20)
New Zealand	0.13	-2.9	(1.88)	-16.6	(1.90)
United Kingdom[1]	0.04	-1.7	(1.75)	-15.1	(1.62)

Score point difference per unit change in total homework



1. Response rate too low to ensure comparability.
Source: OECD PISA 2003 Database.

Note: Statistically significant score point differences are marked in a darker tone.

The results for students' use of control strategies appear in Figure 3.23. Here the picture is much more mixed that for elaboration strategies. There is an observed positive association between students' use of control strategies and mathematics performance in 20 countries, but in the teaching and learning analytical model, there are only small positive effects found in New Zealand, Portugal, Australia, Canada, Korea, Turkey, Spain and in the partner economy Hong Kong-China. Further, there are negative effects in Sweden, the Netherlands, Denmark, the Slovak Republic, the Czech Republic and Belgium, as well as in the partner countries Latvia, the Russian Federation and Uruguay. The positive and negative effects are quite consistent across countries (country level correlation 0.67).

These three indices strongly intercorrelate: correlations as high as 0.60 or more are common within countries. In particular there are strong correlations between students' use of control strategies and students' use of memorisation/rehearsal strategies, with correlations of at least 0.90 in 16 of the OECD countries (Table B.1). Further factor analysis of the items making up these indices shows that, while each of the three learning strategies can be clearly identified, students' use of memorisation/rehearsal strategies accounts for much more of the mathematics performance variance than the other two learning strategies. However, the three measures of learning strategies are distinct and it is not the case that all students respond to each of the items included in the measures in a similar way.[9]

One possible explanation for these results is that students' use of learning strategies relates to their sense of self-efficacy in mathematics. Both areas involve perceptions of mathematics learning. In particular, if attempting to find meaning in mathematics is an effective learning strategy, students who employ elaboration strategies "to a greater extent" might be expected to have a higher sense of their self-efficacy in learning mathematics. In fact, all three learning strategies correlate positively with self-efficacy in mathematics. The most consistent correlations are found between students' use of control strategies and student self-efficacy in mathematics, with correlations of at least 0.20 in 29 of the OECD countries, including correlations of 0.50 in Korea, 0.43 in Finland and Mexico and 0.40 in Turkey (see Annex B, Table B.1, Correlations among Selected Index Variables). There are correlations of at least 0.20 in 22 of the OECD countries for students' use of elaboration strategies and in 18 of the OECD countries for students' use of memorisation/rehearsal strategies. However, in Austria, the Czech Republic, Germany and Switzerland there is no correlation between students' use of memorisation/rehearsal strategies and students' self-efficacy in mathematics. Accounting for students' self-efficacy in mathematics reduces the observed positive effects of using learning strategies on mathematics performance, altering most of the positive values to negative ones (see Annex C, Multilevel Model, Table C.5, Effect of Mathematics Achievement of Learning Strategies Controlling for Self-Efficacy), a result which is consistent with the correlations in Table B.1. Nevertheless, removing self-efficacy in mathematics from the teaching and learning analytical model yielded almost no changes in the results.

Of course, this raises further questions concerning the links between the underlying constructs of self-efficacy in mathematics and student learning strategies. Does greater use of learning strategies contribute to the development of a sense of self-efficacy? To what extent do the joint effects of learning strategies and self-efficacy in mathematics contribute to achievement? More importantly, can teaching strategies influence students' sense of self-efficacy in mathematics and use of learning strategies in ways that can enhance achievement? Or are these attributes, especially self-efficacy in mathematics, simply consequences of achievement or proxies for achievement? Models based on survey data break down at this point because the direction of causality cannot clearly be delineated.

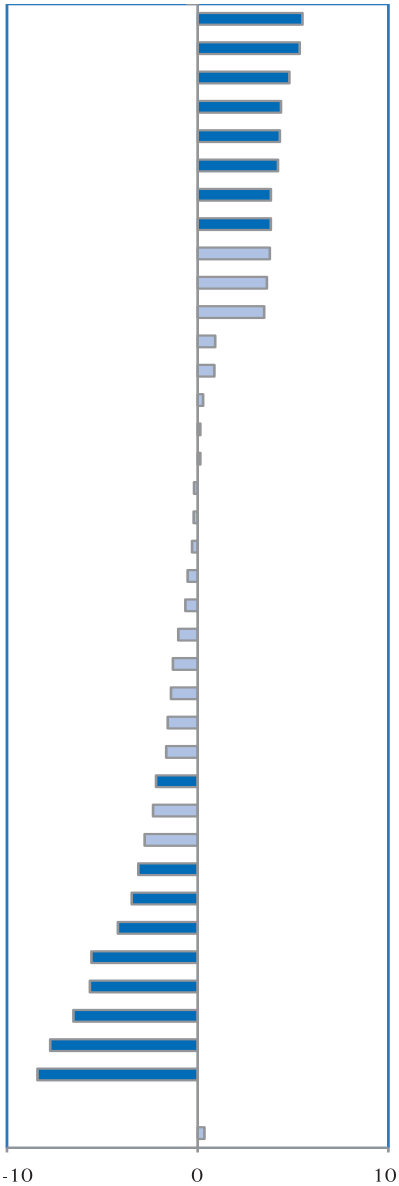
Co-operative and competitive learning situations

The indices measuring students' reported preference for co-operative and competitive learning situations in mathematics were derived from student responses to items on whether they prefer working with others or helping others, or whether they want to be the best or do better than others. It is important to note that the co-operative learning construct used here as a student

Figure 3.23 ■ **Control strategies and mathematics performance**

	Mean index	Change in mathematics score		Change in mathematics score when accounting for other background, teaching and learning characteristics	
Hong Kong-China	-0.07	14.9	(1.45)	5.5	(1.31)
New Zealand	-0.03	11.0	(1.46)	5.4	(1.61)
Portugal	0.14	12.3	(1.53)	4.8	(1.65)
Australia	0.01	12.4	(1.27)	4.4	(1.18)
Canada	0.06	11.5	(1.05)	4.3	(1.13)
Korea	-0.49	20.0	(1.16)	4.2	(1.85)
Turkey	0.26	8.9	(1.43)	3.8	(1.93)
Spain	-0.02	11.5	(1.13)	3.8	(1.47)
Macao-China	0.07	4.5	(4.07)	3.8	(3.82)
Thailand	-0.03	6.1	(1.34)	3.6	(2.03)
Brazil	0.57	0.6	(1.59)	3.5	(1.94)
Tunisia	0.68	7.0	(1.02)	0.9	(1.34)
Italy	0.21	2.0	(1.30)	0.9	(1.33)
Norway	-0.26	14.5	(1.58)	0.3	(1.71)
Switzerland	0.19	-3.0	(1.50)	0.1	(1.18)
Greece	0.27	3.0	(1.41)	0.1	(1.71)
Mexico	0.45	2.7	(0.99)	-0.2	(1.16)
Austria	0.52	-3.6	(1.06)	-0.2	(1.17)
Serbia	0.50	-4.1	(1.02)	-0.3	(1.31)
Finland	-0.48	11.4	(1.36)	-0.5	(1.50)
United States	0.01	5.5	(1.32)	-0.6	(1.52)
Germany	0.38	-5.9	(1.23)	-1.0	(1.39)
Luxembourg	0.08	-4.6	(1.30)	-1.3	(1.40)
Iceland	0.00	4.4	(1.62)	-1.4	(1.50)
Poland	-0.03	4.3	(1.88)	-1.6	(1.58)
Ireland	-0.01	3.7	(1.48)	-1.6	(1.49)
Belgium	-0.05	-2.4	(1.19)	-2.2	(1.05)
Japan	-0.54	7.4	(1.13)	-2.3	(1.27)
Czech Republic	0.06	-0.9	(1.67)	-2.8	(1.42)
Hungary	0.06	-4.7	(1.33)	-3.1	(1.57)
Slovak Republic	0.07	-5.2	(1.49)	-3.5	(1.40)
Uruguay	0.20	-0.7	(1.50)	-4.2	(1.85)
Denmark	-0.19	4.4	(2.17)	-5.6	(1.84)
Netherlands	-0.27	-3.6	(1.95)	-5.7	(1.29)
Russian Fed.	-0.09	-2.0	(1.37)	-6.5	(1.72)
Latvia	-0.26	-6.1	(2.74)	-7.7	(2.33)
Sweden	-0.40	0.2	(1.86)	-8.4	(1.41)
United Kingdom[1]	-0.11	9.2	(1.74)	0.4	(1.97)

