4

Mathematics Self-Beliefs and Participation in Mathematics-Related Activities

This chapter examines several ways in which students' beliefs in their own mathematics skills manifest themselves: self-efficacy (the extent to which students believe in their own ability to solve specific mathematics tasks), self-concept (students' beliefs in their own mathematics abilities), anxiety (feelings of helplessness and stress when dealing with mathematics), students' engagement in mathematics activities at and outside school, and students' intentions to pursue mathematics-related studies or careers in the future. These are analysed in relation to mathematics performance, gender and socio-economic status. Trends in students' mathematics self-beliefs since 2003 are also examined.

How students think and feel about themselves shapes their behaviour, especially when facing challenging circumstances (Bandura, 1977). Education systems are successful when they equip students with the ability to influence their own lives (Bandura, 2002). Mathematics self-beliefs have an impact on learning and performance on several levels: cognitive, motivational, affective and decision-making. They determine how well students motivate themselves and persevere in the face of difficulties, they influence students' emotional life, and they affect the choices students make about coursework, additional classes, and even educational and career paths (Bandura, 1997; Wigfield and Eccles, 2000).

In 2012 PISA investigated a range of self-beliefs: mathematics self-efficacy (the extent to which students believe in their own ability to handle mathematical tasks effectively and overcome difficulties), mathematics self-concept (students' beliefs in their own mathematics abilities), mathematics anxiety (thoughts and feelings about the self in relation to mathematics, such as feelings of helplessness and stress when dealing with mathematics), and student engagement in mathematics activities at and outside school. Results confirm previous evidence that different mathematics self-beliefs are related, but are conceptually distinct (see Pajares and Kranzler, 1995; Pajares and Miller, 1994; Lent, Lopez and Bieschke, 1991; Lee, 2009).

What the data tell us

- Some 30% of students reported that they feel helpless when doing mathematics problems: 25% of boys, 35% of girls, 35% of disadvantaged students, and 24% of advantaged students reported feeling that way.
- On average across OECD countries, greater mathematics anxiety is associated with a 34-point lower score in mathematics – the equivalent of almost one year of school.
- Countries in which mathematics anxiety decreased or did not change are more likely to be those where students' mathematics self-concept or self-efficacy improved.

▪ Figure III.4.1 ▪

Mathematics self-beliefs, dispositions and participation in mathematics-related activities

Mathematics self-efficacy
Constructed index based on students' responses about their perceived ability to solve a range of pure and applied mathematics problems

Mathematics self-concept
Constructed index based on students' responses about their perceived competence in mathematics

Mathematics anxiety
Constructed index based on students' responses about feelings of stress and helplessness when dealing with mathematics

Dispositions towards mathematics (Mathematics intentions and Subjective norms in mathematics)
Constructed indices based on students' responses about whether they intend to use mathematics in their future and whether students' parents and peers enjoy and value mathematics

Mathematics behaviours
Constructed indices based on students' responses about their participation in a range of mathematics-related activities

Mathematics self-beliefs illustrate students' subjective convictions. While they are built into how well students perform in mathematics over the course of their lives, once established, they play a determining and independent role in individuals' continued growth and in the development of their mathematical skills and competencies (Bandura, 1997; Markus and Nurius, 1986). While they are partly the product of a students' past performance in mathematics, mathematics self-beliefs influence how students function when confronted with mathematical problems. In addition, they have an independent effect on life choices and decisions. Students who perform similarly in mathematics usually choose different courses, educational pathways and ultimately different careers, in part depending on how they perceive themselves as mathematics learners (Bong and Skaalvik, 2003; Wang, Eccles and Kenny, 2013).

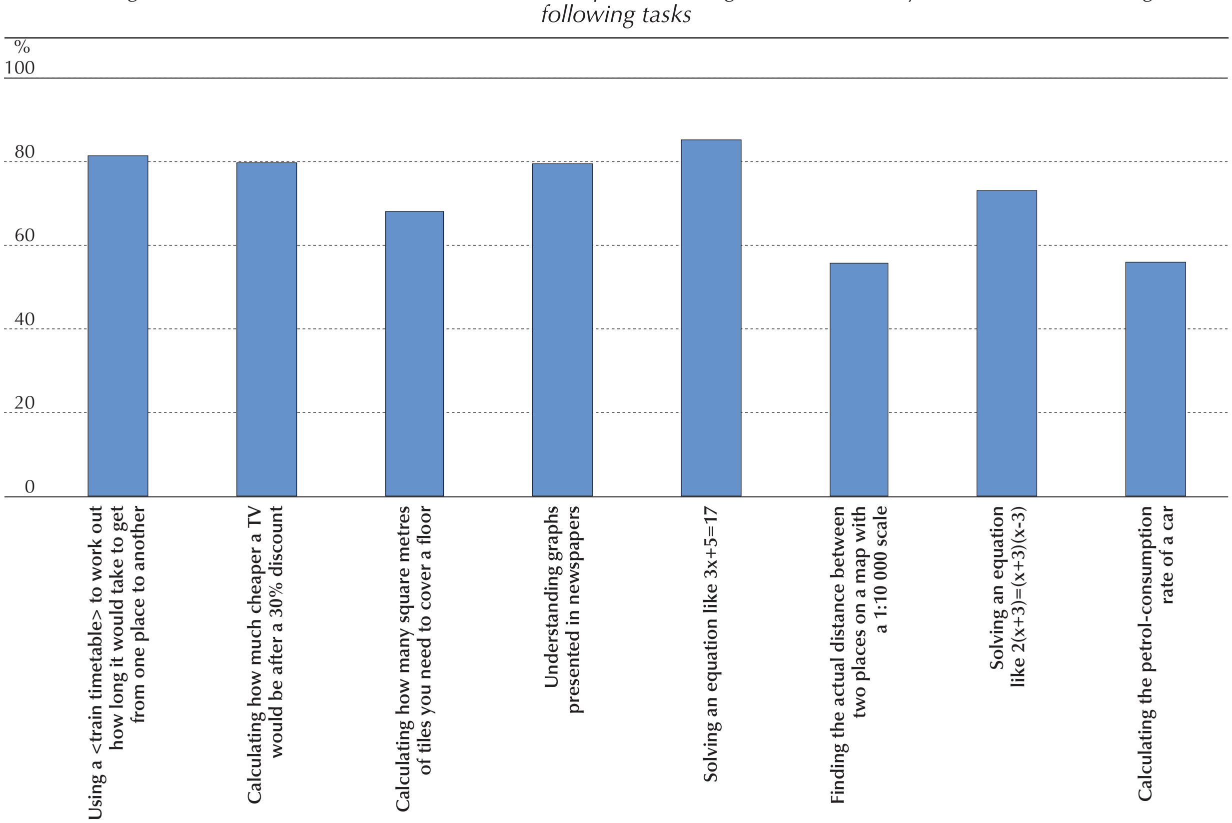
MATHEMATICS SELF-EFFICACY

The term "self-efficacy" is used to describe students' belief that, through their actions, they can produce desired effects, which, in turn, is a powerful incentive to act or to persevere in the face of difficulties (Bandura, 1977). Mathematics self-efficacy refers to students' convictions that they can successfully perform given academic tasks at designated levels (Schunk, 1991). While better performance in mathematics leads to higher levels of self-efficacy, students who have low levels of mathematics self-efficacy are at a high risk of underperforming in mathematics, despite their abilities (Bandura, 1997; Schunk and Pajares, 2009). If students do not believe in their ability to accomplish particular tasks, they will not exert the effort needed to complete the tasks successfully, and a lack of self-efficacy becomes a self-fulfilling prophecy. While other factors apart from self-efficacy can guide and motivate students, when students do not believe in their ability to succeed in a given task, they need to have much higher levels of self-control and motivation in order to succeed. Unfortunately, students who have low self-efficacy are less likely to regulate their achievement behaviors or be motivated to engage in learning (Klassen and Usher, 2010; Schunk and Pajares, 2009).

