2

Factors Associated with School Effectiveness in Science and Mathematics

Overview

The analyses presented in the previous chapter confirm that student home background indicators of socioeconomic status and of parental support for academic work are major correlates of average school achievement in mathematics and science, and reinforce the need to account for such variables in any study of how school factors relate to that achievement. In this chapter, hierarchical linear modeling (HLM) techniques are used to adjust statistically for differences between schools in home background, so as to examine the relationship between a range of school factors and the adjusted average school achievement. This approach has the potential to disentangle, at least in an exploratory way, the relative influence of home and school factors.

What Was the Analytic Approach?

The hierarchical analyses for this chapter were conducted in two stages. In the first stage the analyses quantified across countries the extent to which schools differ in the average achievement of their students, and the extent to which these differences may be due to the home background of the student body. This information provides an overview of the global relationship between home background, schooling, and student achievement, and was helpful in identifying the countries that would be most fruitful for further study. This information also shows the extent to which schools internationally are segregated by home background factors, by describing how much they vary in the home background composition of the student body. The second, more detailed, analyses explored the relationship of student, teacher, and school factors to average school achievement, while adjusting for characteristics of the students' home background. This stage involved constructing seven hierarchical models for both science and mathematics in each of the countries included in the analyses.

The analyses reported in this chapter required a valid measure of the socioeconomic and educational background of the students. To that end, a single composite index of home background was created from variables considered to relate to this construct, and found to relate to each other and to student achievement. The home background index was based upon students' reports on the following:

- number of books in the home
- availability of a study desk
- presence of a computer in the home
- education of each natural parent

- number of natural parents in the home
- number of persons in the family home
- possessions in the home

The home background index was used to make a statistical adjustment to each school's average achievement in science and mathematics to control for differences in student home background. School-level factors were then examined as predictors of adjusted school achievement. Also, the school average home background was used as an important school-level predictor of average school achievement.

How Much Does Achievement Vary Between Schools Across Countries?

As was shown in chapter 1, the extent to which schools in a country differ among themselves in their average achievement limits the potential for school factors to explain between-school differences in student achievement. It is more likely that attributes of the school that co-vary with student achievement will be identified in countries where average school achievement varies a lot than in countries where it varies very little. In short, exploratory studies of school effectiveness are likely to be most fruitful when concentrated on countries with large between-school achievement differences.

Exhibits 2.1 and 2.2 show how the difference between students' achievement scores (the "variance") can be divided into differences between schools and differences between students within schools. The first column of the exhibits presents the variance between schools as a percentage of the total variance in achievement in each country for science and mathematics, respectively. A high percentage implies that the differences between average school scores are large compared with the differences between student scores within schools. This might be expected, for example, in a country with a well-established system of school tracking, with different school types catering to students of different levels of ability. A low percentage for a country implies that average school achievement is very similar from school to school.

The results presented in Exhibits 2.1 and 2.2 support the finding from the previous chapter that countries are not the same in the way that student achievement is distributed across schools. In countries such as Cyprus, Iceland, Japan, Korea, Norway, and Slovenia, average student achievement in science was fairly uniform across schools, with less than 10% of the total variance in student science achievement attributable to differences between school average scores. In contrast, large differences between schools (40% or more of the total variance) were found in Germany, Romania, Singapore, and the United States. In mathematics, the differences between schools were much more pronounced, with just three countries (Cyprus, Japan, and Korea) showing less than 10% of the variance between schools. Many more countries had large differences between schools, with 13 countries – including Australia, Belgium (both French and Flemish), Germany, Hong Kong, Ireland, Lithuania, the Netherlands, New Zealand, Romania, the Russian Federation, Switzerland, and the United States (Exhibit 2.2) – having at least 40% of variance between schools.

In all but two of the participating countries, the differences between schools were greater in mathematics than in science. This probably reflects a real difference between the two subjects, but it is undoubtedly also partly an artifact of the TIMSS sampling design, which was based on sampling a single intact mathematics class.[1] Since in most countries, each school is represented by a single mathematics class, the between-school differences presented in Exhibits 2.1 and 2.2 also include differences between classes within schools. In countries such as Ireland and Singapore that employ some form of streaming, the figures in the exhibits will overestimate the differences between schools.

The second column in Exhibits 2.1 and 2.2 shows the result of taking the percentage of variance that is between schools (column 1) and partitioning it to show what percentage of it can be attributed to differences between schools with respect to the home background of the students. It is clear from these results that home background is a major correlate of average school achievement in most countries, although, of course, the impact is greater in countries with large between-school differences in achievement. For example, although 88% of the between-school variance in mathematics achievement in Korea was attributable to home background differences, only 9% of the total variance was between schools, so this is not a large effect. However, in Belgium (French), Cyprus, England, Germany, Hungary, Ireland, Korea, the Netherlands, New Zealand, Portugal, Scotland, Singapore and the United States more than half of the difference between schools in both science and mathematics achievement could be attributed to differences in the home background of their students.

[1] In Australia, Cyprus, Sweden, and the United States, two mathematics classes were sampled from each participating school. So that the data from these countries could be treated as much as possible like those from other countries, each class was treated as if it came from a separate school.

