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Summary and Implications for Further Research

This chapter summarises the main results of the report, identifies relevant issues for further research and development of PISA, and examines the extent to which the available results speak to the relevant issues. For many of the variables explored, country differences stand out so much that their effects may be best interpreted within countries or clusters of countries with similar cultural backgrounds or school systems.

INTRODUCTION

This chapter offers a stand-alone overview of the report. It summarises the main results, identifies relevant issues of policy and practice and examines the extent to which the results available address these issues. It also considers the design of PISA in the light of interpretation issues encountered in this study.

The analysis in this report contributes to understanding:

- *The differences between teaching and learning practices in different countries, thus allowing countries to benchmark practices.* Some of the descriptive data are therefore of interest, for example in comparing homework practices across education systems. Such comparisons need, however, to be made with caution, especially when comparing statements made by principals and students that require a degree of interpretation (*e.g.* how much certain learning strategies are employed) and where response bias can arise because of different cultural contexts.

- *The extent to which teaching and learning practices vary across schools within each country.* This area is the principal focus of Chapter 2 and is an important concern in education systems that aim to provide equality of opportunity to all students.

- *The extent to which individual aspects of teaching and learning are associated with better or worse performance.* These associations are difficult to identify because of the complexity of interactions between various factors, as well as the interaction of different factors with student characteristics such as socio-economic background or students' belief in their own efficacy. Nevertheless, taken together, it is clear that teaching and learning factors have a significant association with student performance in mathematics.

It is important to recognise that teaching is a complex activity and that an enormous number of variables, many of which are outside the control of schools or teachers, influence learning. Even the most carefully designed studies, such as PISA, cannot be expected to identify a few simple school or classroom practices that, if implemented, would make a major difference to student learning. This argument is especially true here since even the best cross-sectional survey cannot yield a cumulative picture of the school and classroom experience of students near the end of their compulsory school careers. Estimates of school and teaching effects in a cross-sectional study are, at best, a one-year snapshot, while the effects of home background and attitudes are likely to be more stable. Surveys can indicate particular areas of interest and may in a few instances, such as for disciplinary climate in this report, identify a factor which appears to have universal positive or negative effects on performance. However, many teaching and learning factors are likely to interact with each other and with the cultural climate in particular countries to yield different impacts in different countries. It is clear that the teaching and learning factors measured in PISA show more than random effects on mathematics achievement. However, it is equally clear that these effects are not universally in the same direction or of similar magnitude across countries. Country differences stand out for many of these variables, to the extent that analysis within countries or clusters of countries with similar cultural backgrounds or school systems may provide the best interpretation of their effects.

BACKGROUND FACTORS THAT PROVIDE THE CONTEXT FOR TEACHING AND LEARNING

The place of socio-economic status

This report does not directly focus on socio-economic background. Nevertheless, the PISA results clearly show that socio-economic background plays a major role in determining the achievement levels of students. Much of the analytical work using the PISA data has addressed the impact of socio-economic background on achievement. While socio-economic background is a more-or-less fixed background factor which education systems can do little to influence directly, the biggest long-term social change that schools can accomplish is to help children overcome the disadvantages of their backgrounds and hence facilitate social mobility.

The immediate implication of this finding for the analysis in this report is that the impact of teaching and learning strategies needs examination independently of students' backgrounds. Thus the design of the models developed here aims to adjust for socio-economic background when examining the effects of teaching and learning strategies. Ideally, the use of appropriate teaching and learning strategies moderates the impact of socio-economic background on achievement, and many educational policy initiatives are intended to compensate for adverse socio-economic effects. Nevertheless, the models used here make clear that socio-economic background remains one of the strongest predictors of achievement, even in the presence of a large variety of teaching and learning strategy variables. That is, the teaching and learning variables examined here do not seem in practice to mitigate very much the disadvantaged social backgrounds of some students.

Student attitudes, motivations and self-concept

Like socio-economic status, students' self-confidence and motivation as learners show consistent correlations with achievement. These factors could also be related to teaching and learning strategies, and therefore they are included as control variables in the models. Nevertheless, unlike socio-economic background, the direction of causation is not at all clear for these variables. That is, it is possible that attitudes can be influenced by teaching strategies, that attitudes influence learning strategies or that attitudes are affected by achievement. For example, the question remains unresolved of whether a high level of perceived competence in mathematics precedes or follows a high level of achievement, or whether low achievement engenders high mathematics anxiety or vice versa. As noted earlier, cultural differences are likely to affect students' interpretation of self-confidence and motivation questions. Results in these areas should be interpreted with country differences in their mean index values in mind. Readers familiar with particular countries or cultures are better placed than the authors to make judgments about such differences. These variables show some unexpected patterns when taken in the context of other factors in the full model and hence warrant further discussion.

Self-efficacy is often seen as a major determinant of behaviour (Bandura, 1993). However, there is some debate as to whether self-efficacy is best thought of as a generic or a subject-specific trait. The extent of its correlation with achievement seems to depend on the type of self-efficacy measure used (Moulton, Brown and Lent, 1991). PISA 2003 measures self-efficacy, specifically as a mathematics trait, using items in which students evaluate their competence at solving a variety of mathematics problems, yielding the index of self-efficacy in mathematics. Countries in which students have a greater sense of self-efficacy tend to have higher performance, while within most countries there

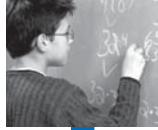
is a correlation with performance that remains even when adjusting for other factors.The average sense of self-efficacy (set as zero internationally) varies considerably across countries. In the Slovak Republic students overall have self-efficacy half a standard deviation above average, while those in Japan and Korea, and the partner country Thailand, are the same amount below average. In countries where students have least confidence in their own efficacy, this variable also makes least difference to their predicted achievement; it is most closely correlated in some countries that have about average self-efficacy overall.