▪ Figure III.4.2 ▪

Students' mathematics self-efficacy

Percentage of students across OECD countries who reported feeling confident or very confident about doing the following tasks



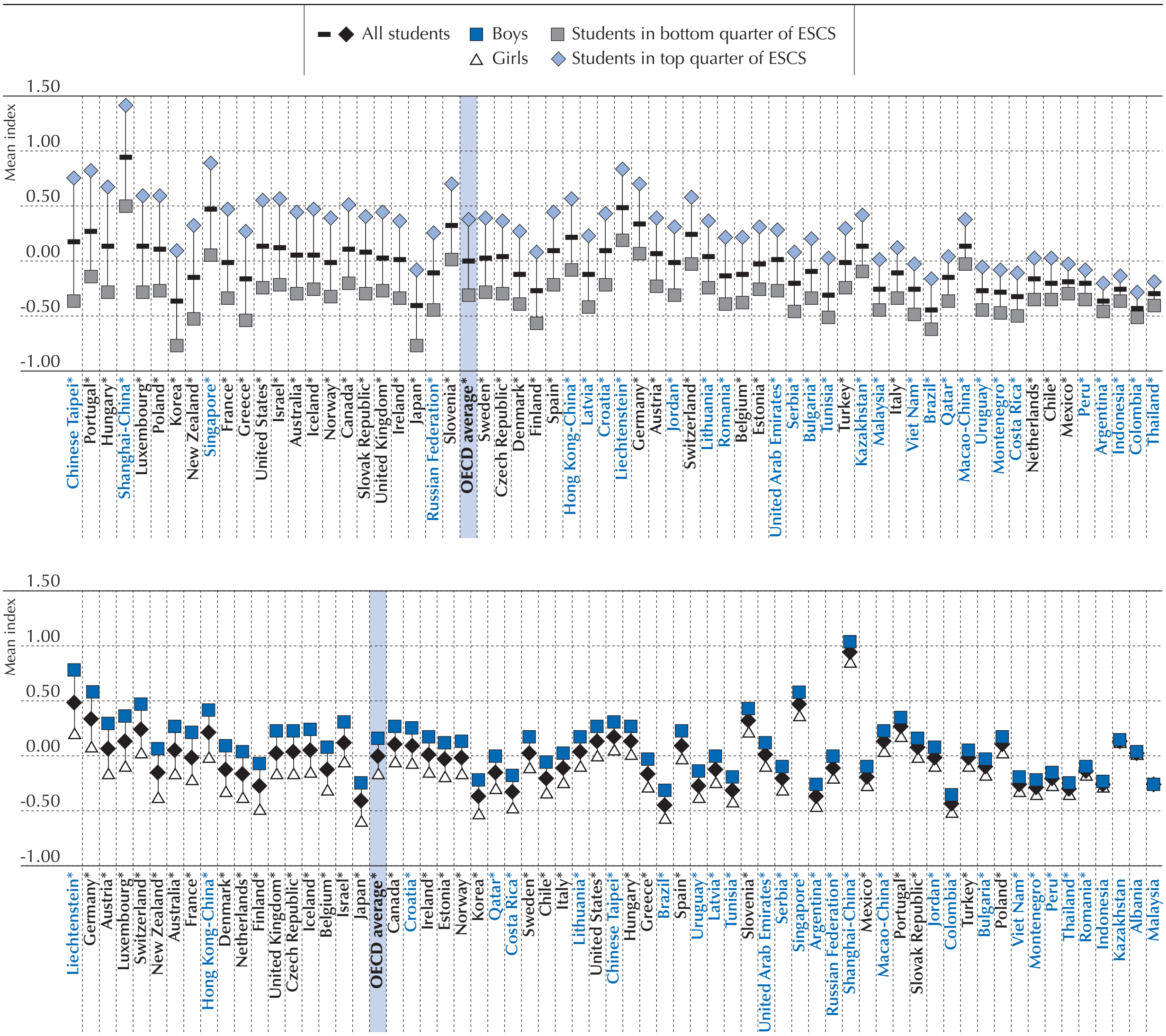
Note: Results for each participating country and economy can be found in Table III.4.1a.
Source: OECD, PISA 2012 Database, Table III.4.1a.
StatLink http://dx.doi.org/10.1787/888932963844

PISA 2012 asked students to report on whether they would feel confident doing a range of pure and applied mathematical tasks involving some algebra, such as using a train timetable to work out how long it would take to get from one place to another; calculating how much cheaper a TV would be after a 30% discount; calculating how many square meters of tiles would be needed to cover a floor; calculating the petrol-consumption rate of a car; understanding graphs presented in newspapers; finding the actual distance between two places on a map with a 1:10 000 scale; and solving equations like 3x+5=17 and 2(x+3)=(x+3)(x-3). Students' responses to questions about whether they feel very confident, confident, not very confident or not at all confident were used to create *the index of mathematics self-efficacy*, which identifies students' level of self-efficacy in mathematics. The index was standardised to have a mean of 0 and a standard deviation of 1 across OECD countries (see Box III.2.1 for a detailed description of how PISA indices were constructed and how they should be interpreted).

Tables III.4.7a and III.4.7b show that girls and socio-economically disadvantaged students are more likely to have low levels of self-efficacy than boys and socio-economically advantaged students. A detailed analysis of gender and socio-economic differences in students' responses to questions about their level of confidence in tackling a number of

▪ Figure III.4.3 ▪

Gender and socio-economic differences in mathematics self-efficacy



Notes: Countries/economies where the gender/socio-economic gap is significant are indicated with an asterisk.
ESCS refers to the *PISA index of economic, social and cultural status*.
Countries and economies are ranked in descending order of gender differences (bottom panel) and socio-economic differences (top panel) on the index of mathematics self-efficacy.
Source: OECD, PISA 2012 Database, Tables III.4.1c and III.4.1d.
StatLink http://dx.doi.org/10.1787/888932963844

mathematical tasks reveal that across OECD countries 75% of girls feel confident or very confident about calculating how much cheaper a TV would be after a 30% discount, compared to 84% of boys. No gender differences in confidence are observed when students are asked about doing tasks that are more abstract and clearly match classroom content, such as solving a linear or a quadratic equation. However, gender differences are striking when students are asked to report their ability to solve applied mathematical tasks, particularly when the mathematics problem is presented in terms of tasks that are associated with stereotypical gender roles (such as calculating the petrol-consumption rate of a car). On average across OECD countries, 67% of boys but only 44% of girls reported feeling confident about performing such a calculation (Table III.4.1b).

While gender differences in mathematics self-efficacy and related beliefs about competence have long been a subject of study (Eccles, 1984; Jacobs et al., 2002; Pajares and Miller, 1994), differences in self-efficacy related to socio-economic status are just as pervasive (Figure III.4.3). Disadvantaged students are generally less likely to feel confident about their ability to tackle specific mathematics tasks than advantaged students (Table III.4.7b). While these differences partly reflect differences in mathematics performance related to socio-economic status, these differences remain large and statistically significant even when comparing students who perform similarly in mathematics (see Table III.7.3b and Chapter 7 more generally for a detailed discussion of differences in self-reported self-efficacy related to gender and socio-economic status among students with similar mathematics performance).

Between 2003 and 2012, students' mathematics self-efficacy increased slightly across OECD countries as students became more likely, for example, to report feeling confident about using a train timetable to work out how long it would take to get from one place to another. However, this general trend masks the fact that students' mathematics self-efficacy decreased in New Zealand, Hungary, the Slovak Republic and Uruguay. In the Slovak Republic, Hungary and New Zealand, for example, the percentage of students who reported that they feel confident in calculating how many square metres of tiles are required to cover a floor dropped by at least eight percentage points during the period. Students' reported mathematics self-efficacy increased in 21 countries and economies. Increases in mathematics self-efficacy were notable in Portugal, Germany, Thailand, Turkey and Spain where the *index of mathematics self-efficacy* grew by more than 0.2 units. Reflecting the increase in the mathematics self-efficacy, the share of students who reported feeling confident in calculating the price of a TV that has been discounted by 30%, for example, increased by more than five percentage points in Thailand, Greece, Portugal, Turkey, Germany, the Russian Federation and Japan between 2003 and 2012 (Table III.4.1f) (Portugal's improvement in PISA and recent educational policies and programmes is outlined in Box III.4.1).

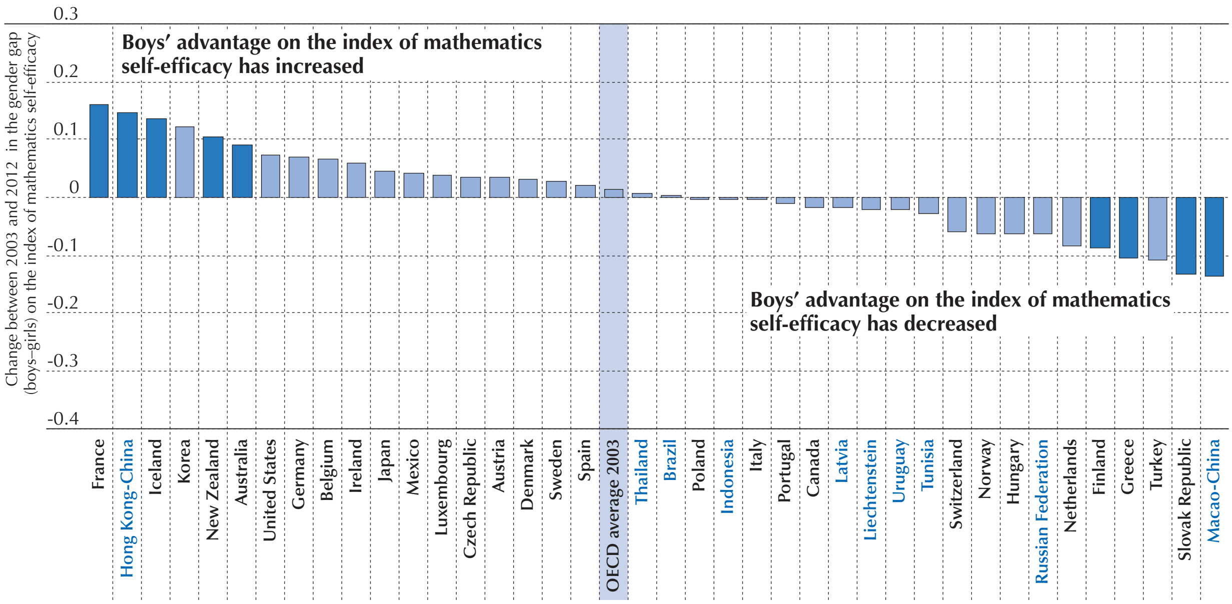
Mathematics self-efficacy tended to increase among countries that show reduced levels of mathematics anxiety (correlation at the country level of -0.4, Table III.4.10). Such is the case in Portugal and Iceland where steep drops in mathematics anxiety coincided with increases in students' mathematics self-efficacy. The relationship between students' mathematics self-efficacy and their mathematics performance was strong in 2003 and remained strong in 2012 (a correlation of 0.5), on average across OECD countries and for 23 countries and economies.