Exhibit 2.1 Partitioning the School Variance in Eighth Grade* Science Achievement

Country	Percent of Variance in Science Achievement that is Between Schools	Percent of Between-School Variance Attributable to Home Background Index**
Australia	22	47
Austria	30	40
Belgium (Fl)	18	48
Belgium (Fr)	20	71
Canada	18	27
Colombia	27	58
Cyprus	7	79
Czech Republic	13	32
England	21	58
France	19	37
Germany	41	50
Hong Kong	29	47
Hungary	17	70
Iceland	9	13
Iran	14	20
Ireland	38	52
Japan	7	–
Korea	7	73
Latvia (LSS)	16	11
Lithuania	35	23
Netherlands	39	54
New Zealand	35	57
Norway	7	27
Portugal	14	56
Romania	51	18
Russian Federation	31	23
Scotland	25	67
Singapore	40	62
Slovak Republic	19	29
Slovenia	7	28
Spain	11	50
Sweden	10	54
Switzerland	38	48
United States	40	64

SOURCE: IEA Third International Mathematics and Science Study (TIMSS), 1994-95.

* Eighth grade in most countries; see Exhibit 1 for information about the grades tested in each country.

** Home Background Index: Average of the following nationally standardized variables: number of people in family home, number of natural parents in home, number of books in home, percentage of possessions from international options list, study desk in home, computer in home, highest level of education of mother and highest level of education of father.

Japan: Questions not administered. England and Scotland: Restricted number of variables in Home Background Index.

Countries shown in italics did not satisfy one or more guidelines for sample participation rates, age/grade specifications, or classroom see Exhibit A.1. Because coverage falls below 65%, Latvia is annoted LSS for Latvian Speaking Schools only.

Exhibit 2.2 Partitioning the School Variance in Eighth Grade* Mathematics Achievement

Country	Percent of Variance in Science Achievement that is Between Schools	Percent of Between-School Variance Attributable to Home Background Index**
Australia	49	46
Austria	36	46
Belgium (Fl)	60	46
Belgium (Fr)	52	70
Canada	25	9
Colombia	39	48
Cyprus	8	74
Czech Republic	22	29
England	24	55
France	33	31
Germany	51	53
Hong Kong	48	46
Hungary	23	67
Iceland	10	14
Iran	16	20
Ireland	50	51
Japan	7	–
Korea	9	88
Latvia (LSS)	27	27
Lithuania	43	29
Netherlands	60	55
New Zealand	46	54
Norway	10	29
Portugal	19	52
Romania	55	24
Russian Federation	40	34
Scotland	36	53
Singapore	39	56
Slovak Republic	23	36
Slovenia	11	34
Spain	19	37
Sweden	34	45
Switzerland	58	43
United States	64	61

SOURCE: IEA Third International Mathematics and Science Study (TIMSS), 1994-95

* Eighth grade in most countries; see Exhibit 1 for information about the grades tested in each country.

** Home Background Index: Average of the following nationally standardized variables: number of people in family home, number of natural parents in home, number of books in home, percentage of possessions from international options list, study desk in home, computer in home, highest level of education of mother and highest level of education of father.

Japan: Questions not administered. England and Scotland: Restricted number of variables in Home Background Index.

Countries shown in italics did not satisfy one or more guidelines for sample participation rates, age/grade specifications, or classroom see Exhibit A.1. Because coverage falls below 65%, Latvia is annoted LSS for Latvian Speaking Schools only.

How Much Does Home Background Vary Across Schools?

Implicit in the foregoing presentation is the idea that schools differ in the home backgrounds of their students. Exhibit 2.3 quantifies these differences in terms of the percentage of variance in student home background that can be attributed to differences between schools in each of the participating countries. In countries with low percentages, schools are fairly similar to each other in the aggregate home background characteristics of their students, but there may be quite a range within a school. In countries with high percentages in this exhibit, schools tend to vary greatly in the home backgrounds of their students.

The difference between schools in student home background was roughly similar to that in science achievement (Exhibit 2.1) in more than half of the countries. However, in five countries, Germany, Ireland, the Netherlands, Singapore, and Switzerland, the differences in science achievement were considerably larger (at least 10 percentage points) than the differences in student home background. It may be significant that all of these countries make differential provision for students of different ability levels through some form of tracking or streaming. Apparently, this has the effect of separating schools or classes by achievement much more than would occur on the basis of student home background alone. In contrast, there was also a range of countries, including Colombia, Hungary, Iran, Korea, Latvia(LSS), Portugal, Romania, Slovenia, and Spain, where the differences between schools in science achievement were much less than in student home background. In these countries, schooling (or at least science education) may have the effect of mitigating the influence of home background on achievement.

Exhibit 2.3 Partitioning the School Variance in Home Background* at Eighth Grade**

Country	Percent of Variance in Home Background Index that is Between Schools
Australia	21
Austria	24
Belgium (Fl)	14
Belgium (Fr)	23
Canada	23
Colombia	44
Cyprus	16
Czech Republic	17
England	18
France	21
Germany	21
Hong Kong	22
Hungary	33
Iceland	6
Iran	30
Ireland	27
Korea	30
Latvia (LSS)	26
Lithuania	32
Netherlands	20
New Zealand	30
Norway	12
Portugal	36
Romania	73
Russian Federation	29
Scotland	18
Singapore	24
Slovak Republic	24
Slovenia	17
Spain	30
Sweden	12
Switzerland	28
United States	42

SOURCE: IEA Third International Mathematics and Science Study (TIMSS), 1994-95

* Home Background Index: Average of the following nationally standardized variables: number of people in family home, number of natural parents in home, number of books in home, percentage of possessions from international options list, study desk in home, computer in home, highest level of education of mother and highest level of education of father.

** Eighth grade in most countries; see Exhibit 1 for information about the grades tested in each country.

England: Mathematics classrooms not directly sampled, mathematics results presented are at the school level; England and Scotland: Restricted number of variables in Home Background Index.