Score point difference per unit change in total homework



1. Response rate too low to ensure comparability.

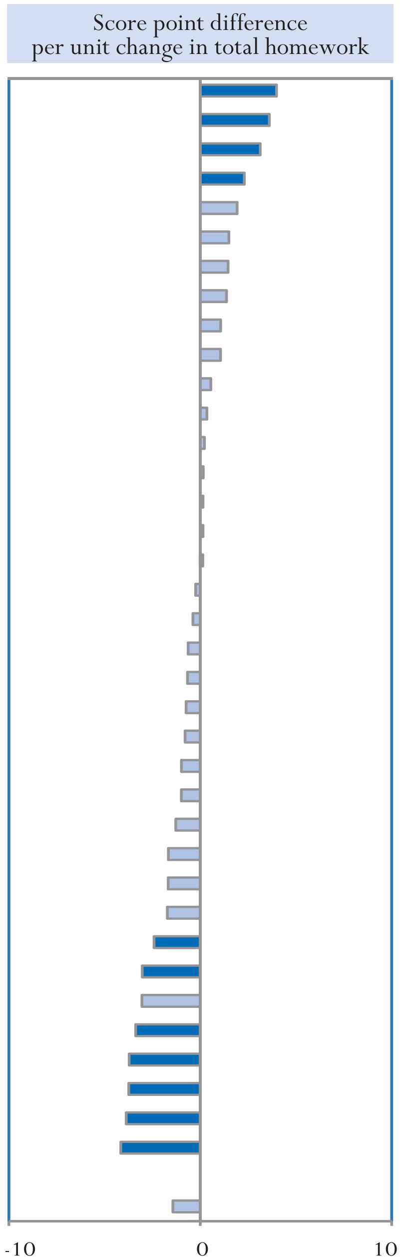
Source: OECD PISA 2003 Database.

Note: Statistically significant score point differences are marked in a darker tone.

preference is different from the construct of co-operative learning as a teaching strategy as used in the literature. In the literature it refers to specific ways of organising groups to facilitate learning (Slavin, 1994). PISA does measure this construct as well, but it would be inappropriate to infer that student preference for co-operative learning is a proxy for use of co-operative teaching strategies or a consequence of teaching through co-operative grouping. Nevertheless, this is not to imply that

Figure 3.24 ■ Preference for co-operative learning situations and mathematics performance

	Mean index	Change in mathematics score		Change in mathematics score when accounting for other background, teaching and learning characteristics	
Japan	-0.72	7.8	(1.19)	4.0	(1.11)
Hungary	-0.11	0.6	(1.43)	3.6	(1.53)
Finland	-0.15	3.0	(1.66)	3.1	(1.36)
Switzerland	0.17	-4.0	(1.16)	2.3	(1.09)
Netherlands	-0.13	1.1	(1.82)	1.9	(1.25)
Norway	0.01	1.0	(1.56)	1.5	(1.20)
Sweden	-0.22	4.3	(2.00)	1.5	(1.28)
Hong Kong-China	-0.04	12.9	(1.55)	1.4	(1.60)
Belgium	-0.05	-4.3	(1.27)	1.1	(1.12)
Germany	-0.01	0.7	(1.09)	1.1	(1.10)
Brazil	0.65	-3.3	(1.65)	0.6	(2.15)
Korea	-0.77	21.3	(1.28)	0.3	(1.54)
Portugal	0.29	2.3	(1.87)	0.2	(1.60)
Spain	0.05	6.9	(1.18)	0.2	(1.33)
Austria	-0.01	-2.2	(1.09)	0.1	(0.84)
Ireland	-0.10	-2.9	(1.73)	0.0	(1.54)
Russian Fed.	-0.07	4.7	(1.46)	0.0	(1.53)
Serbia	0.27	-5.1	(1.28)	-0.2	(1.28)
Czech Republic	-0.04	-5.6	(1.23)	-0.4	(1.06)
Italy	0.14	-3.7	(1.01)	-0.6	(1.01)
Turkey	0.30	2.4	(1.04)	-0.7	(1.50)
Greece	0.20	0.5	(1.23)	-0.7	(1.30)
Uruguay	0.39	-7.9	(1.34)	-0.8	(1.32)
Luxembourg	-0.17	-5.2	(1.08)	-1.0	(0.96)
Canada	0.14	-5.0	(1.01)	-1.0	(0.89)
Slovak Republic	0.25	-11.3	(1.49)	-1.3	(1.24)
Thailand	0.31	4.8	(1.69)	-1.7	(2.12)
Poland	0.11	-5.0	(1.65)	-1.7	(1.31)
Latvia	-0.13	-5.3	(2.44)	-1.7	(2.03)
United States	0.27	-3.8	(1.17)	-2.4	(1.10)
Mexico	0.21	-1.1	(1.03)	-3.0	(1.04)
Macao-China	0.11	5.3	(3.93)	-3.0	(3.58)
Denmark	0.23	-4.0	(1.72)	-3.4	(1.54)
New Zealand	0.16	-5.4	(1.62)	-3.7	(1.45)
Iceland	-0.30	-1.4	(1.43)	-3.7	(1.34)
Australia	0.10	-2.5	(1.30)	-3.9	(1.13)
Tunisia	0.61	3.6	(1.00)	-4.2	(1.14)
United Kingdom[1]	0.16	-1.4	(1.50)	-1.4	(1.15)



1. Response rate too low to ensure comparability.
Source: OECD PISA 2003 Database.

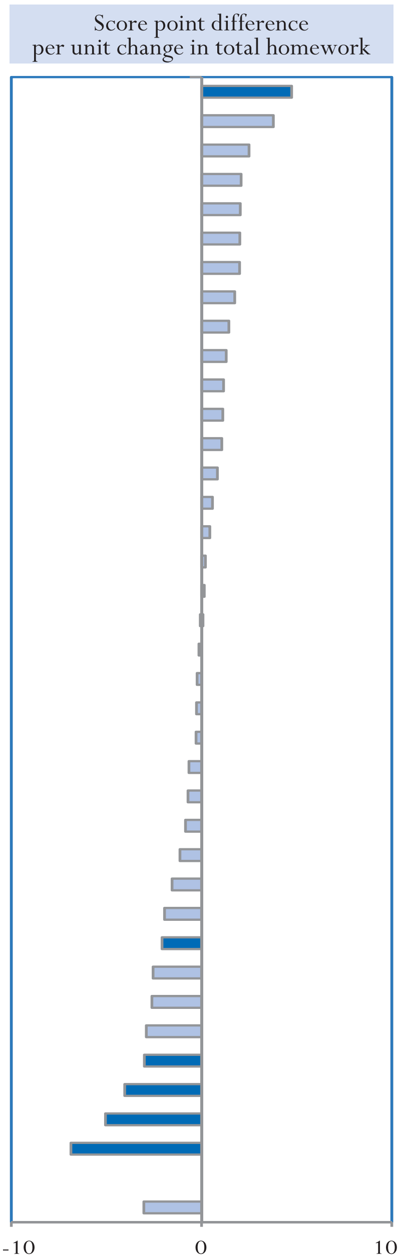
Note: Statistically significant score point differences are marked in a darker tone.

schools or teachers cannot encourage either a co-operative or a competitive learning environment in their classrooms.