Boys' and girls' mathematics self-efficacy improved slightly between 2003 and 2012. On average across OECD countries, boys' mathematics self-efficacy improved by 0.08 units, with a similar improvement observed among girls (0.06 units), maintaining the gender gap in mathematics self-efficacy in favour of boys at over 0.3 points. Despite this average trend, the gap in mathematics self-efficacy widened in favour of boys in France, Hong Kong-China, Iceland, New Zealand and Australia. In France, Hong Kong-China, Iceland and Australia, mathematics self-efficacy increased more among boys than girls; in New Zealand, the decrease in self-efficacy was greater among girls than boys. In Iceland, for example, boys in 2012 were 5 percentage points less likely than boys in 2003 to feel confident about solving an equation like $3x+5=17$, but girls were no more likely to feel such confidence. The gender gap in mathematics self-efficacy narrowed in Macao-China, the Slovak Republic, Greece and Finland (Figure III.4.4a and Table III.4.1g).

In 2012, socio-economically disadvantaged students reported lower levels of mathematics self-efficacy when compared to their advantaged counterparts, and on average across OECD countries these differences remained similar to those in 2003. Socio-economic disparities in mathematics self-efficacy widened in Portugal and Luxembourg due to a larger increase in mathematics self-efficacy among advantaged students than among disadvantaged students, and in Latvia and Canada due to an increase in mathematics self-efficacy among advantaged students concurrent with no change among disadvantaged students. Differences in mathematics self-efficacy related to socio-economic status narrowed between 2003 and 2012 in Thailand, the Slovak Republic, Uruguay, Sweden and Belgium. In Thailand, Sweden and Belgium this was mostly due to an increase in mathematics self-efficacy among disadvantaged students (Figure III.4.4b).

■ Figure III.4.4a ■

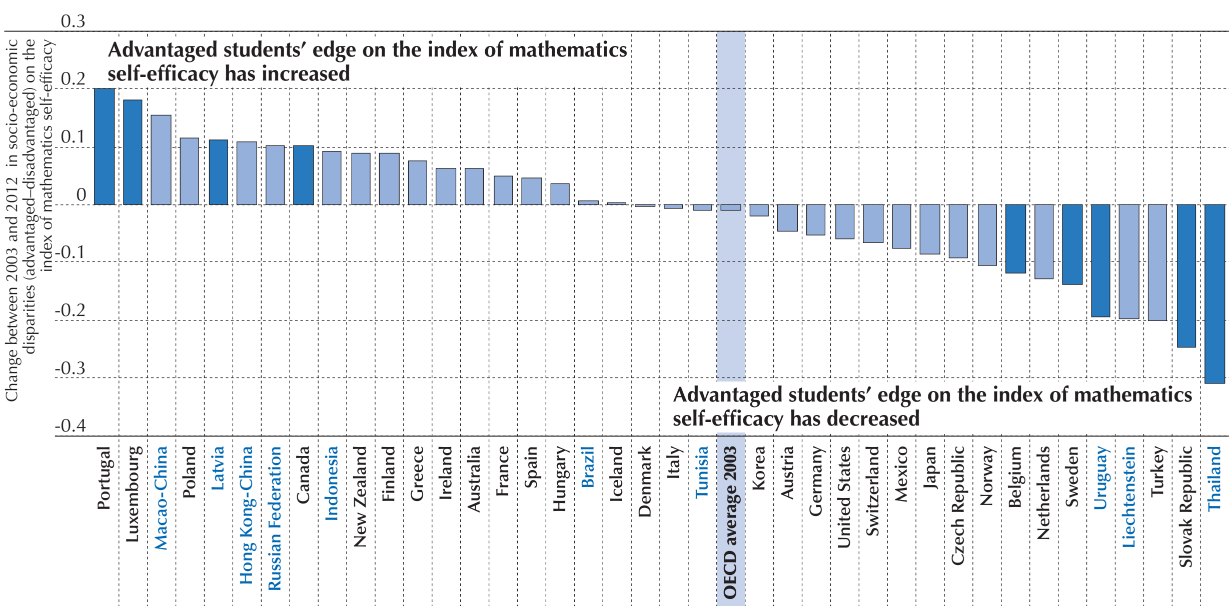
Change between 2003 and 2012 in the gender gap in mathematics self-efficacy



Notes: Statistically significant changes at the 5% level ($p < 0.05$) between PISA 2003 and 2012 are marked in a darker tone.
Only countries and economies with comparable data from PISA 2003 and PISA 2012 are shown.
OECD average 2003 compares only OECD countries with comparable indices of mathematics self-efficacy since 2003.
Countries and economies are ranked in descending order of the change in the gender gap on the index of mathematics self-efficacy *between PISA 2003 and PISA 2012.*
Source: OECD, PISA 2012 Database, Table III.4.1g.
StatLink http://dx.doi.org/10.1787/888932963844

■ Figure III.4.4b ■

Change between 2003 and 2012 in socio-economic disparities in mathematics self-efficacy

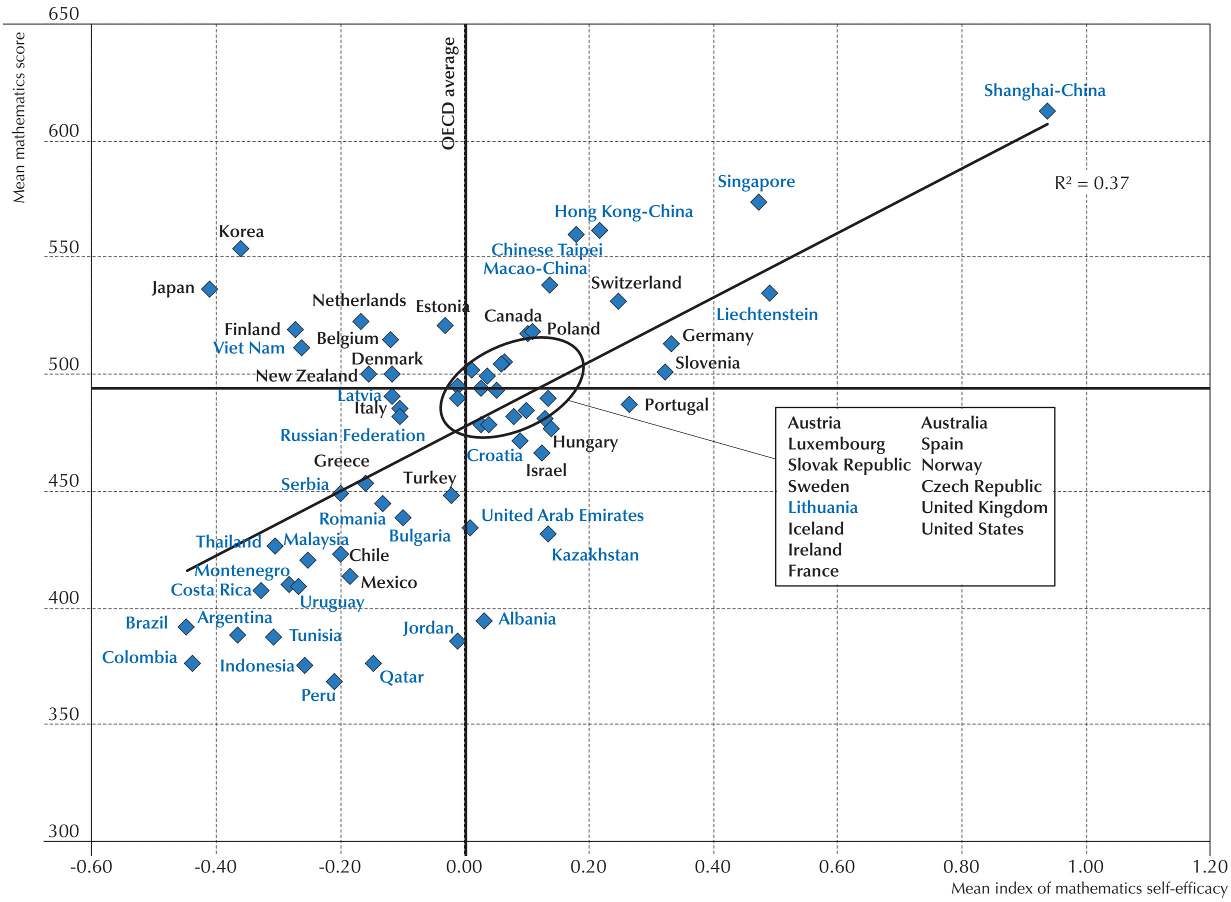


Notes: Statistically significant changes at the 5% level ($p < 0.05$) between PISA 2003 and 2012 are marked in a darker tone.
Advantaged/disadvantaged students are students in the top/bottom quarter of the *PISA index of economic, social and cultural status*.
Only countries and economies with comparable data from PISA 2003 and PISA 2012 are shown.
OECD average 2003 compares only OECD countries with comparable indices of mathematics self-efficacy since 2003.
Countries and economies are ranked in descending order of the change in socio-economic disparities on the index of mathematics self-efficacy *between PISA 2003 and PISA 2012.*
Source: OECD, PISA 2012 Database, Table III.4.1g.
StatLink http://dx.doi.org/10.1787/888932963844