The question arises of whether there would be any benefit in attempting to enhance self-efficacy in mathematics as a means of improving achievement. PISA cannot show whether this would be effective, but the question does highlight a pertinent cultural issue. Students in Japan and Korea have among the lowest average sense of self-efficacy in mathematics, though both countries have among the highest average achievement levels. This finding raises the further question of whether the culture or the school systems of these countries are in some way engendering more negative student opinions of their mathematics competence than the reality of their achievement warrants.

Another affective variable showing wide differences across countries is anxiety in mathematics. Students in Mexico, Japan and Korea, and the partner countries Tunisia, Brazil and Thailand (a contrasting mix of high- and low-achieving countries), express particularly high levels of anxiety about mathematics. However, in Denmark, Finland, the Netherlands and Sweden (all relatively high-achieving countries) students show particularly low anxiety. Both within and across countries, students who are anxious about learning mathematics tend to perform worse in the subject. Again, there may be lessons for teachers here, especially in countries where anxiety is highest, to make more efforts to reduce it. Particularly in Mexico and the partner country Brazil, high anxiety tends to go with low mathematics performance.

PISA also gives some indication to teachers that students' motivation is an important aspect of their learning. When asked about their motivation to learn mathematics – out of interest or for more instrumental reasons – students once again responded differently across countries. Although cultural differences may influence the way students respond to this question across countries, within countries those with the highest motivation perform best on average (there is a moderate correlation between motivation and performance).

Much of the research on efficacy, attitudes and motivation hinges on the working hypothesis that high values of such variables are associated with high achievement (*e.g.* Baumert and Koeller, 1998; Aitken, 1974; Lepper, 1988; Wigfield, Eccles and Rodriguez, 1998; Moulton, Brown and Lent, 1991; Branden, 1994). However, some sources suggest that the relationship between these factors and achievement is subtler and more indirect than the simple hypothesis would indicate. This study strongly reinforces that view. While most of the bivariate relationships operate in the predicted direction when examined within countries, there is an obvious country-specific component in the patterns. For example, students in several high-achieving countries, particularly Asian ones, show a generally negative sense of self-efficacy and have relatively negative attitudes and motivations. The existence of negative between-country effects suggests that country-specific features strongly influence the measurement of these factors. Even within countries, however, positive associations between certain attitudes and performance sometimes become negative when adjusting for other factors.



Common-sense logic dictates that teaching can and should influence such attitudes and motivations. If, in their turn, these factors influence achievement, it might be desirable to direct teaching strategies towards improving attitudes and motivations in the hope that this would have indirect positive effects on achievement. While there is no way of measuring the extent to which teachers deliberately aim to improve attitudes in order to improve achievement, in practice there is a consistent bivariate association between good student attitudes and the adoption of helpful teaching strategies, for example by creating a positive classroom climate. This finding needs to be interpreted with caution, however, since teaching strategies in PISA are rated by students, and it is possible that those who have positive views of what their teachers are doing also tend to have positive attitudes in general. Nevertheless, it seems that there is little to be lost in having teachers act in ways that help reduce mathematics anxiety and increase students' sense of self-efficacy in mathematics and their self-concept. However, teachers should also note that students who enjoy mathematics or feel a sense of belonging at school actually tend to perform worse in mathematics when adjusting for all other factors. This evidence does not mean that enjoying mathematics causes students to perform worse, but that a student who enjoys mathematics more than another will not necessarily perform better if she does not also have other characteristics that tend to go with enjoyment, such as greater confidence in her mathematics ability.

Time allocations

Since Carroll's groundbreaking 1963 paper, time allocation has become one of the most significant variables in studies of achievement. Although Carroll suggested in his 1989 retrospective that he had not done much more than state the obvious, his model took the analysis of time well beyond the common-sense notions that no learning can take place without spending time and that more time should lead to greater learning. In particular, the distinction between time allocated and time needed, and the relationship of these variables to student aptitude, quality of instruction, opportunity to learn and perseverance have become established elements in the analysis of time and its impact on learning. One can think of this model, therefore, as capturing teaching and learning strategies within a framework in which more effective strategies either decrease time needed or increase time spent (through longer periods of instruction or more out-of-class learning).

For school authorities, the length of the school year and school day are the most salient time variables. States can also regulate other aspects of time, such as time allocations to particular subjects or the length of class periods, although the school often decides these matters. Depending on the degree of centralisation of the system, schools can treat state-level time policies as guidelines or as definitive allocations. Since PISA 2003 did not measure jurisdictional-level variables directly, the information on global time allocations available comes from the school questionnaire and hence reflects variations among schools.

The number of weeks in the school year varies considerably in countries taking part in PISA, with a norm of 36-40 weeks, but only 33 weeks in Ireland, 32 in the partner country Tunisia and 24 in Mexico. These country differences do have a positive correlation with performance, but within countries, the correlation is mostly negative, although weak – probably because of limited within-country variation and the influence of a few outlier schools. A second time measure, the length of the school week, shows greater variation than the school year within some countries, especially in the United States, although in Finland and the partner country Latvia, for example, neither the school week nor the school year vary much. In these countries, therefore, the main correlation with

performance is within countries, although when adjusting for other factors the correlation tends not to be significant. Similar results apply for the quantity of mathematics teaching, even though here country differences are striking: the partner economies Hong Kong-China and Macao-China provide over 4.5 hours of mathematics instruction each week to 15-year-olds, whereas Finland provides only 2.5 hours.