The PISA results show that in several countries these two learning situations are not mutually exclusive, that is, students preferring competitive learning situations often tend also to enjoy co-operating with

Figure 3.25 ■ **Preference for competitive learning situations and mathematics performance**

	Mean index	Change in mathematics score		Change in mathematics score when accounting for other background, teaching and learning characteristics	
Denmark	-0.04	22.3	(1.65)	4.7	(1.92)
Russian Fed.	-0.03	13.3	(1.45)	3.8	(1.97)
Greece	0.28	11.8	(1.41)	2.5	(1.78)
Korea	-0.05	22.1	(1.10)	2.1	(1.55)
Mexico	0.68	6.0	(1.28)	2.0	(1.68)
Slovak Republic	0.08	9.1	(1.36)	2.0	(1.22)
Tunisia	0.99	8.9	(1.18)	2.0	(1.62)
Turkey	0.65	10.9	(1.27)	1.7	(1.73)
Czech Republic	-0.10	12.5	(1.34)	1.4	(1.24)
Austria	-0.31	0.5	(1.03)	1.3	(1.05)
Sweden	-0.06	16.5	(1.89)	1.2	(1.55)
Australia	0.31	12.5	(1.26)	1.1	(1.61)
Poland	0.09	12.3	(1.91)	1.1	(1.50)
United States	0.41	8.4	(1.33)	0.8	(1.43)
Macao-China	0.02	9.0	(4.32)	0.6	(4.43)
Spain	0.03	11.5	(1.08)	0.4	(1.21)
Latvia	-0.10	13.2	(2.23)	0.2	(2.48)
Luxembourg	-0.01	1.0	(1.24)	0.0	(1.29)
Germany	-0.03	5.9	(1.22)	-0.1	(1.12)
Finland	-0.32	19.7	(1.34)	-0.1	(1.32)
Iceland	0.26	14.0	(1.69)	-0.2	(1.59)
Ireland	0.08	5.6	(1.79)	-0.3	(1.40)
Thailand	0.31	2.7	(1.79)	-0.3	(2.18)
Japan	-0.47	9.7	(0.94)	-0.7	(1.17)
Serbia	-0.18	-2.4	(1.38)	-0.7	(1.65)
Hungary	-0.45	6.7	(1.30)	-0.8	(1.29)
Italy	0.09	5.7	(1.39)	-1.1	(1.26)
Brazil	0.38	-3.5	(1.87)	-1.6	(1.77)
Portugal	-0.08	5.4	(1.29)	-1.9	(1.44)
Canada	0.19	12.1	(0.93)	-2.1	(0.86)
Norway	-0.31	18.5	(1.44)	-2.5	(1.47)
Netherlands	-0.45	2.8	(1.75)	-2.6	(1.62)
Uruguay	-0.10	-1.0	(1.73)	-2.9	(1.61)
Belgium	-0.29	-0.3	(1.18)	-3.0	(1.15)
Switzerland	-0.35	-3.1	(1.84)	-4.0	(1.89)
New Zealand	0.15	6.9	(1.82)	-5.1	(1.60)
Hong Kong-China	0.10	13.1	(1.47)	-6.9	(1.59)
United Kingdom[1]	0.18	5.7	(1.90)	-3.0	(1.58)



1. Response rate too low to ensure comparability.
Source: OECD PISA 2003 Database.

Note: Statistically significant score point differences are marked in a darker tone.

other students in their learning. Students reported agreement or disagreement with a set of 10 different statements about situations in which to learn mathematics, so that students could report, for example, that they like to work with others while also reporting that they want to be the best in the class. Indeed, the almost universally positive correlations between these two indices show that students often report a preference for both learning situations (Table B.1). There are strong positive latent correlations between student preferences for competitive and co-operative learning situations in the OECD countries Korea (0.84), Mexico (0.70) and Turkey (0.62). However, in several countries there is weak or no correlation between the two learning situations: in Finland (-0.01) and in the partner countries the Slovak Republic (-0.02) and the Czech Republic (0.08). It cannot be determined from the results if this is a function of response bias or of some characteristics of students or schools in these countries.

Student preferences for learning situations are not strongly associated with mathematics performance when considered in the wider context of teaching and learning (Figures 3.24 and 3.25). The effects are non-significant in most countries and inconsistent in direction even in those countries where they are significant. The observed effects for co-operative learning follow a similar pattern to the analytical model effects. Even in the minority of countries where there are strong observed effects, these become insignificant once other contextual and teaching and learning factors are accounted for (for example, there are positive observed effects in Korea and the partner economy Hong Kong-China, and a negative observed effect in the Slovak Republic). The situation for competitive learning is somewhat different: fairly large positive observed effects are attenuated in the teaching and learning analytical model. Similarly as for student learning strategies, removing the measure of self-efficacy in mathematics from the teaching and learning analytical model does not change the results in any significant way. Again, note that these are measured as student factors. It is plausible to argue that dispositions towards either competitive or co-operative learning may themselves be learned or may be characteristics of schools; however, the inclusion of these factors in the teaching and learning analytical model at the school level yields no effect.

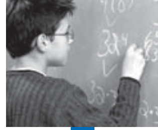
TEACHING STRATEGIES

Although PISA did not directly survey teachers, a limited number of measures of teaching strategies were collected via the student and school questionnaires. This report presents information provided by school principals on innovation, teacher expectations, streaming and assessment in Chapter 2. However, these measures are not included in the teaching and learning analytical model, since they either have low correlations with achievement or only show small effects in early versions of the multi-level model.

The main teaching strategy measures from the student questionnaire are the indices of *student-teacher relations*, *disciplinary climate* and *teacher support*. All of these derive from a series of items in which students were asked to indicate how frequently specified behaviours occur in their mathematics classes (see Chapter 2).

Two additional school-level measures are included in the analytical model as controls. These are school size (total students enrolled) and the socio-economic composition of the school (parents' highest occupational level aggregated to the school). School size shows a moderate correlation with achievement in many countries. The socio-economic composition of the school is highly correlated with achievement in almost all countries.

It is important to point out that, although students may influence the climate of a classroom, teaching strategies are fundamentally characteristic of teachers or classrooms and not of individual students.



Students' perceptions of the classroom climate are the basis of the indices analysed. It would therefore be appropriate to examine these indices at both the student and classroom levels. However, because classrooms within a school are not identifiable in the PISA data, the classroom cannot function as a level of analysis in the model. Therefore the analysis aggregated the indices to the school level for modelling purposes. This procedure is defensible as long as differences between classrooms within a school are small. Unfortunately, the PISA analysis has no measure of the extent of such differences and no indication of the number of different teachers who are represented in the student responses. This lack of refinement is likely to be one of the reasons why many of the reported effects are small.

Disciplinary climate

As indicated in Chapter 2, *disciplinary climate* is an index derived from student responses to items about noise and disruption in the classroom, lost time and student behaviour towards the teacher.

Figure 3.26 shows the effects of disciplinary climate at the student level. There is substantial variation in average disciplinary climate across countries, amounting to close to one standard deviation unit between the highest-rated countries, Japan and the partner country the Russian Federation, to the lowest, the partner country Brazil. A stronger disciplinary climate is positively associated with mathematics performance in all countries. The observed effects and the analytical model effects are of similar magnitudes and are highly correlated, indicating that the impact that disciplinary climate has on performance is largely independent of other contextual and teaching and learning factors analysed in the model.