At the country level, mathematics self-efficacy is strongly associated with mathematics performance. Figure III.4.5 shows that countries with higher mean performance in mathematics are those where students are more likely to report feeling confident about being able to solve a range of pure and applied mathematics problems. When comparing PISA 2003 and PISA 2012 results, Indonesia and Thailand are the only countries where the correlation between students' mathematics self-efficacy and their mathematics performance was weak (at 0.10 and 0.17 in 2003 and 2012 for Indonesia, and 0.24 in 2012 for Thailand); in the remaining countries and economies the correlation between mathematics performance and self-efficacy was moderate (at least 0.3) or strong (at least 0.5). Between 2003 and 2012 this relationship remained relatively stable (Table III.4.9).

▪ Figure III.4.5 ▪

Country-level association between mathematics performance and mathematics self-efficacy



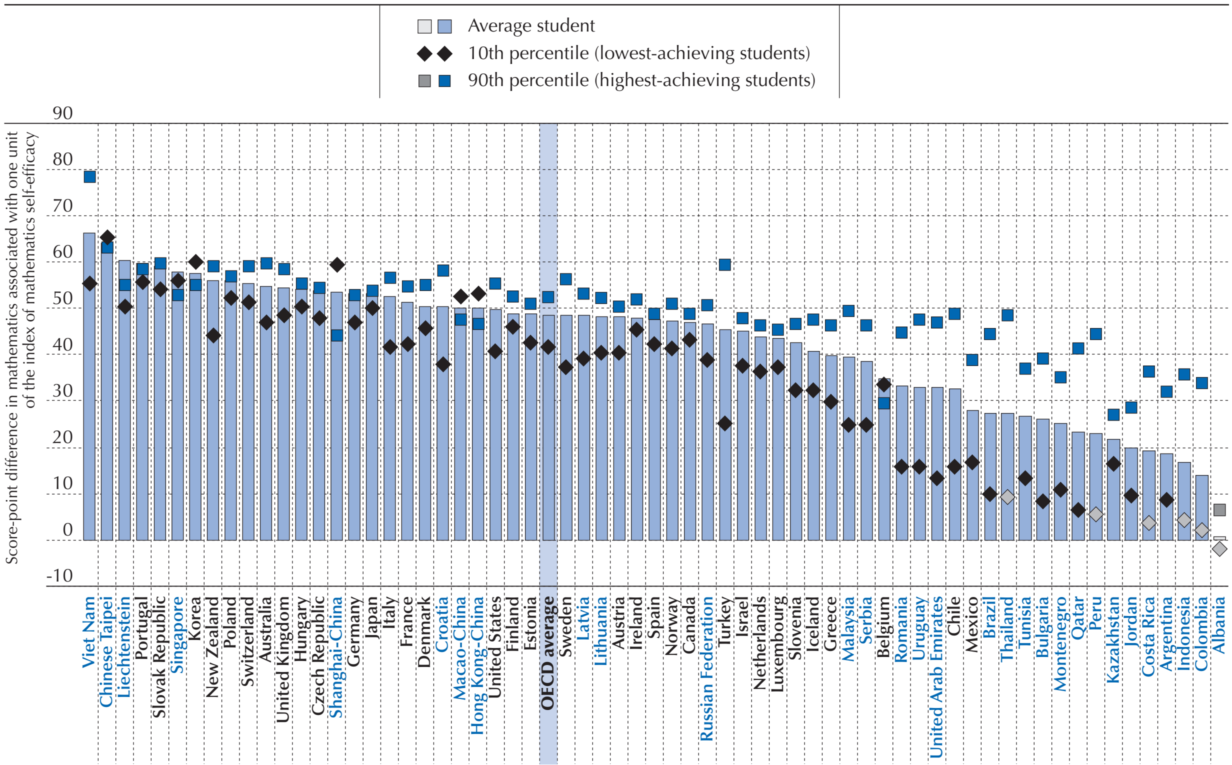
Source: OECD, PISA 2012 Database, Tables I.2.3a and III.4.1d.
StatLink http://dx.doi.org/10.1787/888932963844

As Figure III.4.6 shows, students who have low levels of mathematics self-efficacy perform worse in mathematics than students who are confident about their ability to handle mathematical tasks (Tables III.4.1d and III.4.1e). The blue bars in the Figure III.4.6 illustrates the estimated score-point difference in mathematics performance that is associated with a difference of one unit in *the index of mathematics self-efficacy*. On average across OECD countries, mathematics self-efficacy is associated with a difference of 49 score points – the equivalent of an additional year of school. The last section of the chapter considers the possible role of composition effects (differences in socio-economic status and gender) and how they explain only a small part of the relationship between mathematics performance and mathematics self-efficacy, other self-beliefs, and participation in mathematics activities. In 23 countries and economies, the difference in mathematics performance that is associated with students' self-efficacy is 50 points or more; in Viet Nam, Chinese Taipei and Liechtenstein the difference is at least 60 score points. Albania is the only country where mathematics self-efficacy is not associated with performance; in Colombia, Indonesia, Argentina and Costa Rica the difference is less than 20 score points. Across OECD countries, 28% of the variation in students' mathematics performance can be explained

by differences in how confident students feel about their ability to handle a range of applied and pure mathematics tasks, such as calculating the petrol-consumption rate of a car or solving an algebraic equation. In 21 countries and economies mathematics self-efficacy explains more than 30% of the variation in mathematics performance; in Chinese Taipei, Portugal and Poland it explains more than 40% of the variation in performance. Albania, Colombia, Indonesia, Peru and Argentina are the only countries where knowing students' level of mathematics self-efficacy conveys little information about their likelihood of performing at a certain proficiency level in PISA. In these countries, less than 5% of the variation in student performance in mathematics is associated with students' efficacy (Table III.4.1d and III.4.1e).

▪ Figure III.4.6 ▪

Relationship between mathematics self-efficacy and mathematics performance



Note: Differences that are statistically significant at the 5% level ($p < 0.05$) are marked in a darker tone.
Countries and economies are ranked in descending order of the average score-point difference in mathematics *associated with a one unit difference in the* index of mathematics self-efficiency.
Source: OECD, PISA 2012 Database, Table III.4.1e.
StatLink http://dx.doi.org/10.1787/888932963844

While the blue bars in Figure III.4.6 denotes the association between mathematics self-efficacy and mathematics performance at the mean, the black diamond and the blue square symbolise the relationship between mathematics self-efficacy and mathematics performance among the highest and lowest-achieving students. Across OECD countries, mathematics self-efficacy is positively associated with performance in mathematics; but while the association is 49 points at the mean, it varies substantially among the highest- and lowest-performing students. Greater self-efficacy is less closely related to the performance of the lowest-achieving students than to that of the highest-achieving students. A change of one unit on the index is associated with a 42 score-point difference in the performance of students in the bottom 10% of the performance distribution while it is associated with a 52 score-point difference in the performance of students in the top 10% of the performance distribution.

In 38 countries and economies the performance difference among the highest- and lowest-achieving students is ten score points or more, and in Thailand and Peru it is around 39 points. In Thailand, for example, mathematics self-efficacy is associated with a difference of 49 points in mathematics performance among students at the 90th percentile in performance, but no difference among students at the 10th percentile. Similarly, in Peru the score-point difference at

the 90th percentile is 44 points while there is no association at the 10th percentile. Shanghai-China, Hong Kong-China, Korea, Macao-China, Belgium, Chinese Taipei and Singapore are notable exceptions: in these countries the association between self-efficacy and performance is stronger at the bottom at the performance distribution than it is at the top. In Shanghai-China, for example, the score-point difference is 59 points at the 10th percentile and 44 points at the 90th percentile (Table III.4.1e).