Countries shown in italics did not satisfy one or more guidelines for sample participation rates, age/grade specifications, or classroom see Exhibit A.1. Because coverage falls below 65%, Latvia is annoted LSS for Latvian Speaking Schools only.

How Were the Analyses Organized?

The selection of explanatory variables for the more detailed study of school effectiveness was based primarily on the results of the previous chapter. That is, the variables that were found to discriminate between high- and low-achieving schools were the main focus of interest. However, because the statistical technique used in this chapter is more refined, it was expected that some variables that did not discriminate greatly between the two school types might still play a role in a multi-variable approach. Consequently, a second review was conducted of the variables in the TIMSS database, and a number of variables were added to the list of potential explanatory variables, primarily teacher characteristics and aspects of classroom instruction. The explanatory variables were grouped into the following categories: classroom practices, teacher characteristics, school climate, school location and size, and home-school interface.

The results of the previous chapter, and the between-school analyses at the beginning of this chapter, confirm that home background and schooling are related both to each other and to student achievement. These relationships are impossible to disentangle with survey data such as TIMSS', but it is possible to organize the analysis of data so that the effect of school organizational and instructional variables may be seen both independently of and in conjunction with the school's general level of student home advantage. This approach lessens the temptation to conclude that differences between schools in organizational and instructional variables are "nothing but" differences in student home background.

To guide the analysis, and to keep the primary focus on classroom instruction and other school factors, the following questions were posed, separately for science and for mathematics:

1. Once average achievement in the school has been adjusted for the effects of students' home background, what classroom practices are associated with science and mathematics achievement?

2. Do teacher characteristics relate to the adjusted school science and mathematics achievement when examined alongside classroom practices?

3. What is the relationship of school social climate factors to the adjusted science and mathematics achievement when classroom practices and teacher experience are also considered?

4. Does school location and size relate to adjusted school achievement when considered in conjunction with classroom activities, teacher characteristics, and school social climate?

5. What is the relationship of factors representing student attitude or motivation (mother's press, self press, and students' aspirations) to adjusted school achievement when the other four categories of school-related factors are considered at the same time?

6. Is the average home background of the students in a school related to adjusted school achievement when considered in conjunction with all five categories of variables above?

7. Is adjusted school achievement more strongly related to the combination of average home background and the five categories of variables than average home background alone?

Answering these questions involved building six hierarchical linear models for each country for science and mathematics achievement. The first model examined the relationship of classroom characteristics to school achievement after considering the home background of students. Each successive model added another set of explanatory factors to the previous model. Together, these models provided an analysis of the effects of the various categories of school and classroom variables on school achievement while adjusting for student home background.[2] The relationship of the average home background to science and mathematics achievement was also considered independently of the other exploratory factors for comparative purposes.

The results of these analyses are summarized in Exhibits 2.4 and 2.5 for science and mathematics respectively. The first column in each exhibit shows the percentages of the total variance in student achievement in each country that can be attributed to differences between schools.[3] Since the percentages in the first column include all of the variance in student achievement that exists between schools, they represent the upper limit on the amount of between-school variance that can be accounted for by school or classroom variables. The remaining columns of Exhibits 2.4 and 2.5 display the percentage of the between-school variance that may be explained by the variables in each model. It is important to realize that the percentages in columns 2 to 7 take as their base the percentage shown in the first column. For example, in Exhibit 2.4, the 74% shown for Australia in column two refers to 74% of the between-school variance for Australia, which is itself just 23% of the total student variance. Therefore, although school-to-school differences in "Model 1: Classroom Characteristics" can account for 74% of the total school-to-school differences in student science achievement, this represents just 17% (23% of 74%) of the total student-to-student differences in science achievement.

[2] See Appendix A for a description of the hierarchical analysis.

[3] The percentages in the first columns of Exhibits 2.4 and 2.5 should ideally be identical to those in the first columns of Exhibits 2.1 and 2.2, respectively. However, since data records with incomplete data were eliminated from the analyses for Exhibits 2.4 and 2.5, the analyses were based on somewhat different datasets, with differences in the percentages as a result. See Appendix A for further information.

Further summaries of the results are presented in Exhibits 2.6 through 2.9. Exhibits 2.6 and 2.7 list the explanatory variables for science and mathematics, respectively, and enumerate the countries in which the variables played a statistically significant[4] role in each of the hierarchical models. These exhibits provide one view of the relative importance of each variable in each model. Exhibits 2.8 and 2.9 give another view by showing, for each country, the variables that were significant predictors of adjusted school achievement in science and mathematics in a model that included all of the explanatory variables (except school average home background). Exhibits displaying more detailed information for each country can be found for science in Appendix B and for mathematics in Appendix C.

Criteria for Inclusion in the Analyses

Although the TIMSS database contains a large array of information from students, teachers, and school principals, not every country asked all questions in the questionnaires, and not every respondent provided data on all questions that were asked. In choosing the factors to be examined in the hierarchical analyses the need to include the factors most relevant to achievement therefore had to be balanced with the availability of data in each of the countries. As the home background index was an essential component of the analyses, only countries that asked the questions used to build this index could be included. Similarly, only countries that asked questions of their teachers or principals that were central to the analyses, and had sufficiently high response rates for these questions, could be included.