As already noted, disciplinary climate is more appropriately measured at the classroom level than at the student level. In the absence of a classroom-level identifier, aggregation to the school level has been carried out. Indeed, an argument can be made that classroom disciplinary climate is a component of the broader school climate, although more directly under teacher control than other school climate factors, hence its identification as a teaching strategy.[10]

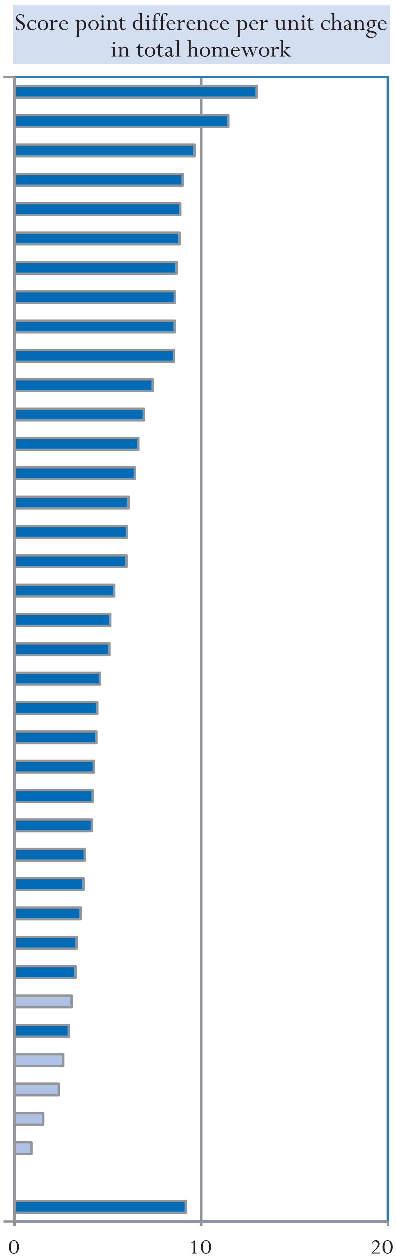
The effects of school average disciplinary climate appear in Figure 3.27. The pattern of school-level means for each country is essentially the same as that at the student level. There is a positive observed association between disciplinary climate and mathematics performance in all countries, but this ranges from effects of 40 score points or more in Luxembourg, Turkey, Japan and the partner economies Hong Kong-China and Macao-China to less than 10 score points in Poland, Finland, Ireland, Iceland and the partner country Latvia. The effects from the teaching and learning analytical model follow a similar pattern, remaining significantly positive in all countries except Finland, Ireland, Iceland, Poland and the partner country Thailand. Turkey, Belgium, Japan, Korea and Portugal and the partner economy Hong Kong-China have the strongest positive association between school average disciplinary climate and mathematics performance.

These results indicate that disciplinary climate is one of the most robust predictors of achievement studied in the PISA 2003 survey. The existence of much larger school-level effects than student-level effects in many countries shows the importance of examining the effects of disciplinary climate at the school level, and that averaging student responses over schools yields a separate strong predictor of achievement. In Korea, the Netherlands, Greece, Denmark and Norway the school average disciplinary climate has positive effects, but disciplinary climate at the student level shows no association with performance in the analytical model. Overall, the effects of school average disciplinary climate

are twice as strong as those effects at the student level in 19 countries. The country-level correlation of the mean value for school average disciplinary climate and the size of the effect in the teaching and learning analytical model is close to zero. This finding suggests that the observed effect within a country is a function of the relative values of disciplinary climate within the country rather than of the average position of the country on the international scale.

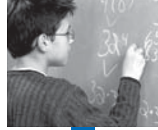
Figure 3.26 ■ Disciplinary climate and mathematics performance

	Mean index	Change in mathematics score		Change in mathematics score when accounting for other background, teaching and learning characteristics	
Thailand	0.00	19.2	(1.50)	13.0	(1.52)
Macao-China	0.09	15.4	(4.12)	11.4	(3.38)
United States	0.12	20.6	(1.23)	9.6	(1.28)
Latvia	0.30	15.2	(2.48)	9.0	(1.75)
Portugal	0.01	15.2	(1.64)	8.9	(1.43)
Switzerland	0.10	11.0	(2.13)	8.8	(2.10)
Russian Fed.	0.49	14.7	(1.56)	8.7	(1.48)
Ireland	0.27	15.8	(1.52)	8.6	(1.35)
Spain	-0.04	13.1	(1.34)	8.6	(1.08)
Turkey	-0.12	13.5	(1.71)	8.5	(1.55)
Belgium	0.04	10.8	(0.90)	7.4	(0.91)
Canada	0.02	14.3	(0.93)	6.9	(0.83)
New Zealand	-0.17	14.7	(1.61)	6.6	(1.23)
Australia	-0.01	16.0	(0.89)	6.4	(0.85)
Poland	0.10	15.0	(1.38)	6.1	(1.23)
Tunisia	-0.08	7.1	(1.23)	6.0	(1.29)
Serbia	-0.09	10.3	(1.52)	6.0	(1.62)
Luxembourg	-0.21	7.4	(1.23)	5.3	(1.07)
Mexico	0.00	10.5	(1.32)	5.1	(1.27)
Austria	0.21	6.9	(1.31)	5.1	(1.17)
Czech Republic	-0.01	6.2	(1.05)	4.6	(1.01)
Brazil	-0.35	10.4	(1.90)	4.4	(1.78)
Iceland	-0.15	13.1	(1.76)	4.4	(1.75)
Japan	0.44	5.3	(1.84)	4.3	(1.45)
Germany	0.30	7.5	(1.16)	4.2	(1.04)
Hong Kong-China	0.15	10.7	(1.33)	4.1	(1.34)
Finland	-0.15	10.3	(1.42)	3.8	(1.30)
Uruguay	-0.03	7.4	(1.82)	3.7	(1.59)
Sweden	-0.05	13.2	(1.81)	3.5	(1.18)
Slovak Republic	-0.10	5.1	(1.34)	3.3	(1.09)
Italy	-0.10	4.6	(1.12)	3.3	(1.06)
Norway	-0.24	11.4	(1.84)	3.1	(1.71)
Hungary	0.17	3.1	(1.11)	2.9	(1.16)
Netherlands	-0.13	4.3	(1.68)	2.6	(1.47)
Denmark	-0.08	6.8	(1.97)	2.4	(1.49)
Greece	-0.22	5.3	(1.56)	1.5	(1.32)
Korea	0.12	1.7	(1.38)	0.9	(1.11)
United Kingdom[1]	-0.01	20.0	(1.10)	9.2	(1.03)



1. Response rate too low to ensure comparability.
Source: OECD PISA 2003 Database.

Note: Statistically significant score point differences are marked in a darker tone.