These results suggest that giving more overall time to mathematics instruction does not greatly contribute to better achievement. While this does not negate the value of time spent on mathematics learning, it does suggest that other intervening variables can offset any advantages of longer overall time allocations. This area requires further investigation within some countries, particularly those with very low time allocations and very low achievement.

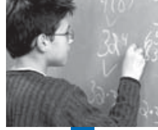
STUDENT LEARNING STRATEGIES

Student use of time

The Carroll model addresses time use at the level of the individual. Total allocated learning time in the school is only one aspect of this model. While this aspect might be a limiting factor on learning, the reality is that students may fail either to use all of the instructional time available or may find ways to extend this time. PISA does not investigate lost time in any comprehensive way (although the issue is touched on when looking at classroom climate, where students are asked, for example, whether at least five minutes at the start of lessons are spent doing nothing). However, PISA does measure additional time spent on learning using questions on exposure to tutoring and other out-of-class instruction and on time spent on homework.

The proportion of students tutored in mathematics is in the 10% to 20% range for most countries. It is less than 10% in several high-achieving countries such as Belgium, Finland and Japan, but exceeds 30% in some low-achieving countries, particularly Greece, Mexico and Turkey. Patterns of out-of-class lessons are similar. However, in both cases it is difficult to find positive effects on learning – although the literature suggests these positive effects do exist (Cohen, Kulik and Kulik, 1982; Hattie, 1992) – because those who receive such extra support may be more likely to be less able students. Indeed, there is generally a strong negative correlation between participation in such activities and achievement in mathematics. The prevalence of tutoring and extra lessons in some low-achieving countries suggests that extra efforts are being made by many students and by their parents (who must pay for such services) to overcome low achievement. However, these efforts are clearly not yielding sufficient payoff to raise achievement levels significantly for the country as a whole. The obvious policy implication is that countries cannot rely on services provided outside the school setting to overcome those characteristics of their school systems or of their societies that are contributing to low achievement. Taking this argument a step further, it is possible that the value of extra-school instruction is being oversold by a large and growing industry.

Several other related issues follow from these results. It is particularly important to investigate whether students from more affluent families are taking tutoring and out-of-class lessons. The results indicate that there is a small positive relationship between socio-economic background and these activities. It is not clear if the high prevalence of these activities in some countries is related to the cost of such services, to such factors as the availability of qualified but unemployed personnel and to whether regular teachers engage in such activities after school hours, perhaps to supplement



low salaries. It is also unclear whether the high proportions recorded in some countries simply represent over-reporting. These points warrant detailed investigation in the light of the mixed results on whether the impact of extra learning on individual students is positive, especially in countries with low average achievement and where these activities are prevalent.

The second major area of student use of time measured in PISA is homework. There is substantial support in the literature for the value of homework as a contributor to achievement (Paschal, Weinstein and Walberg, 1984; Hattie, 1992; Cooper, Robinson and Patall, 2006) when the homework assignment reinforces the material that has been learnt, rather than being given in place of instruction. However, a report by Mullis *et al.* (2000), based on the IEA Third International Mathematics and Science Study (TIMSS), found that homework time was a negative predictor of mathematics and science achievement.

The PISA student questionnaire contains items on hours per week spent on all homework and on mathematics homework. As with tutoring and extra classes, the assignment of homework occurs more in countries with lower overall achievement. However, in the case of homework, unlike with tutoring, the evidence suggests an overall beneficial effect within countries. Even adjusting for other variables, total homework time shows significant positive effects on achievement for almost all countries, although the effects for mathematics homework are mainly significantly negative. A key finding that helps explain the latter result is that the small proportion of students reporting no mathematics homework tend to have higher achievement than those reporting some mathematics homework. This evidence indicates that some students can learn mathematics effectively through their within-school work and thus have no need for homework.

All of this presents a complex picture for the effect of homework. Negative country-level correlations and the inordinate amount of time spent by students in some low-achieving countries on homework suggest that homework is being used to compensate, but not very effectively, for the limitations of schooling or to substitute for instruction by teachers. It also seems likely that in many high-achieving countries, and for high-achieving students in all countries, the current approach to teaching mathematics in school is sufficient to allow students to function well without much homework. However, it is clear that within each country, higher-achieving students do more total homework than other students.

The policy implications of these results are not straightforward. A general argument can be made, based on these results and on the literature, that schools and school systems should encourage homework. However, further investigation is required to determine if homework is being used to offset problems occurring within schools and on the effectiveness of homework for low-achieving students. More specifically, it would be useful to know what particular forms of homework students are doing and whether teachers primarily assign homework as specific tasks or as a general requirement to practise certain topics.

Meta-cognitive strategies

Meta-cognitive strategies are generic approaches that students use in addressing a learning task. There is support in the literature for the hypothesis that student use of meta-cognitive strategies contributes to achievement. Indeed, this is one of the proximal areas considered by Wang, Haertel and Walberg (1994) as having the greatest influence on achievement.