MATHEMATICS SELF-CONCEPT

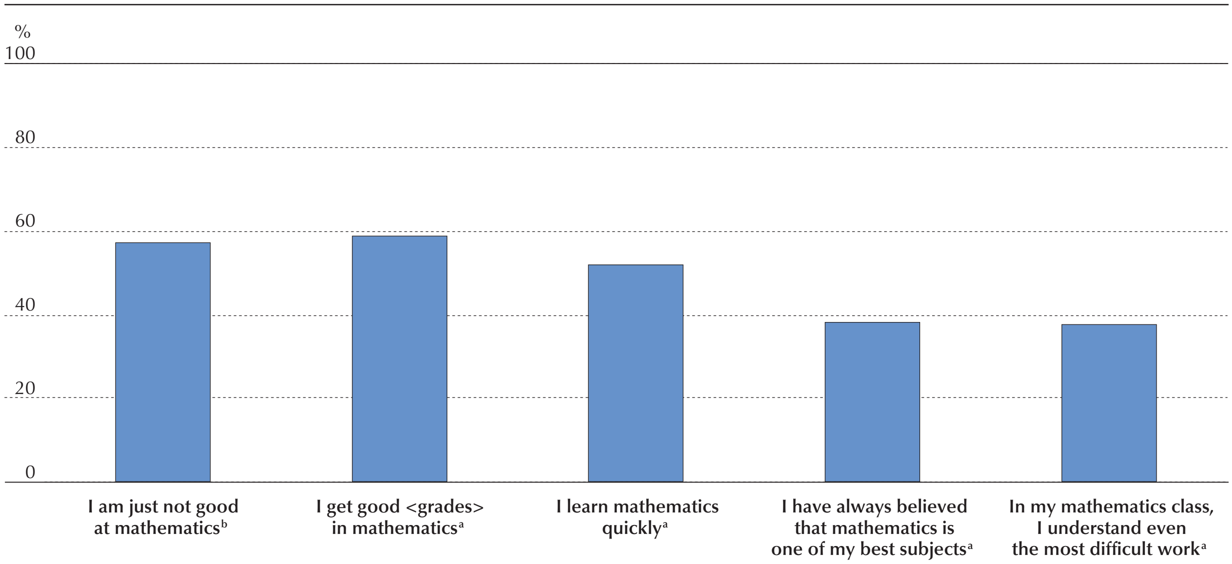
Students' mathematics self-concept, or belief in their own abilities, is an important outcome of education and strongly related to successful learning (Marsh, 1986; Marsh and O'Mara, 2008). Longitudinal studies of self-concept and achievement show that they are reciprocally related over time (Marsh, Xu and Martin, 2012; Marsh and Martin, 2011). Self-concept can also affect well-being and personality development. PISA 2012 measured students' mathematics self-concept by using students' responses as to whether they strongly agreed, agreed, disagreed or strongly disagreed that they are just not good in mathematics; that they get good grades in mathematics; that they learn mathematics quickly; that they have always believed that mathematics is one of their best subjects; and that they understand even the most difficult concepts in mathematics class. Student responses were used to create *the index of mathematics self-concept*, which was standardised to have a mean of 0 and a standard deviation of 1 across OECD countries (see Box III.2.1 for a detailed description of how PISA indices were constructed and how they should be interpreted).

On average across OECD countries, 43% of students reported that they agree or strongly agree that they are not good at mathematics; 59% reported that they get good grades in mathematics; 37% reported that they understand even the most difficult work; 52% reported that they learn mathematics quickly; and 38% reported to have always believed that mathematics is one of their best subjects (Figure III.4.7 and Table III.4.2a). These responses vary markedly among countries: while in Jordan, the United Arab Emirates, Qatar, Kazakhstan, Singapore, the United States and Costa Rica at least 60% of students reported learning mathematics quickly, in Chinese Taipei, Korea, Viet Nam and Japan fewer than 40% of students agreed with the same statement. Gender disparities in students' mathematics self-concept closely mirror gender disparities in mathematics self-efficacy: 63% of boys, but only 52% of girls, reported that they disagree that they are just not good at mathematics. Conversely, across OECD countries, 30% of girls, but 45% of boys, reported that they understand even the most difficult work in mathematics classes (Table III.4.2b). Gender differences in mathematics self-concept are particularly wide in Switzerland, Denmark, Germany, Macao-China, Liechtenstein and Luxembourg, while no gender differences can be observed in Malaysia, Albania and Kazakhstan (Table III.4.2d).

▪ Figure III.4.7 ▪

Students' mathematics self-concept

Percentage of students across OECD countries who reported that they "agree" or "strongly agree" (a) or who reported "disagree" or "strongly disagree" (b) with the following statements:

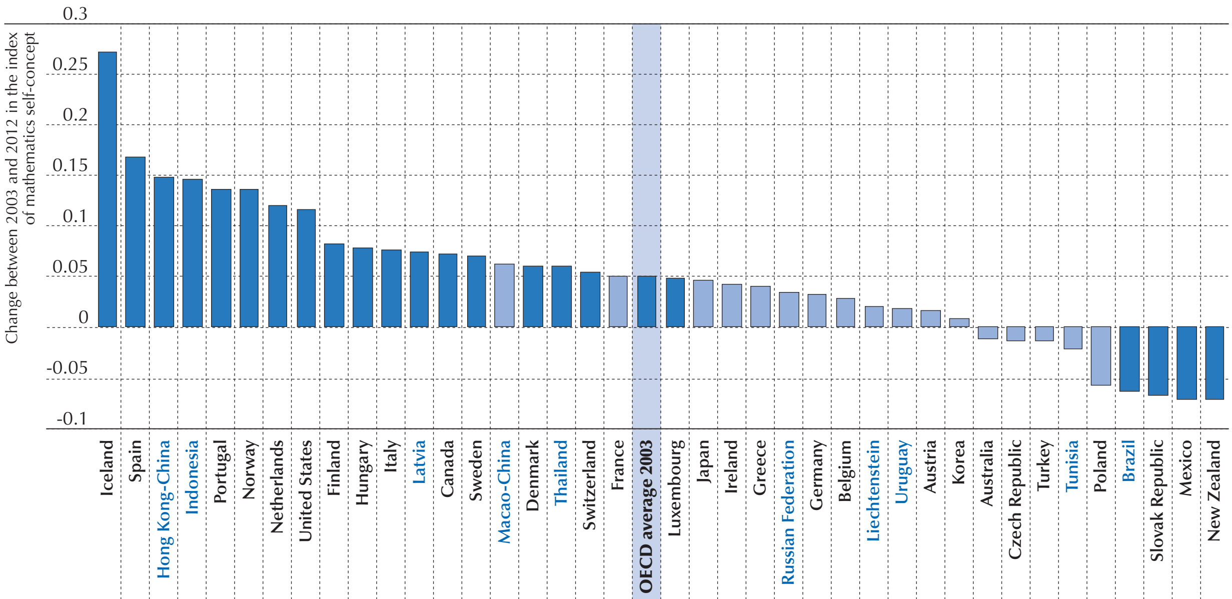


Note: Results for each participating country and economy can be found in Table III.4.2a.
Source: OECD, PISA 2012 Database, Table III.4.2a.
StatLink http://dx.doi.org/10.1787/888932963844

A comparison of the responses of students who participated in PISA 2003 and those who participated in PISA 2012 reveals that, on average across OECD countries, mathematics self-concept improved slightly during the period. Students in 2012 were four percentage points more likely to report that they understand even the most difficult work in mathematics compared to students in 2003, and three percentage points more likely to believe that mathematics is one of their best subjects. Significant improvements in mathematics self-concept were observed in 18 countries and economies, with the *index of mathematics self-concept* improving by more than 0.1 units in Iceland, Spain, Hong Kong-China, Indonesia, Portugal, Norway, the Netherlands and the United States. The improvement was greatest in Spain and Iceland (Figure III.4.8). In Spain, for example, students in 2012 were 10 percentage points more likely than their peers in 2003 to report they understand even the most difficult work, and 7 percentage points more likely to report that they learn mathematics quickly or that mathematics is one of their best subjects. In Iceland, students in 2012 were 14 percentage points more likely than their peers in 2003 to report that they get good grades in mathematics, and 10 percentage points less likely to report that they are just not good at mathematics (Table III.4.2f).