Furthermore, since the purpose of the hierarchical analyses was to examine factors related to average school achievement in science and mathematics, attention focused on countries where school-to-school differences in achievement were large (at least 10%), and where the effects of such factors were likely to be most apparent. A third criterion for inclusion in the analyses was that countries had met the TIMSS standards for data quality and have relatively high achievement levels. Such countries should provide the best opportunity to examine factors associated with high student achievement. Countries with average achievement close to or above the international mean in either science or mathematics were included in the analyses.

Based on these criteria, 14 countries in science and 18 countries in mathematics were selected for further analysis. Countries included in both sets of analyses were Australia, Belgium (Flemish), Belgium (French), Canada, Czech Republic, France, Hong Kong, Ireland, New Zealand, Singapore, Slovak Republic, Sweden, and the United States. The science analyses also included Austria. In mathematics, findings are also presented for Germany, Iceland, the Netherlands, the Russian Federation, and Slovenia.

4 Since the emphasis in this study was on an exploratory approach, a significance level of 0.10 was adopted as the criterion for significance, in preference to the more stringent 0.05.

Exhibit 2.4

Percent of Between School Variance in Eighth Grade* Science Achievement Explained by Each Hierarchical Linear Model

Country	Percent of Variance in Science Achievement that is Between Schools[1]	Percentage of Between-School Variance Explained by a Series of Models						
		Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7
		Classroom Characteristics	Model 1 with Teacher Characteristics	Model 2 with School Climate	Model 3 with School Location and Size	Model 4 with Home – School Interaction	Model 5 with Average Home Background	Average Home Background Only
Australia	23	74	74	74	74	75	75	48
Austria	22	33	37	36	42	51	54	46
Belgium (Fl)	18	40	38	42	51	68	72	46
Belgium (Fr)	20	52	54	56	64	82	85	75
Canada	15	27	28	30	31	35	37	30
Czech Republic	12	43	44	49	51	75	75	32
France	15	38	43	48	50	60	60	31
Hong Kong	30	65	64	65	66	68	75	44
Ireland	36	61	61	61	61	67	72	49
New Zealand	35	56	55	55	56	68	72	58
Singapore	41	64	63	66	66	82	83	62
Slovak Republic	15	39	38	37	38	48	47	32
Sweden	11	53	54	52	52	62	68	54
United States	34	73	73	73	74	76	78	66
Average	23	51	52	53	55	66	68	48

SOURCE: IEA Third International Mathematics and Science Study (TIMSS), 1994-95

* Eighth grade in most countries; see Exhibit 1 for information about the grades tested in each country.

1 Results differ from Exhibit 2.1 because of missing data on predictor variables.

Classroom Characteristics: homework in three subjects; amount of science homework; efficacy of science; attitude to science; experiments

Teacher Characteristics: years of teaching experience; confidence to teach a general science course

School Climate: student administrative violations; serious student misbehavior

Home-School Interaction: future aspirations for education; mother's academic press; self academic press

Exhibit 2.5

Percent of Between School Variance in Eighth Grade* Mathematics Achievement Explained by Each Hierarchical Linear Model

Country	Percent of Variance in Science Achievement that is Between Schools[1]	Percentage of Between-School Variance Explained by a Series of Models						
		Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7
		Classroom Characteristics	Model 1 with Teacher Characteristics	Model 2 with School Climate	Model 3 with School Location and Size	Model 4 with Home – School Interaction	Model 5 with Average Home Background	Average Home Background Only
Australia	50	71	71	71	71	81	81	50
Belgium (Fl)	53	46	45	44	43	66	69	38
Belgium (Fr)	32	42	41	44	47	78	81	59
Canada	20	25	25	27	29	39	39	8
Czech Republic	21	43	43	43	43	71	71	29
Germany	49	41	40	46	44	71	77	63
France	29	43	42	50	52	57	56	24
Hong Kong	47	64	64	66	67	69	78	42
Iceland	15	54	52	49	52	67	70	31
Ireland	51	67	67	67	67	76	80	52
Netherlands	54	62	61	66	65	79	83	54
New Zealand	48	52	52	53	53	65	69	53
Russian Federation	39	35	34	34	35	37	45	34
Singapore	39	52	53	56	56	79	82	57
Slovak Republic	20	32	32	34	32	54	55	32
Slovenia	12	42	40	38	36	51	51	32
Sweden	31	48	47	47	47	53	68	48
United States	52	52	55	54	54	61	73	64
Average	37	48	48	49	50	64	68	43

SOURCE: IEA Third International Mathematics and Science Study (TIMSS), 1994-95

* Eighth grade in most countries; see Exhibit 1 for information about the grades tested in each country.

1 Results different from Exhibit 2.2 because of missing data on predictor variables.

Classroom Characteristics: homework in three subjects; amount of mathematics homework; checking homework in class; attitude to mathematics, mathematics class size

Teacher Characteristics: years of teaching experience

School Climate: student administrative violations; serious student misbehavior

Home-School Interaction: future aspirations for education, mother's academic press; self academic press

Exhibit 2.6 Number of Countries with Significant Predictors of School Effectiveness in Eighth Grade* Science (14 Countries)

Predictors	Base Model	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7
	Between School Model	Classroom Characteristics	Model 1 with Teacher Characteristics	Model 2 with School Climate	Model 3 with School Location and Size	Model 4 with Home – School Interaction	Model 5 with Home Background	Home Background Only
Intercept	14	10	10	10	9	5	9	14
Homework (3 Subjects)		12	13	12	13	12	11	
Homework (Amount Sci.)		7	8	9	9	6	5	
Attitude to Science		3	4	3	3	3	4	
Efficacy of Science		10	9	9	9	8	6	
Experiments		3	2	3	2	1	2	
Teaching Experience			2	1	3	0	2	
Readiness to Teach Gen. Sci.			1	1	2	0	0	
Administrative Violations				3	3	2	1	
Serious Misbehavior				2	1	3	3	
Urban Location					3	2	3	
Class Size					5	2	2	
Future Aspirations						11	10	
Self Press						5	3	
Mother's Press						2	1	
Home Background Index							10	14

SOURCE: IEA Third International Mathematics and Science Study (TIMSS), 1994-95.