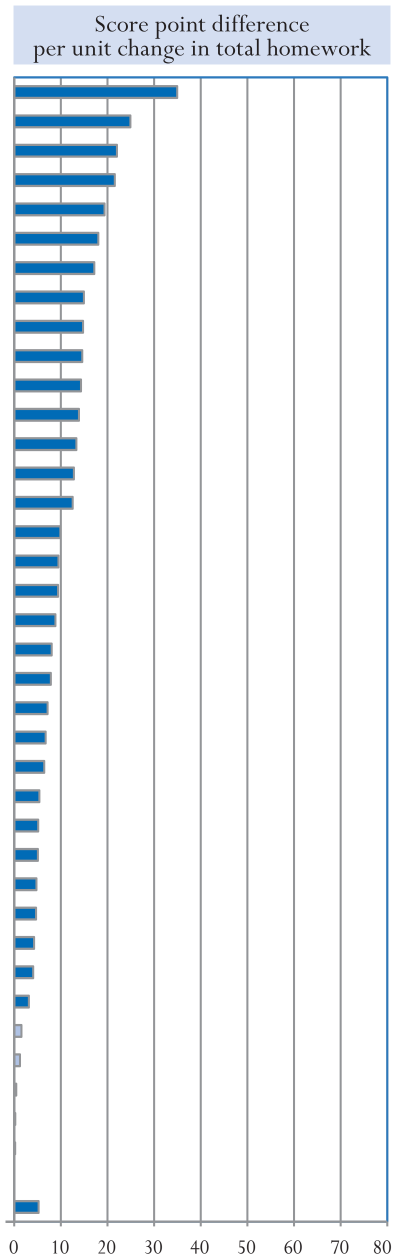


Student-teacher relations

The PISA *index of student-teacher relations* is derived from student responses to items on how well students get along with teachers, how interested teachers are in students' work and whether teachers treat students fairly. The results for this index appear in Figure 3.28. Like *disciplinary climate*, the means for *student-teacher relations* vary by close to one standard deviation unit between countries, with

Figure 3.27 ■ **School average disciplinary climate and mathematics performance**

	Mean index	Change in mathematics score		Change in mathematics score when accounting for other background, teaching and learning characteristics	
Hong Kong-China	0.16	77.2	(1.28)	35.0	(1.62)
Turkey	-0.10	45.3	(1.50)	24.9	(2.14)
Belgium	0.02	38.9	(3.48)	22.0	(1.25)
Japan	0.43	42.1	(0.89)	21.6	(0.98)
Korea	0.11	37.1	(3.69)	19.4	(3.60)
Portugal	-0.01	36.5	(1.03)	18.0	(1.41)
Serbia	-0.09	33.7	(0.68)	17.2	(1.06)
Brazil	-0.36	35.1	(3.97)	14.9	(2.65)
Netherlands	-0.13	19.3	(7.38)	14.8	(4.21)
Macao-China	0.07	45.0	(3.93)	14.6	(5.46)
Uruguay	-0.05	33.9	(1.07)	14.3	(1.23)
Luxembourg	-0.20	60.3	(2.32)	13.9	(2.98)
Tunisia	-0.08	20.3	(0.66)	13.3	(0.81)
Germany	0.30	25.7	(2.40)	12.8	(1.55)
Mexico	0.04	23.8	(0.98)	12.5	(0.78)
Switzerland	0.11	19.8	(1.00)	9.9	(1.17)
Austria	0.21	24.2	(1.97)	9.5	(1.47)
Russian Fed.	0.53	17.5	(1.12)	9.4	(1.57)
Czech Republic	0.00	18.6	(2.26)	8.8	(1.74)
Hungary	0.13	18.0	(1.60)	8.0	(1.25)
Slovak Republic	-0.11	19.5	(0.75)	7.9	(0.85)
Italy	-0.12	22.3	(0.49)	7.2	(0.63)
United States	0.12	27.9	(0.95)	6.7	(0.98)
Greece	-0.27	24.6	(2.60)	6.4	(2.46)
Australia	-0.05	29.5	(0.59)	5.4	(0.97)
Denmark	-0.07	15.9	(1.60)	5.1	(1.41)
Spain	-0.02	15.0	(0.80)	5.1	(0.84)
Canada	0.03	14.8	(0.97)	4.8	(0.83)
Norway	-0.22	13.1	(1.62)	4.7	(1.38)
Sweden	-0.04	15.3	(2.00)	4.3	(1.60)
Latvia	0.32	7.0	(0.92)	4.1	(1.22)
New Zealand	-0.15	20.7	(1.38)	3.1	(1.50)
Poland	0.14	3.1	(1.55)	1.6	(1.36)
Iceland	-0.06	6.7	(1.80)	1.2	(1.83)
Thailand	0.00	16.1	(1.06)	0.4	(1.20)
Ireland	0.26	5.7	(0.92)	-0.2	(1.16)
Finland	-0.11	3.4	(1.29)	-0.2	(1.02)
United Kingdom[1]	0.10	22.6	(1.76)	5.2	(1.15)



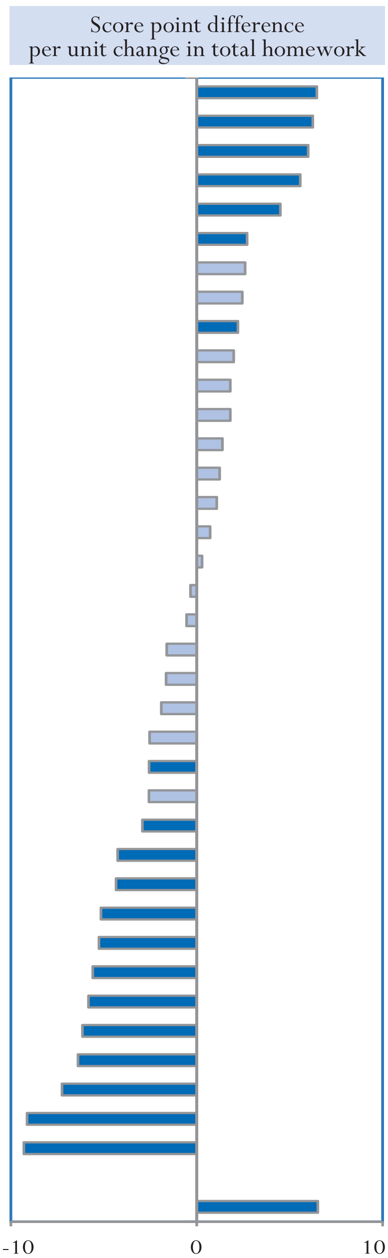
1. Response rate too low to ensure comparability.
Source: OECD PISA 2003 Database.

Note: Statistically significant score point differences are marked in a darker tone.

students in Mexico and the partner countries Brazil, Thailand and Tunisia reporting the most positive perceptions of student-teacher relations and students in Japan and Luxembourg the most negative. Within each OECD country there are weak positive correlations between students' reports on disciplinary climate and student-teacher relations, thus indicating that many students who see their teachers as helpful and fair also tend to report a more positive classroom disciplinary climate.

Figure 3.28 ■ **Student-teacher relations and mathematics performance**

	Mean index	Change in mathematics score		Change in mathematics score when accounting for other background, teaching and learning characteristics	
New Zealand	0.11	15.4	(1.72)	6.5	(1.57)
Australia	0.21	13.4	(1.02)	6.2	(0.89)
Norway	-0.09	16.1	(1.61)	6.0	(1.50)
Sweden	0.21	14.8	(1.37)	5.6	(1.37)
Denmark	0.27	8.0	(1.65)	4.5	(1.63)
Ireland	-0.01	4.5	(1.70)	2.7	(1.31)
Hong Kong-China	0.06	6.7	(1.41)	2.6	(1.34)
Macao-China	-0.09	4.0	(3.81)	2.5	(3.51)
Canada	0.22	9.3	(1.05)	2.2	(0.86)
Iceland	0.02	11.7	(1.43)	2.0	(1.44)
Japan	-0.41	3.0	(1.52)	1.8	(1.61)
Luxembourg	-0.39	0.3	(1.33)	1.8	(1.33)
United States	0.20	10.0	(1.41)	1.4	(1.27)
Korea	-0.08	6.2	(1.22)	1.2	(1.36)
Netherlands	-0.07	3.0	(1.83)	1.1	(1.53)
Germany	-0.03	0.4	(1.06)	0.7	(1.10)
Finland	-0.03	8.9	(1.37)	0.3	(1.37)
Belgium	-0.05	-1.1	(1.11)	-0.3	(0.98)
Austria	0.04	0.3	(1.29)	-0.5	(1.22)
Czech Republic	-0.18	-1.4	(1.27)	-1.6	(1.24)
Switzerland	0.32	0.0	(1.81)	-1.6	(1.31)
Hungary	-0.12	-3.8	(1.19)	-1.9	(1.42)
Portugal	0.24	-0.5	(1.42)	-2.5	(1.43)
Spain	-0.13	1.1	(1.30)	-2.6	(1.23)
Brazil	0.59	-4.6	(1.34)	-2.6	(1.49)
Italy	-0.29	-5.1	(1.06)	-2.9	(1.28)
Greece	-0.10	-2.7	(1.69)	-4.3	(1.79)
Latvia	0.02	0.8	(2.05)	-4.3	(1.75)
Russian Fed.	-0.01	-4.7	(1.35)	-5.2	(1.41)
Poland	-0.29	-7.4	(1.80)	-5.3	(1.70)
Mexico	0.54	-3.1	(1.29)	-5.6	(1.33)
Slovak Republic	-0.25	-9.6	(1.42)	-5.8	(1.31)
Uruguay	0.27	-6.7	(1.27)	-6.1	(1.48)
Turkey	0.18	-2.3	(1.46)	-6.4	(1.43)
Tunisia	0.35	-4.3	(0.85)	-7.2	(0.96)
Thailand	0.55	-4.8	(1.34)	-9.1	(1.35)
Serbia	-0.09	-11.8	(1.35)	-9.3	(1.44)
United Kingdom[1]	0.08	14.2	(1.46)	6.5	(1.42)