The three index variables used in PISA are memorisation/rehearsal, elaboration strategies and control strategies. Memorisation involves activities such as going through examples repeatedly and trying to remember all of the steps in a procedure. Elaboration is associated with activities such as thinking of new ways to solve a problem and relating the problem to existing knowledge. Control strategies involve trying to discern what are the important parts of a problem and working out what needs to be learnt. Although memorisation has been widely investigated by psychologists, today they generally regard it as a low-level strategy, associated with a behaviourist approach to learning, and hence it is often discouraged as a general strategy for school learning. Elaboration is a more comprehensive strategy, consistent with the more constructivist view of learning now prevalent, especially in teacher education programmes. Control strategies seem to relate to efficiency in learning, though it is more difficult to situate such strategies within any particular psychological framework.

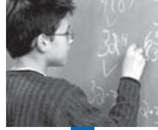
Consistent with expectations, memorisation strategies tend to be less frequently used than either elaboration or control strategies. They tend to be used more by students in relatively low-performing countries: students in Mexico, Brazil, Thailand and Tunisia say that they use memorisation the most, which produces a very high negative correlation between countries' use of memorisation and their performance in PISA. The within-country correlations with achievement are mostly close to zero, but with a few significant positive and negative values.

It must therefore be concluded that memorisation is an ineffective strategy. This finding has important implications for policy and practice in some of the lowest-achieving countries, where students rely extensively on memorisation. It is clear that teachers need to find ways to enable students to reduce their reliance on memory. One possible approach is to teach generic strategies for attacking mathematics problems: to teach methods, not a memorisable body of information.

The report suggests that the *index of elaboration strategies* can be an indicator of whether students use such generic strategies, though not of whether students have learned these methods from teachers directly. While students use elaboration strategies more often than memorisation strategies in most countries, the patterns of relationship with achievement are similar. On the standard scale, students in Mexico and Turkey, and the partner countries Brazil, Serbia, Thailand and Tunisia, show the highest positive levels of use of elaboration strategies, while those in Japan and Korea show the highest negative levels. Within-country correlations are mostly small but the between-country correlation is strongly negative. This evidence suggests that those countries using memorisation are not doing so at the cost of elaboration, but it is also possible that cultural bias affects responses to these questions, and in particular that students in some countries are generally more inclined to agree with statements of this type, whatever their actual learning habits.

This tendency would seem to be confirmed by students' self-reports on use of control strategies: students in Mexico and the partner countries Tunisia and Brazil, along with those in Austria and the partner country Serbia, were the most likely to say they controlled their learning. Control strategies differ from the other two meta-cognitive strategies in that, in some countries, there is a correlation between adopting such strategies and performance even after adjusting for other factors. However, this applies to only one-half of these countries, and the correlation is negative as often as positive.

One possible explanation for the limited degree to which control strategies have unique effects on performance after accounting for other factors is that one of the variables controlled for is self-efficacy in mathematics. The hypothesis here is that students with higher levels of self-efficacy are



more likely to use elaboration and control strategies and that these act jointly to influence achievement. In fact, all three meta-cognitive strategies are found to correlate positively with self-efficacy, and the impact of adjusting for self-efficacy is to change bivariate positive effects for all three meta-cognitive strategies into negative effects in the joint model. If, as seems plausible, adopting an effective learning strategy results in both greater confidence in mathematical efficacy and higher mathematical achievement, by adjusting for self-efficacy the possible benefits of such strategies may be masked. This issue could be investigated by treating self-efficacy as the outcome variable, adjusting for achievement, and comparing the modelled effects of the meta-cognitive variables on that outcome with those for achievement.

It is difficult to know how to interpret these results. They are clearly inconsistent with the literature as they show only small and inconsistent bivariate effects and mainly negative effects on achievement when other variables are controlled. In fact, these three variables are highly intercorrelated, suggesting that the concept of meta-cognitive strategies has only one dimension. However, if this is so, it could be argued that a specific strategy adopted on its own will not make a significant difference to achievement.

These variables are clearly more complex than expected, both from an international perspective and when examined in the presence of other factors. In particular, the between-country correlations again suggest a generalised response bias under which students in high-achieving countries report low level of use of such strategies and those in many low-achieving countries hold what may be an overly optimistic view of how much they elaborate and control their learning.

Educators who intuitively perceive the usefulness of these learning strategies would like a clear statement for policy makers and practitioners which says that encouraging, or perhaps even explicitly teaching, the use of meta-cognitive strategies will enhance student achievement. However, the results of this study do not unequivocally support such a statement, particularly as student perceptions of use of these strategies are measured here, rather than actual approaches to teaching.

Co-operative and competitive learning situations

A substantial literature exists on co-operative learning in classrooms (see, for example, Slavin, 1994; Johnson and Johnson, 1989). Entire programmes operate that are built around the notion that working in co-operative groups can enhance student achievement and social skills. On the one hand, there has been little in-depth investigation into the alternative approach of engendering competitive learning environments and, indeed, this type of investigation seems inconsistent with the ethos of many school systems. On the other hand, at levels beyond those in which universal participation is expected (the tertiary level in some countries but the secondary level in others), competition for places can be extreme.

The PISA *index of co-operative learning strategies* and the PISA *index of competitive learning strategies* derive 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. Overall, a majority of students in most countries tend to agree with statements reflecting both of these strategies, suggesting that they may not be opposites on a single continuum. Indeed, these indices correlate positively with each other in most countries. Students in Japan show much less enthusiasm for either strategy than elsewhere

in the OECD, while students in Turkey and in the partner countries Brazil and Tunisia are strongly positive on both.