* Eighth grade in most countries; see Exhibit 1 for information about the grades tested in each country.

The countries were: Australia, Austria, Belgium (Fl), Belgium (Fr), Canada, Czech Republic, France, Hong Kong, Ireland, New Zealand, Singapore, Slovak Republic, Sweden, and United States. Count represents the number of countries for which the predictor was significant (P<.1)

Exhibit 2.7 Number of Countries with Significant Predictors of School Effectiveness in Eighth Grade* Mathematics (18 Countries)

Predictors	Base Model: Between School Model	Model 1: Classroom Characteristics	Model 2: Model 1 with Teacher Characteristics	Model 3: Model 2 with School Climate	Model 4: Model 3 with School Location and Size	Model 5: Model 4 with Home – School Interaction	Model 6: Model 5 with Home Background	Model 7: Home Background
Intercept	18	15	14	14	14	9	11	18
Homework (3 Subjects)		17	17	16	16	13	12	
Homework (Amount)		11	11	11	11	9	9	
Homework (In Class Checking)		3	3	4	4	2	3	
Attitude to Mathematics		5	5	5	4	4	4	
Classroom Environment		9	9	9	10	8	9	
Mathematics Class Size		12	12	11	9	8	7	
Teaching Experience			1	2	2	2	2	
Student Admin. Violations				7	7	4	6	
Serious Student Misbehavior				4	3	4	5	
Urban Location					0	2	1	
Class Size					2	3	3	
Future Aspirations						17	15	
Self Press						3	1	
Mother's Press						2	1	
Home Background Index							13	18

SOURCE: IEA Third International Mathematics and Science Study (TIMSS), 1994-95.

* Eighth grade in most countries; see Exhibit 1 for information about the grades tested in each country.

The countries were: Australia, Belgium (Fl), Belgium (Fr), Canada, Czech Republic, Germany, France, Hong Kong, Iceland, Ireland, Netherlands, New Zealand, Russian Federation,Singapore, Slovak Republic, Slovenia, Sweden, and United States

Count represents the number of countries for which the predictor was significant (P<.1)

Exhibit 2.8 Summary of Predictors of Grade 8* Science Achievement in Model 5

	Homework (3 Subjects)	Homework (Amount)	Attitude to Science	Efficacy of Science	Experiment	Teaching Experience	Readiness to Teach Gen. Sci.	Student Admin. Violations	Serious Student Misbehavior	Urban Location	Class Size	Future Aspirations	Self Press	Mother's Press	Count
Australia	■	■		■									■	■	5
Austria	■	■										■			3
Belgium (Fl)			■	■							■	■			4
Belgium (Fr)	■							■	■			■	■		5
Canada			■	■									■	■	4
Czech Republic	■			■					■		■	■	■		6
France	■							■	■			■			4
Hong Kong	■														1
Ireland	■											■			2
New Zealand	■	■		■						■		■			5
Singapore	■	■	■	■	■							■			6
Slovak Republic	■											■			2
Sweden	■	■		■								■			4
United States	■	■		■						■		■	■		6
Count	12	6	3	8	1	0	0	2	3	2	2	11	5	2	

■ Predictor significant at .1 level

SOURCE: IEA Third International Mathematics and Science Study (TIMSS), 1994-95.

*Eighth grade in most countries; see Exhibit 1 for information about the grades tested in each country.

Exhibit 2.9 Summary of Predictors of Grade 8* Mathematics Achievement in Model 5

	Homework (3 Subjects)	Homework (Amount)	Homework (In Class Checking)	Attitude to Mathematics	Classroom Environment	Math Class Size	Teaching Experience	Student Admin. Violations	Serious Student Misbehavior	Urban Location	Class Size	Future Aspirations	Self Press	Mother's Press	Count
Australia	■	■	■		■	■		■	■	■		■			9
Belgium (Fl)					■	■						■			3
Belgium (Fr)		■			■						■	■	■		5
Canada		■		■	■				■		■	■	■	■	8
Czech Republic	■	■			■							■			4
Germany	■							■				■	■		4
France	■				■	■		■		■		■			6
Hong Kong	■														1
Iceland	■					■						■			3
Ireland	■					■					■	■			4
Netherlands	■	■		■		■		■				■			6
New Zealand	■	■				■						■			4
Russian Federation	■											■			2
Singapore	■	■			■		■		■			■			6
Slovak Republic				■					■			■			3
Slovenia		■										■			2
Sweden	■	■		■		■						■			5
United States	■		■		■		■					■		■	6
Count	13	9	2	4	8	8	2	4	4	2	3	17	3	2	

■ Predictor significant at .1 level

SOURCE: IEA Third International Mathematics and Science Study (TIMSS), 1994-95.

*Eighth grade in most countries; see Exhibit 1 for information about the grades tested in each country.

What Classroom Characteristics Were Associated with Science and Mathematics Achievement?