■ Figure III.4.8 ■

Change between 2003 and 2012 in students' mathematics self-concept



Notes: Statistically significant changes at the 5% level ($p < 0.05$) between PISA 2003 and PISA 2012 are marked in a darker tone.
Only countries and economies with comparable data from PISA 2003 and PISA 2012 are shown.
OECD average 2003 compares only OECD countries with comparable indices of mathematics self-concept since 2003.
Countries and economies are ranked in descending order of the change in the index of mathematics self-concept *between PISA 2003 and PISA 2012.*
Source: OECD, PISA 2012 Database, Table III.4.2f.
StatLink http://dx.doi.org/10.1787/888932963844

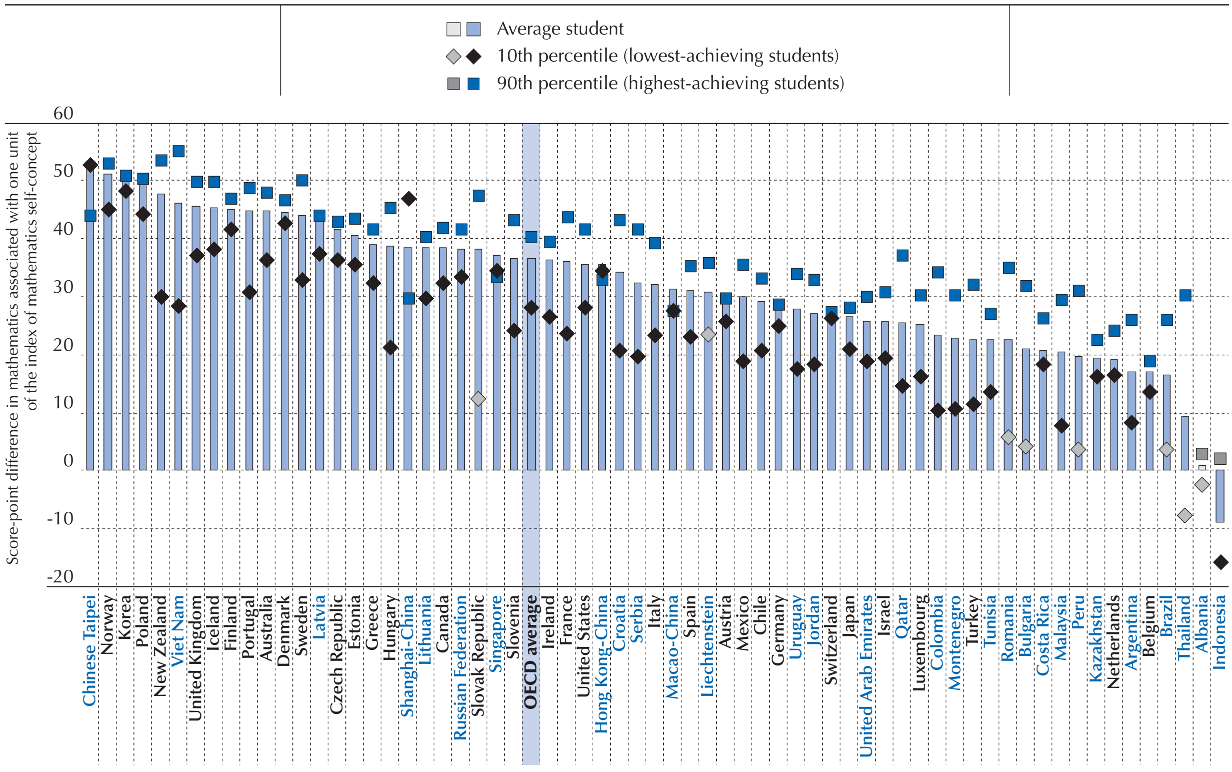
Mathematics self-concept tends to improve among those countries that saw improvements in students' intrinsic motivation to learn mathematics and in which reductions in students' anxiety towards mathematics were observed (a discussion of mathematics anxiety can be found in the following section) (Table III.4.10). Most notably, Iceland saw one of the greatest improvements in students' self-concept and intrinsic motivation to learn mathematics, and one of the largest reductions in anxiety towards mathematics among countries and economies that participated in both PISA 2003 and PISA 2012.

The magnitude of differences in mathematics self-concept related to gender and socio-economic status remained stable between 2003 and 2012, on average across OECD countries. Gender gaps in mathematics self-concept widened in favour of boys in eight countries and economies, especially in Uruguay, Mexico and Hong Kong-China, while there was little overall change in differences in mathematics self-concept related to socio-economic status during the period. The differences in favour of socio-economically advantaged students shrank most notably in Finland, Thailand and Norway, where disadvantaged students' mathematics self-concepts improved and that of advantaged students remained constant or declined between 2003 and 2012 (Table III.4.2g).

The relationship between mathematics self-concept and mathematics performance closely mirrors the relationship between mathematics self-efficacy and mathematics performance: as Figure III.4.9 shows, students who have low levels of mathematics self-concept perform worse in mathematics than students who are more confident in their own abilities as mathematics learners (Tables III.4.2d and III.4.2e). In 2003 as in 2012, the relationship between students' self-concept and their mathematics performance was strong and positive, on average across OECD countries with comparable data (Table III.4.9). The blue bars in the Figure III.4.9 illustrate the estimated score-point difference in mathematics performance that is associated with a difference of one unit in *the index of mathematics self-concept* and indicate that on average across OECD countries, mathematics self-concept is associated with a difference of 37 score points – the equivalent of almost an additional year of school. While the blue bars in Figure III.4.9 denote the association between mathematics self-concept and mathematics performance at the mean, the black diamond and the blue square symbolise the relationship between mathematics self-concept and mathematics performance among the lowest- and highest-achieving students. Across OECD countries, mathematics self-concept is positively associated with performance in mathematics; but while the association is 37 points at the mean, it varies substantially among the highest- and lowest-performing students. Greater self-concept tends to make less of a difference to the performance of the lowest-achieving students than to that of the highest-achieving students. A change of one unit on the index is associated with a 28 score-point difference in the performance of students in the bottom 10% of the performance distribution while it is associated with a 40 score-point difference in the performance of students in the top 10% of the performance distribution. Chinese Taipei and Shanghai-China are notable exceptions: in these countries, the difference in mathematics performance that is associated with a difference of one unit in mathematics self-concept is greater at the bottom than at the top of the performance distribution.

■ Figure III.4.9 ■

Relationship between mathematics self-concept and mathematics performance



Note: Differences that are statistically significant at the 5% level ($p < 0.05$) are marked in a darker tone.
Countries and economies are ranked in descending order of the average score-point difference in mathematics associated with a difference of one unit in the index of mathematics self-concept.
Source: OECD, PISA 2012 Database, Table III.4.2e.
StatLink http://dx.doi.org/10.1787/888932963844

MATHEMATICS ANXIETY

While many students worry about their performance in school and are anxious when they have to take exams, large proportions of students report feeling anxious about mathematics in particular (Ashcraft and Ridley, 2005; Hembree, 1990; Wigfield and Meece, 1988). Students who have high levels of mathematics anxiety generally report feeling tense, apprehensive and fearful of mathematics (Richardson and Suinn, 1972; Ma, 1999; Zeidner and Matthews, 2011; Tobias, 1993); they tend to underperform in mathematics tasks compared to students with no or low levels of mathematics anxiety (Hembree, 1990; Ma, 1999; Tobias, 1985). While poor performance in mathematics tends to be associated with high mathematics anxiety (Ma and Kishor, 1997; Ma and Xu, 2004), evidence indicates that part of the performance gap between students with high and low levels of mathematics anxiety is directly related to the adverse effect of anxiety on cognitive resource activation (Ashcraft and Kirk, 2001). In other words, when students are very anxious in general, and are anxious about mathematics in particular, their brains cannot devote sufficient attention to solving mathematics problems because they are, instead, occupied with worrying about such tasks (Beilock, Kulp, Holt and Carr, 2004; Hopko et al., 1998; Hopko et al., 2002; Kellogg, Hopko and Ashcraft, 1999).

Mathematics anxiety is not merely a psychological phenomenon that limits the ability to solve mathematical problems; individuals who suffer from mathematics anxiety may experience a physical reaction to mathematics that can be likened to pain. As a result, individuals who experience mathematics anxiety generally avoid mathematics, mathematics courses and career paths that require the mastery of some mathematical skills (Hembree, 1990; Ashcraft and Ridley, 2005; Beasley, Long and Natali, 2001; Ho et al., 2000). For these individuals, avoiding mathematics is as natural a response as avoiding pain, since, to them, even the mere anticipation of being confronted with a mathematical problem can be painful (Lyons and Beilock, 2012).

PISA 2012 asked students to report whether they agree or strongly agree that they often worry that mathematics classes will be difficult for them; that they get very tense when they have to do mathematics homework; that they get very nervous doing mathematics problems; that they feel helpless when doing a mathematics problem; and that they worry that they will get poor grades in mathematics. Student responses about their feelings of stress associated with anticipating mathematical tasks, anticipating their mathematics performance, and while attempting to solve mathematics problems were used to identify students' specific level of anxiety towards mathematics and to construct the *index of mathematics anxiety*, standardised to have a mean of 0 and a standard deviation of 1 across OECD countries. Positive values on the index indicate that students reported higher levels of anxiety towards mathematics than the average student across OECD countries, while negative values indicate that students reported lower levels of anxiety towards mathematics than the average student across OECD countries.