Students who engage in competitive learning tend in many countries to be among the higher achievers, but this effect mainly disappears once one accounts for other characteristics of these students. Co-operative learning does not correlate with achievement at either level. This finding suggests that while achievement can predict student learning styles to some extent (high achievers may compete more, because they also have other characteristics such as confidence in their abilities), there is no evidence to indicate that a particular learning style is more effective. In interpreting these limited findings about competition and co-operation, it is important to note that what are being measured are student preferences for these strategies and not classroom organisation or instruction in reference to them. Moreover, the tendency for students to express enthusiasm for these strategies in some countries with low average achievement, where students also tend to be enthusiastic about other learning strategies, suggests a cultural bias that makes it hard to draw firm conclusions.

TEACHING STRATEGIES

Disciplinary climate

Across countries, disciplinary climate is the teaching and learning factor with the strongest correlation with performance and this correlation remains positive and significant in most countries even after adjusting for other factors.

Disciplinary climate refers to the creation of a classroom atmosphere that is conducive to learning. More specifically, it refers to a classroom that is efficient, free of disruptions and in which on-task behaviour is maximised. Despite the common-sense significance of disciplinary climate and its public visibility as an issue in schooling, it has not been widely investigated in studies of teaching. However, studies of time on task (Denham and Lieberman, 1980), classroom distractions (Behnke *et. al.,* 1981) and teacher control (Crocker and Brooker, 1986) do address elements of disciplinary climate. Effective classroom management is one of the factors identified in a recent review of Marzano's (2003) review "What Works in Schools."

The PISA *index of disciplinary climate* consists of items in which students are asked to report the frequency with which negative behaviours occur in their mathematics classrooms. Examples include: students not listening to the teacher, noise and disorder in the classroom, waiting for a long time for lessons to start or for students to quieten down, and student inability to work well in the classroom.

The proportion of students indicating that these things occur in most or all lessons tend to be in the 20% to 40% range. The most positive disciplinary climates are in Japan and the partner country the Russian Federation, and the most negative in the partner country Brazil, but overall the average scores on this variable do not differ greatly across countries.

By contrast, within-country differences in disciplinary climate are a key issue. One of the most important findings in this study is that not only is disciplinary climate the teaching and learning factor with the closest link to performance, but it is also one in which differences across schools are particularly high. (Although reported by students, this factor is aggregated to the school level). Moreover, the correlation between disciplinary climate and achievement is much higher at the

school than at the student level. These results show that if school systems are to provide equal learning opportunities to all of their students, it is very important to improve the disciplinary climate in those schools where it is poor.

Teacher support and student-teacher relations

The *index of teacher support* derives from items concerning whether the teacher shows an interest in student work, helps students with their learning and allows students to express opinions. A majority of students in most countries are of the view that their teachers act in these ways. However, there is more variation across countries in this factor than in disciplinary climate. The highest average levels of teacher support occur in Mexico and Turkey and in the partner countries Thailand and Brazil, while the lowest levels occur in Austria, Japan, Luxembourg and Germany. Teacher support mainly correlates negatively with achievement within countries and most of the model effects are negative, suggesting that support is intentionally targeted towards weaker students.

Although considered in PISA to be an aspect of school climate rather than of teaching strategies, the *index of student-teacher relations* consists of items that closely resemble those for teacher support, concerning how well students get along with teachers, whether teachers listen to students and whether teachers treat students fairly.

The response patterns are similar for these two variables. Most of the within-country correlations are either significantly negative or close to zero. However, the model effects are more mixed. Several western European countries show positive effects for student-teacher relations while several eastern European countries, along with Mexico and the partner countries Thailand and Tunisia, show negative effects.

Teacher support and student-teacher relations may be thought of as affective counterparts to the management emphasis reflected in disciplinary climate. Soar and Soar (1979) are among the few researchers to have examined emotional climate in the classroom in relation to achievement. Their research reports a non-linear relationship, with negative emotional climate (*e.g.* criticism, student resistance) yielding negative results but positive emotional climate not yielding the expected positive effect on student achievement. It is possible to infer from the Soar and Soar studies that an emotional climate that is free of the most negative features, combined with strong teacher management behaviours (*e.g.* setting limits on student movement and disruption), yields the highest achievement levels.

The results for these teaching strategy variables are consistent with the literature and have direct implications for teaching practice. Teachers who create classroom conditions that are free of disruptions and lost time can expect better student performance than those who do not. Teachers who exhibit high levels of warmth or positive affect towards students are not likely to have higher-achieving students than those teachers showing less positive feelings towards their students. School administrators need to identify classrooms with frequent negative behaviours and take steps to improve the management skills of teachers in these classrooms. Identifying whole schools with such problems and helping them to address them are tasks for higher-level education authorities.

All of this analysis provides specific directions for change in what might be an important component of a school improvement plan. However, the results need to be differentiated further to determine

if the observed effects are universal or are applicable to schools that are not average in terms of student ability, socio-economic background or other characteristics. It is also important to note that most of the studies of discipline and affect occur at lower grade-levels than those in PISA. The consistency in general pattern suggests common aspects of good teaching and not grade-specific effects.

WHAT DOES THE EVIDENCE SAY?

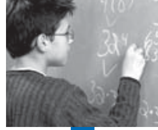
Table 4.1 gives a summary of the range and variation of values of the main teaching and learning variables studied here, their univariate and multivariate effects and the interpretations and policy implications that one can drawn from the results.