In both science and mathematics, the first analysis considered variables that directly relate to classroom experiences. In science, the explanatory variables were: time spent on homework in general, time spent on science homework, students' attitude to science, perceived efficacy of science, and frequency of conducting science experiments in class. In mathematics the variables were: time spent on homework in general, time spent on mathematics homework, checking mathematics homework in class, students' attitude to mathematics, an orderly classroom environment, and size of the class. Beginning with a model that included just these classroom variables provided the best opportunity to examine the relationship between these variables and adjusted school achievement in isolation from other variables.

As may be seen from the second column of percentages in Exhibits 2.4 and 2.5 (headed "Model 1: Classroom Characteristics"), characteristics of the class accounted for a substantial percentage of the differences between schools in both science and mathematics achievement. In science, the percentage ranged from 74% in Australia to 33% in Austria, while in mathematics the range was from 71% in Australia to 25% in Canada.

From Exhibit 2.6 it is apparent that not all of the classroom explanatory variables in science were equally effective in all countries. Of the five variables, the three that were significant in most countries were:

- daily doing homework in a range of subjects (language, science and mathematics)
- time spent on homework in science
- a belief in the efficacy of science

These variables were significant components not just of the model consisting of class variables only ("Model 1: Classroom Characteristics"), but also of Models 2 through 5 where the other school-related variables are added.

In the same way, Exhibit 2.7 shows that not all of the explanatory variables in mathematics were equally effective. Of the six mathematics variables, the four that were significant in most countries were:

- daily doing homework in a range of subjects (language, science and mathematics)
- time spent on homework in mathematics

- size of the mathematics classroom
- an orderly classroom environment

Again, these variables were significant components not just of the model consisting of class variables only, but also of the models containing the other school-related variables.

Daily Doing Homework in a Range of Subjects
The most consistently significant variable for both science and mathematics was whether the student had completed homework, on a daily basis, in language, science, and mathematics. In science, this variable was a significant component of the model containing only the classroom-related variables in 12 of the 14 countries (Exhibit 2.6). Even when combined in a more general model that consisted of all of the other school-related explanatory variables (Model 5), amount of time spent on homework was a significant independent component in 12 countries. These were Australia, Austria, Belgium (French), Czech Republic, France, Hong Kong, Ireland, New Zealand, Singapore, Slovak Republic, Sweden, and the United States (Exhibit 2.8).

In mathematics the results were even more striking. The general homework variable proved a significant component of the classroom characteristics model in 17 of 18 countries, and was significant in 13 countries in Model 5: Australia, Czech Republic, Germany, France, Hong Kong, Iceland, Ireland, Netherlands, New Zealand, Russian Federation, Singapore, Sweden, and the United States (Exhibit 2.9). Taken together, these results suggest that in most countries, even adjusting for the home background of the students and for the other school and classroom variables included in this study, schools where eighth-grade students are expected to spend time on homework in a range of subjects have higher average achievement in both science and mathematics.

Time Spent on Science or Mathematics Homework
The questionnaire item asking students about the amount of time that they spend specifically on science or mathematics homework provides a different perspective on the homework issue. The amount of time spent doing science homework was a significant component of the model containing class variables only in 7 of the 14 countries in the science analyses, and the time spent doing mathematics homework was a significant component in 11 of 18 countries. However, in most of the countries, time spent on homework in science and on homework in mathematics were negative predictors of adjusted school achievement, which implies that higher achievement was associated with less time spent on homework specifically in mathematics

and science. (See Appendix B and Appendix C for individual country results). A likely reason for this result is that more talented students need less time to complete their homework, and that large amounts of time spent on science or mathematics homework are more characteristic of students struggling to keep up.

The three additional classroom-related variables, one for science and two for the mathematics analysis, were significant predictors of adjusted school achievement in a number of the participating countries.

Efficacy of Science

In most countries, a belief in the contribution science could make to solving environmental problems was associated with higher adjusted school science achievement. The same pattern persisted across all other analyses, with the variable remaining significant in 8 countries even when all 5 categories of explanatory variables were considered. The countries were Australia, Belgium (Flemish), Canada, Czech Republic, New Zealand, Singapore, Sweden, and the United States.

Mathematics Class Size

The number of students in the mathematics class as reported by the teacher was a significant component of the classroom characteristics model (Model 1) in 12 of the 18 countries in the mathematics analysis. Even when included in a model with all of the other school-related explanatory variables, mathematics class size was a significant component of the model in 8 of the 18 countries – Australia, Belgium (Flemish), France, Iceland, Ireland, the Netherlands, New Zealand, and Sweden. In each of these countries, class size was positively related to adjusted school achievement, meaning that higher mathematics achievement was associated with larger class sizes. This may be due to a tendency for schools to assign weaker students to smaller classes.

Orderly Classroom Environment

The classroom environment variable, derived from students' agreement with three statements about student behavior in their mathematics class (students are orderly and quiet during lessons; students do as the teacher says; and students rarely neglect their work), is an indicator of the orderliness of the mathematics class. It was a significant predictor of adjusted school achievement in about half of the countries and remained significant even when all of the other explanatory variables were included in the model. These results indicate that more orderly mathematics classroom sessions tend to be associated with higher achievement regardless of the background of students.

How Do Teacher Characteristics Add to the Explanation of School Effectiveness?