A considerable proportion of 15-year-olds reported feelings of helplessness and emotional stress when dealing with mathematics. Across OECD countries 59% of students reported that they often worry that it will be difficult for them in mathematics classes; 33% reported that they get very tense when they have to do mathematics homework; 31% reported that they get very nervous doing mathematics problems; 30% feel helpless when doing a mathematics problem, and 61% worry about getting poor grades in mathematics (Figure III.4.10). In Argentina, Tunisia, Jordan, Mexico, Korea, Romania, Indonesia, Uruguay and Malaysia students are particularly likely to worry that it will be difficult for them in mathematics classes: in these countries and economies at least 75% of students reported feeling worried. Similarly, in Jordan, Thailand, Tunisia, Brazil, Qatar and Argentina at least 45% of students feel helpless when doing a mathematics problem (Table III.4.3a).

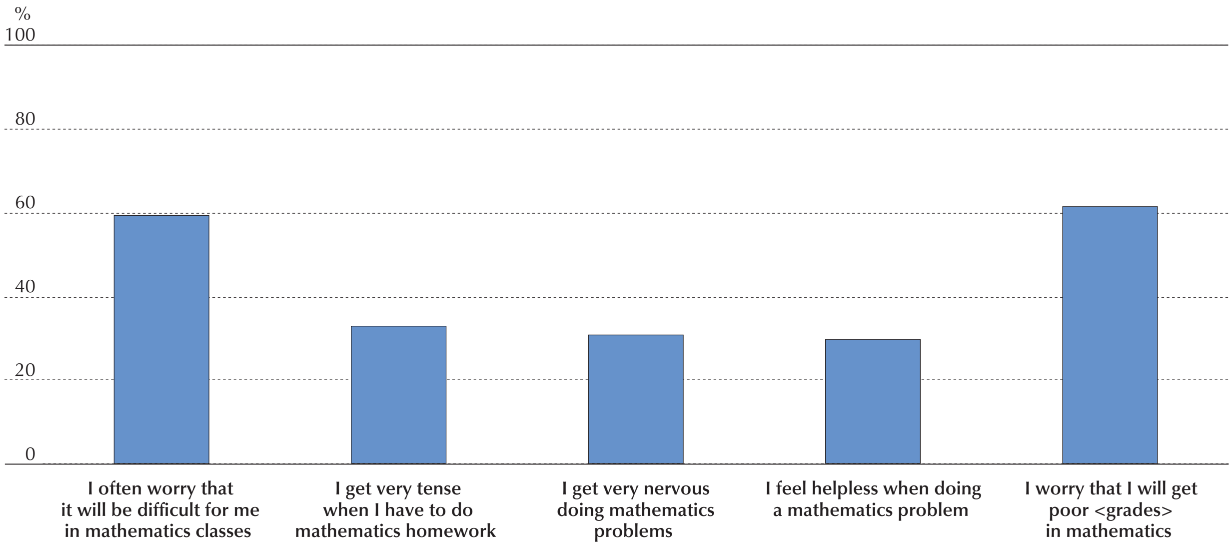
Across most countries and economies, differences in levels of mathematics anxiety related to gender are wide. In all countries and economies that participated in PISA 2012, except Albania, Turkey, Bulgaria, Indonesia, Kazakhstan, Montenegro, Malaysia, Serbia and Romania, girls reported stronger feelings of mathematics anxiety than boys; in Jordan, the United Arab Emirates and Qatar boys reported greater feelings of anxiety than girls (Table III.4.3d). Gender differences in mathematics anxiety tend to be particularly wide in Denmark, Finland and Liechtenstein: in all these countries, the gender gap in the percentage of boys and girls who worry that it will be difficult for them in mathematics classes is greater than 20 percentage points (with girls more worried than boys) (see Tables III.4.3b, III.4.3d for overall gender differences in mathematics anxiety and Table III.4.7a for a comparison of gender differences across students' self-beliefs). Overall, the gender difference in mathematics anxiety appears to be widest in those countries that have comparatively low levels of mathematics anxiety.

In parallel with the slight increase in students' mathematics self-concept over time, on average across OECD countries, mathematics anxiety also increased slightly since 2003. That year, 29% of students reported getting very tense when

▪ Figure III.4.10 ▪

Students' mathematics anxiety

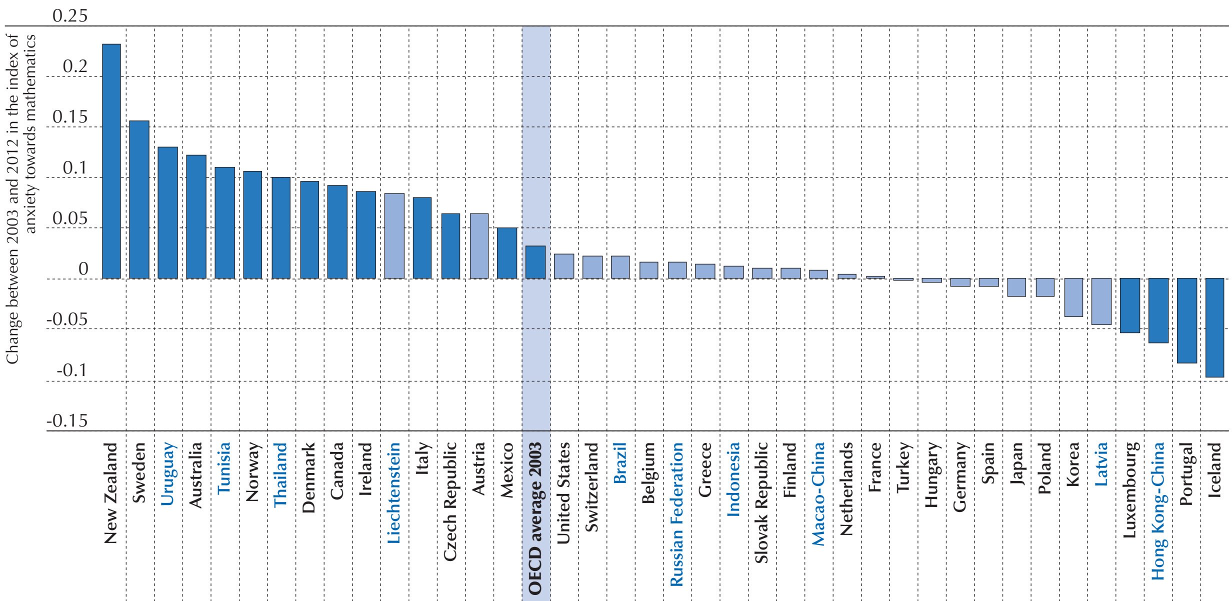
Percentage of students across OECD countries who reported that they "agree" or "strongly agree" with the following statements:



Note: Results for each participating country and economy can be found in Table III.4.3a.
Source: OECD, PISA 2012 Database, Table III.4.3a.
StatLink http://dx.doi.org/10.1787/888932963844

▪ Figure III.4.11 ▪

Change between 2003 and 2012 in students' anxiety towards mathematics



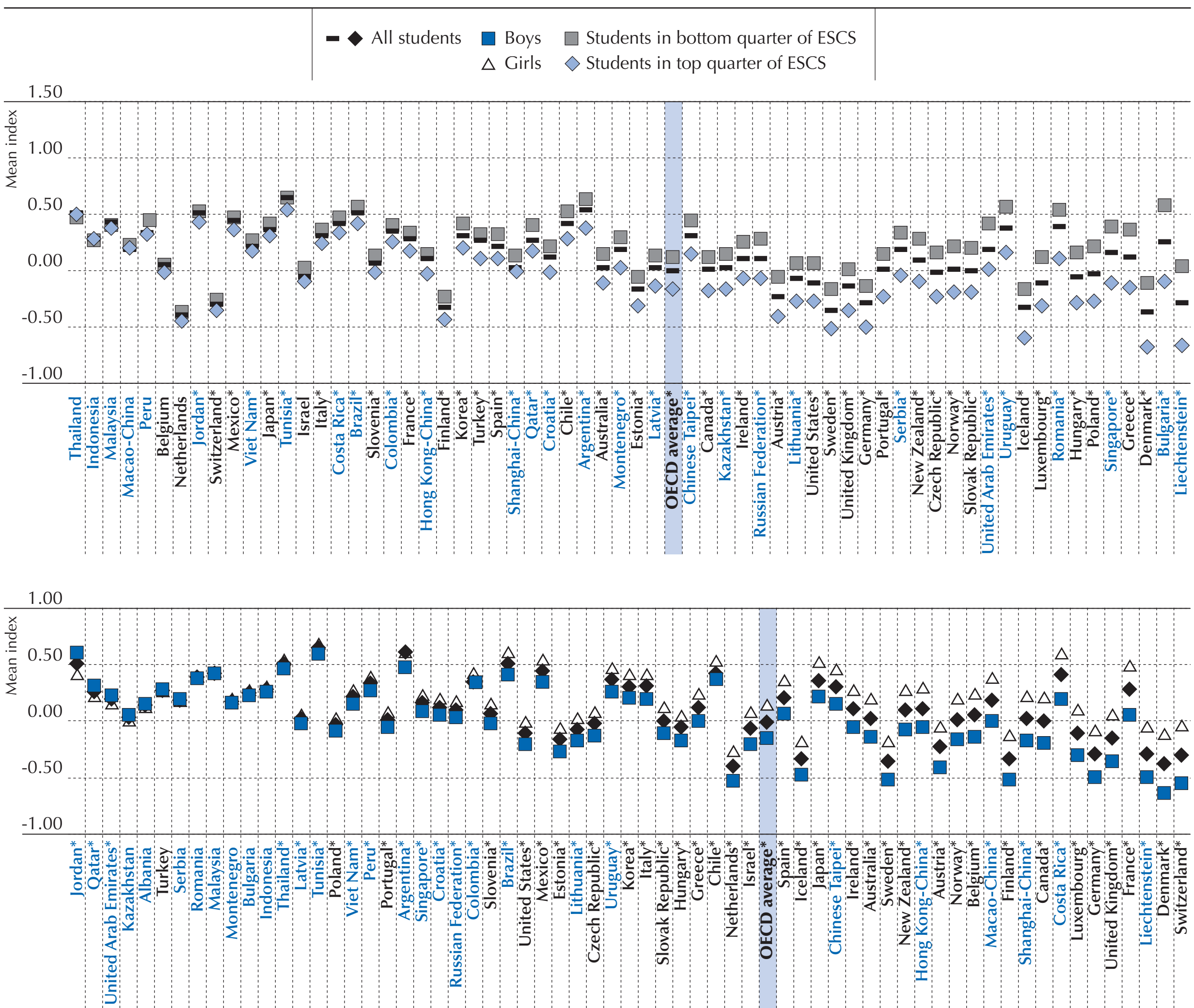
Notes: Statistically significant changes at the 5% level ($p < 0.05$) between PISA 2003 and PISA 2012 are marked in a darker tone.
Only countries and economies with comparable data from PISA 2003 and PISA 2012 are shown.
OECD average 2003 compares only OECD countries with comparable indices of anxiety towards mathematics since 2003.
Countries and economies are ranked in descending order of the change in the index of anxiety towards mathematics *between PISA 2003 and PISA 2012.*
Source: OECD, PISA 2012 Database, Table III.4.3f.
StatLink http://dx.doi.org/10.1787/888932963844