The results clearly show wide variations among countries in the average values of the variables of interest and in the diversity among schools of values of these variables. There seems to be some evidence of clustering of countries with similar cultural features or with similar school systems. For example, a few countries show consistent patterns of high diversity across schools, suggesting a highly decentralised school system. However, the degree of diversity across schools does not seem to be clearly linked to mathematics achievement. In some cases, the results indicate interesting teaching and learning patterns, such as the relatively high homework levels in some low-achieving countries, which appear to conflict with the overall average effects for these variables across all the countries studied. In other cases, such as the high level of memorisation found in some low-achieving countries, the between-country differences are consistent with the overall achievement effects for these variables. In general, the absolute values of the variables across countries appear to be of less importance than their relative values within countries.

The analysis does not provide a clearly defined picture of a set of teaching and learning conditions associated with strong student performance. In many cases, the model shows weak, non-significant or negative associations between individual factors and performance in mathematics, once all other factors are controlled for. This finding does not mean that teaching and learning factors are irrelevant, or that success is entirely determined by other factors such as a student's background or self-confidence: it may simply be that the separate effects of teaching and learning factors are difficult to measure. Nevertheless, the results do seem to indicate that a combination of conditions is associated with effective teaching and learning, not a single factor alone.

There is one factor that seems to have a universally strong association with performance when adjusting for other factors: disciplinary climate, especially at the school level. Students who experience disorderly classrooms are less likely to perform well, whatever their other characteristics. This finding seems to indicate that having an orderly place to learn is an important prerequisite without which teaching and learning cannot thrive. Beyond this condition, factors such as good relations with teachers, the adoption of effective learning strategies and homework assignments contribute collectively to a student's chances of success, but no individual practice can be said to make a decisive difference.

Figure 3.2 illustrates vividly that these and other factors play a part in explaining differences between the performance of different students and schools. At the school level, three-quarters of school variance can be attributed to the particular combination of the background factors and teaching and learning factors presented in this report. In this context, the analysis of school differences discussed in Chapter 2 is useful. In particular, some countries tend to show relatively wide



differences among schools on a range of variables, and this will have a cumulative effect on students' chances. These differences seem to be particularly large with respect to school climate and student-teacher relations, indicating that it is not just instructional strategies but the learning environment that countries need to look at when pursuing equal educational opportunities.

Moreover, even though there are a few teaching and learning variables with a consistent effect across countries, some of those noted above may be context-specific. For example, while positive disciplinary climate seems to be related to higher achievement in all countries, positive student-teacher relations have a positive effect on achievement in some countries and a negative effect in others. It is not possible, in a broad study such as this, to investigate the specific cultural characteristics of countries, features of national education systems or the extent to which interpretations of items vary in different languages or cultural contexts. Individual countries may wish to pursue longitudinal studies to delve into issues such as homework time, or observation studies to deepen understanding of issues such as classroom climate.

Final thoughts

The recent publication of first results from the Teaching and Learning International Survey (TALIS) (OECD, 2009) sheds new light on many of the teaching and learning strategies reported here. Using many of the same constructs as found in PISA, the TALIS study addresses a major gap in the PISA studies by using a teacher questionnaire to record teaching strategies as well as teacher beliefs and attitudes. TALIS categorises teacher beliefs under two main theoretical viewpoints, referred to as direct transmission and constructivist. The contrast between these viewpoints is the basis for much of the literature on teaching and teacher education. Many of the teaching strategy indices used in both PISA and TALIS may be associated, to a greater or lesser degree, with one or other of these positions.

While TALIS investigates the links between specific teaching strategies and these broader constructs, it does not include measures of student achievement, so cannot address the key question of which of these constructs is most conducive to learning or the circumstances under which one or the other may be more effective. This exercise could be done in future PISA studies, either by including a TALIS-like teacher questionnaire or by linking existing PISA variables to transmissive or constructivist orientations at the school level. The examination of these orientations would be a particularly interesting approach to adopt for PISA 2012, when mathematics will again be the main focus of research. Most contemporary approaches to mathematics curriculum and instruction emphasise the importance of problem-solving, which is widely believed to be better taught from a constructivist than from a transmissive perspective.