The "teacher characteristic" variables that were combined with the classroom variables to constitute Model 2 consisted of years of teacher experience (science and mathematics) and preparedness to teach a range of science topics (science only). When considered in conjunction with the classroom variables, the teacher characteristics were not effective predictors of adjusted school science or mathematics achievement. From the third column of percentages in Exhibits 2.4 and 2.5 (labeled "Model 2: Model 1 with Teacher Characteristics"), it is apparent that the model containing both teacher characteristics and classroom variables accounts for little more between-school variance than a model containing just the classroom variables.[5]

Teaching Experience

From Exhibit 2.6 it can be seen that teacher experience was a significant component of the classroom/teacher model in just two of the participating countries for science, while in the more general model containing all school variables (Model 5) it was not significant in any country (Exhibit 2.8). In mathematics, teacher experience was a significant component of the classroom/teacher model in just two countries: Singapore and the United States.

Readiness to Teach a Range of Science Topics

The science teacher's reported readiness to teach a range of science topics was a significant component of the classroom/teacher model in just one country, the Czech Republic. However, when combined with all of the school variables in Model 5 it was not significant in any country.

How Does School Climate Add to the Explanation of School Effectiveness?

As discussed in the previous chapter, the idea of a positive school social climate as used in this study embodies respect for the individual student and a safe orderly environment for learning. Considerable research over the past four decades has shown the importance of the school climate in fostering an environment conducive to learning. A school with such a social climate, for example, would be marked by relatively few discipline problems. In Model 3, two indicators based upon principals' reports, administrative violations and serious misconduct, were combined with classroom and

[5] In several countries, including Belgium (Flemish), Hong Kong, and New Zealand, the percentage of variance accounted for by Model 2 was actually less than that accounted for by Model 1. This apparent anomaly is because the explanatory power introduced by the extra variables in Model 2 was not worth the degrees of freedom lost in fitting them.

teacher characteristics for science and for mathematics. Generally, school climates that foster learning and achievement were less likely to be prone to either administrative or serious violations even when considering student home background.

Student Administrative Violations

Student misbehaviors that interfere with the orderly running of the school, such as lateness for class and violations of school dress codes, were labeled "Student administrative violations". While in some cases such behavior may be seen as merely expressions of the developing adolescent psyche, it can disrupt school routine and detract from the school's focus upon learning.

In science, three countries showed a significant negative relationship between student administrative violations and achievement when the school climate variables were introduced in Model 3 (Exhibit 2.6). When combined with all of the school variables in Model 5, the relationship was significant in just two countries, Belgium (French) and France (Exhibit 2.8).

The link between student administrative violations and school effectiveness was stronger with respect to mathematics, with seven countries showing adjusted mathematics achievement to be negatively related to such student misbehavior (Exhibit 2.7). Four countries continued to show a significant relationship between student administrative violations and mathematics achievement when all explanatory school variables were considered together (Model 5). These countries were Australia, France, Germany, and the Netherlands (Exhibit 2.9).

Serious Student Misbehavior

The serious student misbehavior index consisted of frequency of inappropriate student behavior directed at other persons or the property of others, including harm to a member of the school community and theft. It is reasonable to assume that environments where this type of behavior is common would not be conducive to student learning. In science, when school climate was combined with classroom and teacher characteristics (Model 3), the serious student misbehavior variable was a significant predictor in two countries (Exhibit 2.6). However, when combined with all of the school variables in Model 5, it was a significant predictor in three countries, Belgium (French), the Czech Republic, and France (Exhibit 2.8). In mathematics, the variable was a significant predictor in four countries when combined with classroom and teacher characteristics in Model 3, and was still a significant predictor when combined in Model 5 with all of the school variables. The four countries were Australia, Canada, Singapore and the Slovak Republic. In three of these countries, a higher incidence of serious misbehavior was associated with higher average achievement when considered in conjunction with other variables.

How Do School Location and Size Add to the Explanation of School Effectiveness?

Model 4 for science and mathematics included not only classroom, teacher, and school climate factors, but also school location and average class size, as reported by school principals.

School Location

In science, when combined with classroom and teacher characteristics, and school climate in Model 4, school location was a significant predictor of adjusted school achievement in three countries (Exhibit 2.6). In Model 5, with all of the school variables, school location was significant in just two countries, New Zealand and the United States. In both countries, schools located outside urban areas performed better than those in urban centers. In mathematics, school location was not significant in any country for Model 4, and only in Australia and France when combined with all school factors in Model 5.

Average Class Size

Five countries showed average class size to be a significant predictor of school science achievement when combined in Model 4 with classroom and teacher characteristics and school climate. These were Belgium (Flemish), Belgium (French), the Czech Republic, New Zealand, and the Slovak Republic. When all of the science factors were considered together (Model 5), this was reduced to two countries, Belgium (Flemish) and Czech Republic (Exhibit 2.8). In mathematics, average class size in Model 4 was significant in only two countries, Belgium (French) and Canada. In Model 5, with all of the school factors combined, average class size was also a significant predictor in Ireland (Exhibit 2.9).

How Do Factors at the Home-School Interface Add to the Explanation of School Effectiveness?

Variables at the home-school interface that were selected for study in the hierarchical analyses included the level of education the student expected to attain, the student's press for academic success, and maternal press for academic success. The model that included these variables (Model 5) also included all of the other school factors: classroom and teacher characteristics, school climate, and school location and class size. This model had considerably greater explanatory power than models without the home-school interface variables. In science, on average 66% of the between-school variance was accounted for by the variables in Model 5, compared with 55% by the variables in Model 4. In mathematics the situation was similar, with 64% of the variance accounted for by Model 5 compared with 50% by Model 4.