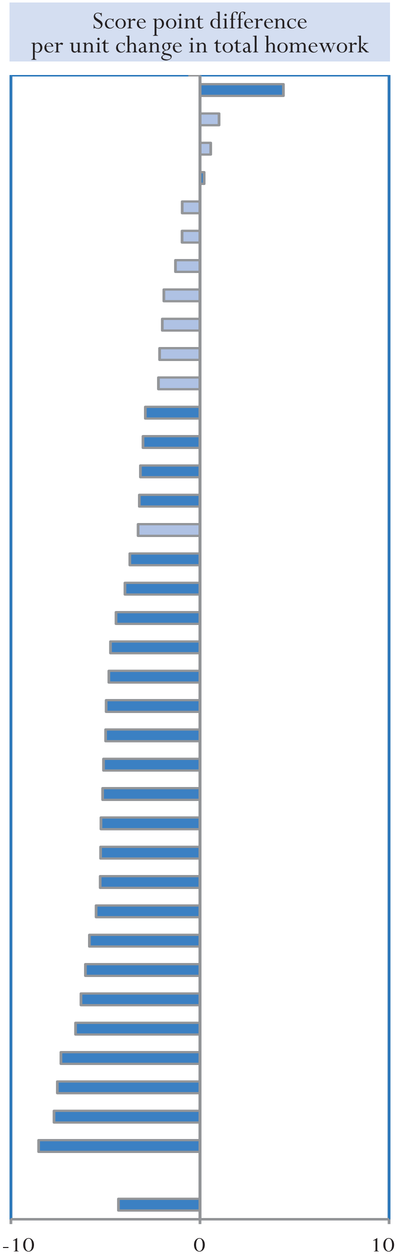
1. Response rate too low to ensure comparability.
Source: OECD PISA 2003 Database.

Note: Statistically significant score point differences are marked in a darker tone.

Despite this, the effects of student-teacher relations on achievement are quite different from those of disciplinary climate in the majority of countries, although they are similar in Australia, New Zealand, Sweden, the United Kingdom and the partner economy Hong Kong-China. In 12 of the 25 countries where the observed association between student-teacher relations and mathematics performance is positive, it becomes negative when other contextual and teaching and learning factors

Figure 3.29 ■ **Teacher support and mathematics performance**

	Mean index	Change in mathematics score		Change in mathematics score when accounting for other background, teaching and learning characteristics	
Thailand	0.67	5.3	(1.28)	4.4	(1.31)
Greece	-0.06	0.5	(1.70)	1.0	(1.79)
Turkey	0.41	2.0	(1.40)	0.6	(1.17)
Korea	-0.22	3.8	(1.42)	0.2	(1.52)
Hong Kong-China	0.03	8.1	(1.63)	-0.9	(1.40)
Iceland	0.20	9.7	(1.87)	-0.9	(1.83)
Netherlands	-0.27	1.0	(1.33)	-1.3	(1.35)
Russian Fed.	0.26	3.5	(1.46)	-1.9	(1.32)
Mexico	0.48	0.1	(1.02)	-2.0	(1.11)
Tunisia	0.24	-0.1	(1.17)	-2.1	(1.51)
Hungary	-0.08	0.0	(1.21)	-2.2	(1.16)
Australia	0.25	7.4	(1.24)	-2.9	(1.02)
Austria	-0.39	-0.9	(1.46)	-3.0	(1.25)
United States	0.34	6.7	(1.31)	-3.2	(1.14)
Denmark	0.14	6.6	(2.00)	-3.2	(1.54)
Japan	-0.34	1.7	(1.77)	-3.3	(1.76)
Germany	-0.29	0.5	(1.13)	-3.7	(0.92)
Serbia	-0.17	-8.2	(1.22)	-4.0	(1.46)
Switzerland	0.01	-1.6	(1.88)	-4.4	(1.49)
Brazil	0.56	-5.8	(1.42)	-4.7	(1.63)
Luxembourg	-0.30	-2.8	(1.13)	-4.8	(1.03)
Belgium	-0.11	-2.2	(0.92)	-5.0	(1.07)
Portugal	0.27	-0.9	(1.75)	-5.0	(1.31)
Poland	-0.18	-0.8	(1.58)	-5.1	(1.32)
Canada	0.27	6.3	(1.02)	-5.2	(0.86)
Czech Republic	-0.16	-1.6	(1.44)	-5.2	(1.24)
Uruguay	0.32	-4.8	(1.55)	-5.3	(1.40)
Spain	-0.07	-0.8	(1.46)	-5.3	(1.32)
Italy	-0.12	-2.6	(1.07)	-5.5	(1.12)
New Zealand	0.16	4.4	(1.40)	-5.8	(1.30)
Norway	-0.11	13.7	(1.90)	-6.1	(1.80)
Slovak Republic	-0.10	-6.8	(1.13)	-6.3	(1.17)
Latvia	0.05	0.3	(2.11)	-6.6	(1.80)
Finland	0.08	4.9	(1.78)	-7.4	(1.44)
Sweden	0.20	3.1	(1.84)	-7.5	(1.67)
Ireland	0.00	-1.7	(1.67)	-7.7	(1.47)
Macao-China	-0.05	-3.6	(4.41)	-8.5	(4.03)
United Kingdom[1]	0.18	7.4	(1.31)	-4.3	(1.36)



1. Response rate too low to ensure comparability.
Source: OECD PISA 2003 Database.

Note: Statistically significant score point differences are marked in a darker tone.

are taken into account. However, once other contextual and teaching and learning factors have been accounted for there is a positive association between student-teacher relations and mathematics performance in the United Kingdom, New Zealand, Australia, Norway, Sweden, Denmark, Ireland, Canada and the partner economy Hong Kong-China (Figure 3.28).

It is worth noting that student-teacher relations were analysed at the school level in earlier models. Student reports on student-teacher relations generally showed no effect when aggregated to the school level, indicating that such perceptions are more student-specific than school-specific, unlike student reports on disciplinary climate.