Table 4.1
Summary of teaching and learning effects and policy implications

Variable	Range across countries	Variation across schools within countries	Relationship with mathematics outcome[5]	Interpretation	Implications for further research
Total homework time[1]	Highest in Italy, Hungary and the Slovak Republic, and in the partner countries the Russian Federation and Latvia Lowest in Korea, Finland, the Czech Republic, Japan and Sweden	Widest variation in Italy, Hungary, Greece and the partner countries the Russian Federation and Thailand Least variation in Finland, Sweden, Denmark and Luxembourg	Univariate: positive for 25 countries, negative for 4, non-significant for 10 Multivariate: positive for 29 countries, non-significant for 10	Consistent with literature on overall positive effects of homework. Wide variations in means across countries. Low-performing countries have some of the largest homework times and some of the highest-performing countries have little homework. This suggests that effect is relative rather than absolute and that homework interacts with other aspects of school work.	Large absolute homework hours in some countries may not yield large absolute effects on achievement. The exceptionally large amounts of homework combined with low achievement suggests that the measurement of total homework may need to be revised to ensure cultural and response biases are avoided. .
Mathematics homework time[1]	Highest in Poland, Italy and in the partner economies the Russian Federation, Macao-China, Thailand and Latvia Lowest in Sweden, Finland, the Czech Republic, Liechtenstein and New Zealand	Widest variation in Italy, Japan and in the partner countries Thailand, Macao-China and Hong Kong-China Least variation in Luxembourg, Liechtenstein, Finland, Sweden, Norway and Portugal	Univariate: positive for 10 countries, negative for 19, non-significant for 10 Multivariate: negative for 25 countries, non-significant for 14	These results probably reflect the non-independence of total and mathematics homework. Once total homework is controlled for there is little additional contribution made by mathematics homework. It is also possible that extra mathematics homework is assigned more often for those students that need it most, as a remedial strategy.	Since mathematics homework is included in the total, mathematics homework is desirable as part of a total homework assignment.
Tutoring[2]	Relatively few students: <10% in most countries, but 90% in Mexico, 43% in Turkey, 29 % in Greece and 26% in Portugal. Fewer students tutored in mathematics than overall, except in Mexico where the percentage remains at 90%.	Not reported because of small numbers being tutored	Univariate: negative for 34 countries, non-significant for 3 Multivariate: negative for 35 countries, non-significant for 3	The effect of tutoring on individuals could not be measured in PISA. The overall negative effect may be due to the fact that students being tutored are likely to be the lowest-achieving students and that tutoring is insufficient to change this. Results for some countries are probably a function of positive response bias.	Studies specific to tutoring are required to separate individual from overall population effects. If possible, identifying issues related to who selects to undertake tutoring and the reasons for doing this may help in disentangling the relationship between tutoring and performance.

Table 4.1
Summary of teaching and learning effects and policy implications *(continued)*

Variable	Range across countries	Variation across schools within countries	Relationship with mathematics outcome[5]	Interpretation	Implications for further research
Out-of-school classes[2]	All results and interpretations are similar to those for tutoring. There is a high correlation between these two variables, suggesting either that both phenomena are closely related, students are giving socially acceptable responses or that the two variables are viewed as having the same meaning.				
Memorisation/ rehearsal strategies	Highest use (>0.40)[3] in Mexico and in the partner countries Brazil, Thailand and Tunisia Lowest use (<-20) in Japan, Korea and Denmark	Widest variation (>0.40)[4] in Liechtenstein, Germany, Austria, Switzerland, Mexico and Indonesia Least variation (<0.25) in Luxembourg, Japan, and the partner economies Thailand, Latvia, Greece and Macao-China	Univariate: positive for 17 countries, negative for 13, non-significant for 8 Multivariate: negative for 26 countries, non-significant for 12	Taking account of other factors, use of memorisation generally shows a negative effect on achievement. This is consistent with literature indicating that memorisation is not an effective strategy for learning mathematics. The change in the direction of the relationship when accounting for other factors suggests this strategy is mostly utilised by certain groups of students who share an observable characteristic.	The use of memorisation may be discuraged, especially in countries showing extensive use of this strategy. Further research could focus on who uses this strategy and why.
Elaboration strategies	Highest use (>0.50)[3] in Mexico and in the partner countries Tunisia, Brazil, Thailand and Indonesia Lowest use (<-0.25) in Japan, Korea, Germany, the Netherlands and Austria	Widest variation (>0.45)[4] in Austria, Germany, Italy and in the partner country Liechtenstein Least variation (<0.25) in Portugal, Finland and the partner economies Latvia, Macao-China, Indonesia and Thailand	Univariate: positive for 26 countries, negative for one Multivariate: negative for 22 countries, non–significant for 13	The reversal of effects from univariate to multivariate suggests strong mediation of this effect by other variables. Here again, given that observed student characteristics contribute significantly to this change, it is possible to try to understand better who these students are.	Understanding who relies on elaboration strategies may help identify ways of making these strategies more effective. It is also possible that this analysis reveals ways of measuring and approaching metacognitive strategies in a a more policy relevant manner.

Table 4.1
Summary of teaching and learning effects and policy implications *(continued)*

Variable	Range across countries	Variation across schools within countries	Relationship with mathematics outcome[5]	Interpretation	Implications for further research
Control strategies	Highest use (>0.40)[3] in Austria, Mexico and in the partner countries Tunisia, Brazil and Serbia Lowest use (<-0.40) in Japan, Finland, Korea and Sweden	Widest variation (>0.40)[4] in Korea, Belgium, Canada, Germany, Mexico and Turkey Least variation (<0.25) in Latvia, Finland, Hungary, Luxembourg and Thailand	Univariate: positive for 21 countries, negative for 9, non-significant for 8 Multivariate: non-significant for 21 countries, positive for 8 and negative for 9	Substantial decrease in effect sizes in the multivariate analysis suggests mediation by other variables. All three student learning strategies are highly correlated, indicating that they may have more of a unitary effect than theoretically indicated or that a response bias may exist.	Measuring metacognitive strategies has proven to be quite a challenging task for a project like PISA. A cross sectional international perspective add value as a description of practices most commonly used but it is more limited in identifying the effectiveness of these strategies for enhancing student performance.
Preference for competitive learning	Highest use (>0.40)[3] in Mexico, Turkey, the United States and in the partner countries Tunisia and Indonesia Lowest use (< -0.35) in Hungary, the Netherlands, Japan and Switzerland	Widest variation (>0.50)[4] in Austria, Korea, Liechtenstein and Italy Least variation (<0.25) in the partner ecomomies Macao-China, Greece and Latvia	Univariate: positive for 29 countries, non-significant for all others. Multivariate: mostly non-significant	Suppressive effects are evident in the shift from mostly positive univariate to multivariate non-significance. Self-efficacy in mathematics appears to be the main suppressor variable.	The evidence is quite mixed and more research is required to determine the interaction between competitive preference, self-efficacy and achievement.
Preference for co-operative learning	Highest use (>0.30)[3] in the partner countries Brazil, Tunisia and Uruguay Lowest use (<-0.20) in Korea, Japan, Iceland and Sweden	Widest variation (>0.40)[4] in Austria, Mexico, Korea, the United States and the partner country Serbia Least variation (<0.25) in Hungary, Australia, Finland, Greece, Liechtenstein and in the partner country Thailand	Univariate: positive for 9 countries, negative for 16, non-significant for 13 Multivariate: mostly non-significant; positive for 4 countries and negative for 7	Mixed univariate results suggest that effect may be related to characteristics of school systems in different countries. Other factors appear to mediate the relationship of this variable on performance.	Results do not suggest that encouraging a co-operative learning environment will positively influence achievement. The definition of co-operative learning in PISA differs from that used in much of the literature on forming co-operative groups in the classroom. Improvements in the analysis and the measurement of these concepts are needed to produce further solid policy advice.