Educational Aspirations

In both science and mathematics, the student's aspirations for future education was the strongest predictor in the home-school interface category and one of the strongest school-level predictors of achievement overall. As can be seen from Exhibits 2.6 and 2.7, this variable was a significant predictor in 11 countries in science and 17 in mathematics. In science, these countries were Austria, Belgium (Flemish), Belgium (French), the Czech Republic, France, Ireland, New Zealand, Singapore, the Slovak Republic, Sweden, and the United States (Exhibit 2.8). In mathematics this variable was a significant predictor in every country except Hong Kong (Exhibit 2.9). Even when taking into account home background factors, students who expect to attend a university attain higher levels of achievement in both science and mathematics.

Self Academic Press

A student's academic press to do well in a range of subjects including science and mathematics was also measured. In science, this variable was a significant predictor in five countries: Australia, Belgium (French), Canada, Czech Republic and the United States. In mathematics, student's academic press was found to be a significant predictor in Belgium (French), Canada, and Germany. In these few countries, higher self academic press was associated with lower overall achievement.

Mother's Academic Press

Parents can exert considerable influence over their children's attitudes towards education and their aspirations. Maternal academic press was found to be significant in two countries, with higher press generally being found in the higher-achieving schools. The countries were Australia and Canada for science and Canada and the United States for mathematics.

How Does the Average Level of Student Home Background Add to the Explanation of School Effectiveness?

While all of the between-school analyses presented in this chapter control statistically for differences in the home background characteristics of the students *within* the school, they do not address differences *between* schools in the average level of the home background index. This average has the potential to represent characteristics of the school and its community that are not captured at the individual student level. A school with a high average on the home background index, for example, would likely be located in an affluent community, with all of the advantages that that implies, whereas a school with a low average would likely be less advantageously situated.

In Model 6, average home background of the students was combined with all of the other school variables to see whether this aspect of the school offered any further explanatory information beyond that provided by the school variables. In science, the increase in the percentage of between-school variance explained was small, from 66% to 68% (Exhibit 2.4), but nonetheless average home background was a significant predictor in 10 of the 14 science countries, even after the effects of all of the other school variables are taken into account (Exhibit 2.6). In mathematics the increase in the percentage explained was slightly greater, from 64% to 68% (Exhibit 2.5). Average home background was a significant predictor in 13 of the 18 mathematics countries after controlling for the effects of the other school variables (Exhibit 2.7).

Does the Average Level of Student Home Background Provide a Sufficient Explanation for all Differences Between Schools?

Since in almost all countries, for both science and mathematics, a high school average on the home background index was associated with high average student achievement, it is reasonable to ask what extent the school variables accounted for differences between schools once the effect of average school background has been controlled. The final model in these analyses, Model 7, uses just the school average on the home background index as a predictor; as can be seen from Exhibits 2.6 and 2.7, it is significant in all of the countries for both science and mathematics. Comparing Model 6, which contains average school background and all of the other school variables, with Model 7, which contains just average home background, shows how much of the difference between schools can be attributed to the school variables once average school background has been taken into account.

In science, average home background alone accounted for 48% of the between-school variance (on average across countries), compared with 68% for average home background and school variables combined (Exhibit 2.6). Therefore, an additional 20% of the between-school variance was accounted for by taking all of the school variables together. In mathematics, the difference in the percentage of variance explained was a little greater, up from 43% for average home background alone to 68% for all school variables together (Exhibit 2.7). In this case an additional 25% was accounted for by taking all school variables together.

Summary and Conclusion

The results presented in this chapter show that the extent to which achievement in science and mathematics can be related to school factors varies considerably from country to country. In countries such as Cyprus, Japan, and Korea, average student achievement in science and mathematics was very similar from school to school, implying that the search for factors related to differential school effectiveness in these countries would not be fruitful. More common, especially in mathematics, were countries with substantial differences between schools in student achievement, and these were chosen for further analysis. The results also displayed considerable variation across countries in the extent to which schools differed in the home background of their students, and showed that the relationship between home and school factors and student achievement is not the same in all countries. It is clear that the way student home background relates to student achievement, and the way the school system moderates or magnifies this relationship, are closely linked to societal and school organizational factors unique to each country, and any cross-national analytic efforts should take this into account.

As a contribution to such an effort, the chapter went on to summarize across countries the relationship between a small set of home and school factors and school achievement, while controlling statistically for the home background of the students. The analyses were organized to focus first on classroom factors and teacher characteristics, to illustrate the extent to which such factors were related to school achievement. The classroom variables, while constituting a less than exhaustive list of classroom-related practices, nonetheless accounted for a substantial amount of the variation that exists between schools for both science and mathematics. This not only supports the view that classroom practices may influence achievement, but also indicates that properly tailored classroom practices can be made to address differences in ability. Other school and teacher variables were less consistent predictors of achievement across countries. The home-school interface factors, however, proved more consistent. Of particular note was the strong association between students' educational aspirations and achievement in both science and mathematics.

The results serve to illustrate vividly how home and school influences on student achievement are closely interwoven. The school average on an index of home background is almost as effective a predictor of average school achievement as the whole set of home and school factors used in this study, partly because all of these factors are interrelated in reality. Schools located in and drawing their students from affluent communities not only have a more advantaged student body, but also are likely to enjoy small classes, well-trained and well-paid teachers, a safe and educationally supportive environment, and the support of well-educated and affluent parents. All of these factors serve to support student learning, even though it may not be possible to disentangle completely their relative effects. The home background of students and the affluence of the communities in which they reside remain powerful predictors of science and mathematics achievement. This relationship is pronounced and persists across international contexts. More work needs to be done to identify the most fruitful variables to capture the dynamic processes that take place within schools and to understand how national and cultural contexts interact with other factors to influence how education is transmitted and received.