Teacher support

Teacher support covers areas similar to student-teacher relations. The basis of the teacher support index are questions on: students' perceptions of their teachers, including items on teacher interest in students, whether the teacher helps students with learning and allows students to express opinions. Indeed, this variable has a correlation of 0.78 with student-teacher relations across OECD countries and there are correlations of at least 0.40 at the student level in 26 of the OECD countries. It would therefore be expected that this measure would not yield significant effects in the teaching and learning analytical model, which controls for teacher-student relations among other factors. Nevertheless, as Figure 3.29 indicates, there are negative effects for teacher support in 27 countries, including in the OECD countries where there are positive effects for student-teacher relations in the teaching and learning analytical model. This result is in stark contrast to the observed associations between teacher support and mathematics performance: they are negative in only the Slovak Republic, Luxembourg, Italy and Belgium as well as in the partner countries Serbia, Brazil and Uruguay. In fact, observed positive associations between teacher support and mathematics performance occur in 13 countries.

Aggregating the measure of teacher support to the school level in earlier versions of the teaching and learning analytical model yielded few significant effects.

The results for teacher support suggest the possibility that in some countries teachers give higher levels of support to the lowest-achieving students, a finding that makes sense if teachers are concerned to address the problems of such students. The shift from positive observed effects to negative effects in the analytical model in Norway, Australia, the United States, Denmark, Canada, Finland and New Zealand indicates that teacher support is mediated by some of the other factors included in the analytical model. As in other cases, the key mediator seems to be self-efficacy in mathematics. The correlations between self-efficacy in mathematics and teacher support are generally small but positive (correlations are at least 0.20 only in Canada, Iceland, Mexico, Norway, the United Kingdom and the United States). Adding a control for self-efficacy in mathematics to the student-level bivariate model effectively changes most positive effects into negative ones. However, removing self-efficacy in mathematics from the teaching and learning analytical model results in almost no change in the effects. The implication of this is that much of the positive value of teacher support is a function of its joint effects with other factors, especially those that relate to self-efficacy in mathematics.

Other variables

A variety of other school-level factors and student factors aggregated to the school level enter into the analytical model throughout its preliminary stages of development. In particular, the analysis incorporated several time-related variables, including *total instructional time* and *mathematics instructional time*, and measures of teacher innovation, expectations, streaming and assessment. In no cases did these contribute significantly to the predictive power of the analytical model.[11] From an analytical standpoint, therefore, it seems clear that maximum predictive power has been drawn from the teaching and learning analytical model. Nevertheless, even though the overall predictive power of the model is strong, especially in accounting for school-level variance, only a few of the factors analysed are major contributors to the prediction.

This chapter has examined the contributions of student learning strategies and teaching strategies to mathematics achievement, especially those factors connected with the way in which students approach the learning of mathematics. Rather than emphasising variations among countries, the focus has been on factors that are of universal value. Many such factors appear in the literature. These include use of time, attitudes and dispositions and student use of learning strategies or generic approaches to learning.

This report uses an analytical model which treats factors such as students' socio-economic background and perceptions of school as antecedents to teaching and learning. The results reported for the teaching and learning factors analysed are therefore their unique effects after removing any joint effects of the other contextual and teaching and learning factors included in the analytical model. This type of analytical model has the advantage of being more closely representative of the real world of schools and classrooms, in which all of the antecedent factors may be considered as preconditions on learning. The disadvantage of this analytical model is that, in some cases, there is ambiguity as to what constitutes an antecedent, or indeed an outcome, and that some factors analysed in the model may mediate the effects of the main teaching and learning strategies.

In addition to looking at the observed association between various factors and performance, and at the unique effects of each factor when other factors have been accounted for, it is important to consider the interaction between the different factors discussed in this chapter. A good example here is the relationship between self-efficacy in mathematics (students' rating of their own effectiveness as learners), learning strategies and mathematics performance. In the analytical model, adjusting for self-efficacy in mathematics in many cases turned the positive observed effect of adopting a learning strategy into a negative effect. What can be inferred from this change depends on the nature of the causality in the interaction between these three factors.

HIGHLIGHTS OF THE ANALYTICAL RESULTS

There are links between a sense of self-efficacy and use of learning strategies. If students' views of their mathematics abilities are simply based on how well they do in mathematics (high performance causes self-efficacy), the main effect of adjusting for self-efficacy as a variable may be to mask some of the benefits (in terms of improved performance) of adopting effective learning strategies. In this case, an emphasis on the development of learning strategies such as elaborating and controlling one's learning should contribute to achievement more than is implied by their unique effects alone. If, on the other hand, self-efficacy is a factor that helps contribute to performance and effective learning strategies tend to follow from a belief in one's efficacy in tackling mathematics problems, then the

emphasis in schools should be on building students' belief in their own effectiveness. While evidence from PISA cannot distinguish between these two interpretations of the analytical results, the strength of the relationship between self-efficacy and learning strategies suggests that both are valid, and that building up student confidence needs to go hand in hand with enabling them to develop strategies for effective learning.

A strong sense of one's own ability to learn mathematics is of key importance. Students' self-concept in mathematics and self-efficacy in mathematics yield strong positive effects in all OECD countries where these factors are not overridden by students' socio-economic background, perceptions of school, motivation to learn or other factors. A strong sense of confidence in one's own abilities in mathematics as well as a strong sense of efficacy in overcoming difficulties in learning tasks are both strongly associated with mathematical competencies. Pronounced effects occur particularly in Australia, New Zealand, Sweden and the United States. It is important to reiterate here that no causal effect can be inferred from the relationship between self-concept and self-efficacy on the one hand and mathematics performance on the other. It is just as plausible to infer that high performance yields high self-concept or self-efficacy as to infer the reverse relationship.

The time students invest in study in addition to their lessons is important, but mathematics learning is mainly school-based. In 25 of the OECD countries, the effect of hours per week of total homework on mathematics performance remains positive and these effects are relatively stable compared to the observed associations with performance; conversely, hours per week of mathematics homework showed negative effects in 21 of the OECD countries. (There is, however, evidence that doing some mathematics homework is better than doing none at all for the majority of OECD countries: the small proportion of students who reported doing no mathematics homework at all had lower mathematics performance in 23 of the OECD countries compared to students who reported doing some mathematics homework.) The finding that hours per week of mathematics homework showed negative effects in many countries may be attributed to the inclusion of mathematics homework in total homework. Indeed, mathematics homework makes up a substantial proportion of total homework for most students. However, when these results are interpreted from the perspective of the Carroll model, too much homework may have the effect of adding unnecessarily to time spent, so that it exceeds time needed. Taking this argument a step further, one might hypothesise that students with higher aptitudes do not need to spend so much time on homework. Unfortunately, the data available do not allow the testing of this hypothesis. Longitudinal studies, which follow student behaviours and performance over several years, would be the optimal way to study this issue and the cumulative nature of mathematics learning in general.

Participating in tutoring and taking out-of-school classes in mathematics are negatively associated with mathematics performance, both before and after accounting for other contextual and teaching and learning factors. A common-sense interpretation of this finding is that students who engage in these activities tend to be performing less well in school compared to other students and do not improve sufficiently thanks to these activities to be among the better performers in the PISA mathematics assessment. This interpretation does not imply that these students do not benefit from participating in study organised outside school. The analysis supports this view by the generally small negative correlations between these activities and PISA performance. A second interpretation could be that these activities are narrow in scope, and although they may have positive effects on the students' school performance, these students are nevertheless more challenged by the general mathematical literacy that PISA measures.

Students' use of learning strategies show different associations with mathematics performance across countries, but when other contextual and teaching and learning factors are accounted for, the use of memorisation/rehearsal and elaboration strategies are negatively associated with performance in the majority of countries. The measures of learning strategies generally behave differently in the teaching and learning analytical model compared with their observed effects. In all OECD countries with significant effects, the use of elaboration strategies and memorisation/rehearsal strategies is negatively associated with mathematics performance. However, the use of control strategies is not associated with mathematics performance in the majority of countries, although there are weak positive effects in New Zealand, Portugal, Australia, Canada, Korea, Turkey, Spain, and in the partner economy Hong Kong-China, and weak negative effects in nine countries.