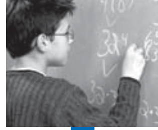
Table 4.1
Summary of teaching and learning effects and policy implications *(continued)*

Variable	Range across countries	Variation across schools within countries	Relationship with mathematics outcome[5]	Interpretation	Implications for further research
Disciplinary climate	Highest (>0.30)[3] in Japan, Germany and in the partner countries Latvia and the Russian Federation Lowest (<-0.20) in Norway, Greece, Luxembourg and the partner country Brazil	Widest variation (>0.60)[4] in Japan, Liechtenstein, Austria, the Czech Republic and Hungary Least variation (<0.40) in Luxembourg, New Zealand and the partner countries Indonesia, Brazil and Thailand	Univariate: positive for all but two countries Multivariate: positive for all but six countries. Effect sizes are widely variable.	Disciplinary climate is defined mainly in terms of absence of disruptions and lost time. This variable shows one of the most consistently positive effects across countries. While the univariate effects are attenuated somewhat in the presence of other variables, they remain positive throughout.	Improving the disciplinary climate is within the control of schools and teachers and policies should be directed towards reducing disruption and lost time in classrooms. Case studies may provide insights as to what policies and practices are most likely to improve disciplinary climate within specific contexts.
School average disciplinary climate	Highest (>0.30)[3] in Japan, Germany and the partner countries the Russian Federation and Latvia Lowest (<-0.20) in Greece, Norway, Luxembourg and the partner country Brazil	Variation across schools is not meaningful for data that are based on school averages within countries.	Univariate: universally positive and generally much larger than for the individual-level variable Multivariate: attenuated but remain positive for all but five countries	School average disciplinary climate is obviously a composite of the individually reported values. Nevertheless, it exerts a strong positive effect in addition to the individual effects.	The existence of an independent school-level effect indicates that policies to improve disciplinary climate can be implemented at the school level as well as directed towards individual students.

Table 4.1
Summary of teaching and learning effects and policy implications *(continued)*

Variable	Range across countries	Variation across schools within countries	Relationship with mathematics outcome[5]	Interpretation	Implications for further research
Student-teacher relations	Highest (>0.50)[3] in Indonesia, Brazil, Thailand and Mexico Lowest (<-0.25) in Japan, Luxembourg, Italy, Poland and the Slovak Republic	Widest variation (>0.50)[4] in Austria, Switzerland and in the partner countries Tunisia, Liechtenstein, Serbia and Brazil Least variation (<0.35) in New Zealand, Portugal and in the partner country Thailand	Univariate: positive for 13 countries, negative for 12 and non-significant for 16 Multivariate: positive for 8 countries, negative for 14 and non-significant for 18	This variable is represented by items such as teachers getting along with students, showing interest in them and treating them fairly. These behaviours seem to have little effect on mathematics achievement.	Student-teacher relations refer to complex processes that are hard to capture in a consistent manner through an international survey such as PISA. Problems of cultural and response bias need to be taken into account when building instruments to measure these constructs.
Teacher support	Highest (>0.40)[3] in Mexico, Turkey and the partner countries Thailand and Brazil Lowest (<-0.25) in Austria, Japan, Luxembourg, Germany and the Netherlands	Widest variation (>0.50)[4] in Austria, Italy, the Slovak Republic and Serbia Least variation (<0.20) in Korea and the Netherlands	Univariate: positive for 13 countries, negative for 7 and non-significant for 17 Multivariate: negative for 26 countries, positive for only one. Mostly small effects.	This variable is similar to teacher-student relations, with a little more emphasis on teachers helping their students, and shows similar effects. A possible interpretation for the negative effects in the multivariate is those teachers focus their support on those students who need it most.	Given the cross-sectional nature of PISA, these measures are most useful as descriptions of the perceptions of students with respect to their teachers. The caveats mentioned above also apply here.

Notes: 1. Unit: hours per week
2. Unit: percentage of students reporting non-zero time per week
3. Unit: standard deviations from the mean
4. Unit: interquartile range (25th-75th percentile)
5. Unit: number of points change in mathematics score for one standard deviation change in teaching/learning strategy variable



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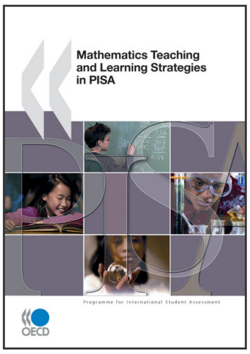

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