Preferences for either co-operative or competitive learning situations are not strongly associated with mathematics performance once other contextual and teaching and learning factors are accounted for. However, there is an observed positive association between a preference for competitive learning situations and mathematics performance in 29 countries, but in the teaching and learning model the only country where the positive association remains is Denmark. In Japan, Hungary, Finland and Switzerland, a preference for co-operative learning situations shows small positive effects in the teaching and learning model; interestingly, among these countries, the observed association with performance is only positive in Japan. Although it is possible to advance arguments about school or societal influences on student dispositions in these areas, the effects are not clear enough to draw any conclusions about whether either of these approaches should be encouraged by schools and teachers.

A strong disciplinary climate is strongly and positively associated with mathematics performance. The notable exception to the pattern of small and inconsistent effects for teaching and learning strategies is the result for disciplinary climate. Positive disciplinary climate shows positive effects on achievement for all countries at either the student or school level, and at both levels for the majority of countries, no matter how the analytical model is structured. Indeed, the average school-level disciplinary climate exerts independent positive effects from those found for student-level disciplinary climate. This finding has important implications because school-level disciplinary climate is something that can potentially be addressed by school-level policies. While school-level disciplinary climate may relate to such factors as the socio-economic composition of the school, PISA results indicate that improving disciplinary climate seems to be a universally valid way to improve achievement. Looked at another way, lost learning time in school mathematics classes is strongly associated with lower mathematics performance.

The socio-economic composition of the school and students' sense of self-efficacy in mathematics generally show the strongest associations with mathematics performance. In 18 of the countries studied, the socio-economic composition of the school has stronger associations with mathematics performance than any of the teaching and learning factors analysed. In 15 of the countries, self-efficacy in mathematics has the strongest association with mathematics performance. In Finland, Denmark, Iceland and Australia, students' self-concept in mathematics shows the strongest association with mathematics performance. Among the teaching and learning factors analysed, disciplinary climate at the student and school levels and hours per week of homework in total stand out as having the strongest unique effects across the majority of countries, with student use of control strategies and student-teacher relations having positive associations with mathematics performance in some countries but not in others.

Chapter 3 has presented the results of multi-level modelling that measures selected features of teaching and learning effects on performance in mathematics after adjusting for other characteristics of students and schools. The next chapter examines some of the policy implications of the results and provides observations for the design of future PISA surveys.

Notes

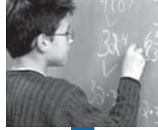
1 Three of the PISA 2003 participating countries are excluded from parts of this analysis. School-level analysis for France is not presented in this report; Indonesia has too much missing data on the measures included in the analytical model; and results for Liechtenstein are not reliable in two-level models, as there are too few participating schools.

2 Initially, correlations among measures were examined and several versions of the analytical model drawn up and examined, using different combinations of measures. Because some of the measures (predictors) were highly intercorrelated or were found to have only small correlations with achievement, not all of the measures of potential analytical interest were included in the final model.

3 A significant concern in building multiple regression models such as those used here is that the measures or predictors are often correlated with each other, and in complex patterns. This means that the impact of a particular variable on the outcome (in this case on mathematics achievement) depends not only on the correlation of that variable with achievement but also on which other variables are included in the model and on how these are correlated with the particular variable of interest. Under certain circumstances, the effects found in a multiple regression model may be quite different from those found in a simple correlational model. The effects reported here are the unique effects of each variable of interest, adjusting for all other variables in the model. Using different combinations of variables in different versions of the model can help determine if the effects of a particular variable are being mediated, or even suppressed, by particular other variables. Mediation or suppression refers to a situation in which two or more variables are associated with the outcome and also with each other. Taken one at a time in a model, such variables may appear to be good predictors of the outcome. However, when taken in combination in a more comprehensive model, the effects of one variable may override the effects of others.

For example, the two socio-economic background variables – parent occupation and parent education – tend to be highly correlated with each other. Taken separately, each is also typically a good predictor of achievement. However, when taken together, the first of these to be entered into the model is likely to account for most of the variability in achievement, and hence mediates or suppresses the effect of the second variable. The effect of the second variable is essentially subsumed by that of the first. One hypothesis tested in developing the model was that students' own confidence in their mathematical ability (self-efficacy in mathematics) was such a strong influence on achievement, and so closely correlated with teaching and learning variables, that it would suppress other observed effects. In fact, very little difference was found in the magnitude of the effects according to whether or not students' self-efficacy in mathematics was included as a background variable. The effects of this variable could therefore be treated as independent of the effects of other variables. While it would have been desirable to examine many other model combinations as a way of probing these effects further, this complicates the presentation significantly when the model contains many variables.

An argument can be made that the unique effects of teaching and learning, rather than those mediated by factors such as student background, are of most interest from the perspective of policy and practice, because teaching and learning takes place in an overall context that cannot easily be controlled by teachers or students. However, it can also be argued that broader policies could be influenced by knowledge of mediating effects, because these may be a consequence of particular ways of organising schools or classrooms. It is also possible that one aspect of teaching and learning can mediate another, and thus there is scope for looking at two or more aspects together as part of an overall teaching and learning strategy.



A simple example of possible mediating effects in this study arises from the composition of the variables "total homework" and "mathematics homework". Because the former includes the latter, these two variables are obviously correlated. The size of the correlation will depend partly on the proportion of total homework that is mathematics homework. On the one hand, the actual correlation between these variables is in the 0.60 range in most countries, which is very high compared to most other correlations of interest here. Intuitively, one might expect mathematics homework to be more highly correlated with mathematics achievement than total homework. On the other hand, total homework may be an indicator of a more general propensity to attend to school work, and thus might be independently correlated with mathematics achievement. Once the two variables are included in the model, the effect of one may be mediated or suppressed by the other. As it happens, this is not what occurs in this case. Nevertheless, this example illustrates in a straightforward way the difficulties in interpreting model effects.

4 The order of entry of the measures analysed is more of an issue when a stepwise analysis is undertaken, that is, when measures are entered in order of relative predictive power.

5 The estimate of the number of books in the home was used directly as it proved to be a better predictor of achievement than the *index of cultural possessions*.

6 Across OECD countries on average the latent correlations among the three measures are: -0.80 for self-concept in mathematics and anxiety in mathematics; -0.52 for self-efficacy in mathematics and anxiety in mathematics; and 0.62 for self-concept in mathematics and self-efficacy in mathematics (Table A.2).

7 On average across the OECD countries, the correlation between participation in tutoring and both the highest parental occupation and educational level is 0.04, and the correlation between participation in out-of-school lessons and both the highest parental occupation and educational level is 0.02.

8 The correlation between the observed effects and the analytical effects for students' use of memorisation/rehearsal strategies is 0.58.

9 This was tested by constructing one composite index that simply combines responses to all of the items making up the three indices for student learning strategies. This composite yielded close to a normal distribution, indicating that the problem is not that of a halo effect or the tendency of students to respond in a similar way to all items in a set. The country-level correlations for the composite were mixed – positive and negative – indicating that the effect of the composite is no more universal than that of the individual components.

10 The PISA school questionnaire contains a number of indices of school climate. However, examination of these indices was considered beyond the scope of this study because they could not be clearly identified with teaching strategies.

11 Exploratory analysis was undertaken using observed variables within selected PISA indices instead of the PISA indices themselves. Other than the variable *number of books in the home*, none of these variables contributed more to the predictive power of the analytical model than the composite PISA indices.

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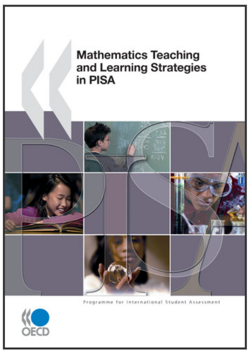

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