having to do mathematics homework; by 2012 this proportion had grown to 32%. Similarly, students in 2012 were more likely than their counterparts in 2003 to worry that they will find it difficult in mathematics classes, more likely to worry that they will get poor grades in mathematics, and more likely to report getting nervous and feeling helpless doing mathematics problems. Consistent with this average trend, the *index of mathematics anxiety* increased in a statistically significant way in 13 countries and economies between 2003 and 2012, most notably in New Zealand, Sweden, Uruguay, Australia, Tunisia, Norway and Thailand, where the *index of mathematics anxiety* increased by more than 0.1 units during the period. In Sweden and New Zealand, for example, 15-year-old students in 2012 were at least ten percentage points more likely to report getting very tense when having to do mathematics homework and ten percentage points more likely to report that they will find it difficult in mathematics classes than their peers did in 2003. By contrast, anxiety towards mathematics has decreased significantly in Iceland, Portugal, Hong Kong-China and Luxembourg (Figure III.4.11 and Table III.4.3f).

While the trends towards greater mathematics anxiety may seem at odds with trends that point towards improving levels of mathematics self-concept and self-efficacy among students, countries that saw increases in the levels of mathematics anxiety between 2003 and 2012 are, in many cases, also those that saw a decline in students' self-concepts and levels of self-efficacy (the correlation at the country level is, in both cases, -0.4, signalling that countries in which mathematics

■ Figure III.4.12 ■

Gender and socio-economic differences in students' mathematics anxiety



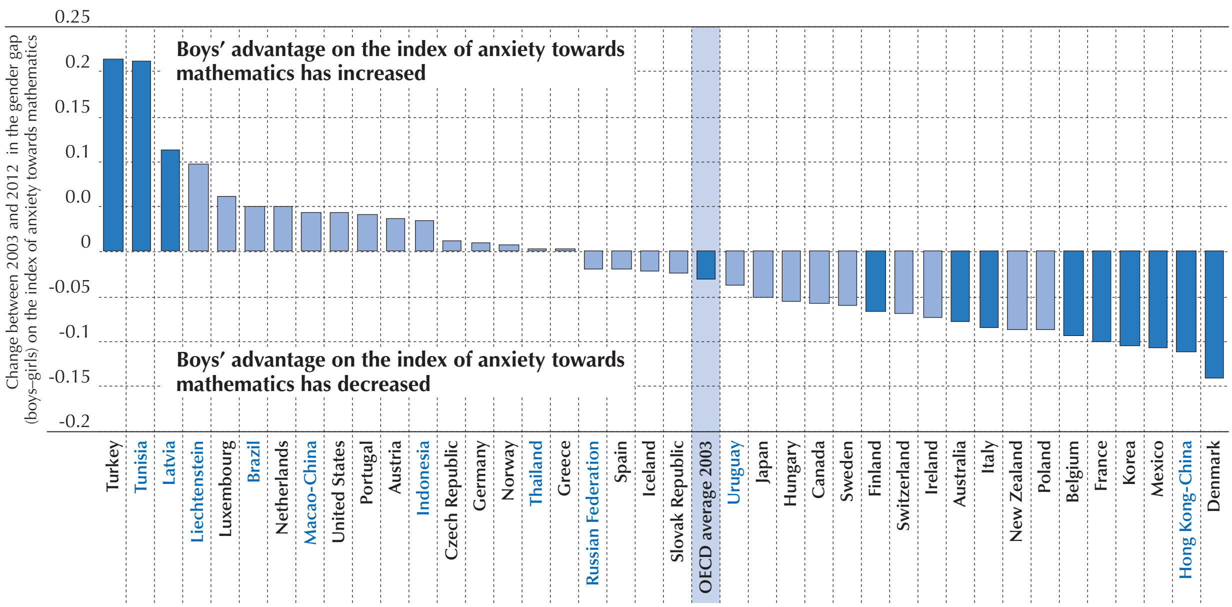
Note: Countries/economies where gender/socio-economic differences are significant are indicated with an asterisk.
Countries and economies are ranked in descending order of gender differences (left panel) and socio-economic differences (right panel) on the index of mathematics *anxiety.*
Source: OECD, PISA 2012 Database, Tables III.4.3c and III.4.3d.
StatLink http://dx.doi.org/10.1787/888932963844

anxiety decreased or did not change are more likely to be those where students' mathematics self-concept or self-efficacy improved). In Iceland, Spain, Indonesia, Hong Kong-China and Portugal, for example, reductions in levels of mathematics anxiety were coupled with increases in mathematics self-concept during the period. Conversely, in New Zealand, mathematics anxiety increased as mathematics self-concept deteriorated. The exceptions to these concurrent changes are, most notably, Norway, Sweden, Thailand and Italy where both mathematics self-concept and mathematics anxiety improved/increased (Table III.4.2f and Table III.4.3f).

Differences in mathematics anxiety related to socio-economic status are less pronounced than gender differences but are nonetheless present in many countries and economies that participated in PISA; these differences tend to be particularly wide in Greece, Bulgaria, Denmark, Singapore and Liechtenstein (Tables III.4.3c and III.4.7c). In Greece, for example, 81% of disadvantaged students but only 63% of advantaged students reported worrying that it will be difficult for them in mathematics classes, and 46% of disadvantaged students but only 25% of advantaged students reported getting very tense when they have to do mathematics homework. Similarly, in Singapore 70% of disadvantaged students but only 49% of advantaged students reported worrying that it will be difficult for them in mathematics classes; 47% of disadvantaged students but only 28% of advantaged students reported getting very nervous doing mathematics problems; and 47% of disadvantaged students but only 23% of advantaged students reported getting very tense when they have to do mathematics homework (Table III.4.3a).

▪ Figure III.4.13 ▪

Change between 2003 and 2012 in the gender gap in anxiety towards mathematics



Notes: Statistically significant changes at the 5% level ($p < 0.05$) between PISA 2003 and PISA 2012 are marked in a darker tone.
Only countries and economies with comparable data from PISA 2003 and PISA 2012 are shown.
OECD average 2003 compares only OECD countries with comparable indices of anxiety towards mathematics since 2003.
Countries and economies are ranked in descending order of the change in the gender gap on the index of anxiety towards mathematics *between PISA 2003 and PISA 2012.*
Source: OECD, PISA 2012 Database, Table III.4.3g.
StatLink http://dx.doi.org/10.1787/888932963844

Differences in mathematics anxiety related both to gender and to socio-economic status have narrowed between 2003 and 2012. In 2012, boys reported lower levels of mathematics anxiety than girls, and this difference is somewhat smaller than it was in 2003. Similarly, the difference in the reported levels of mathematics anxiety in favour of socio-economically advantaged students decreased slightly, on average across OECD countries, between 2003 and 2012. In both cases, however, the differences in mathematics anxiety related to gender and to socio-economic status remain large (Figure III.4.13 and Table III.4.3g).

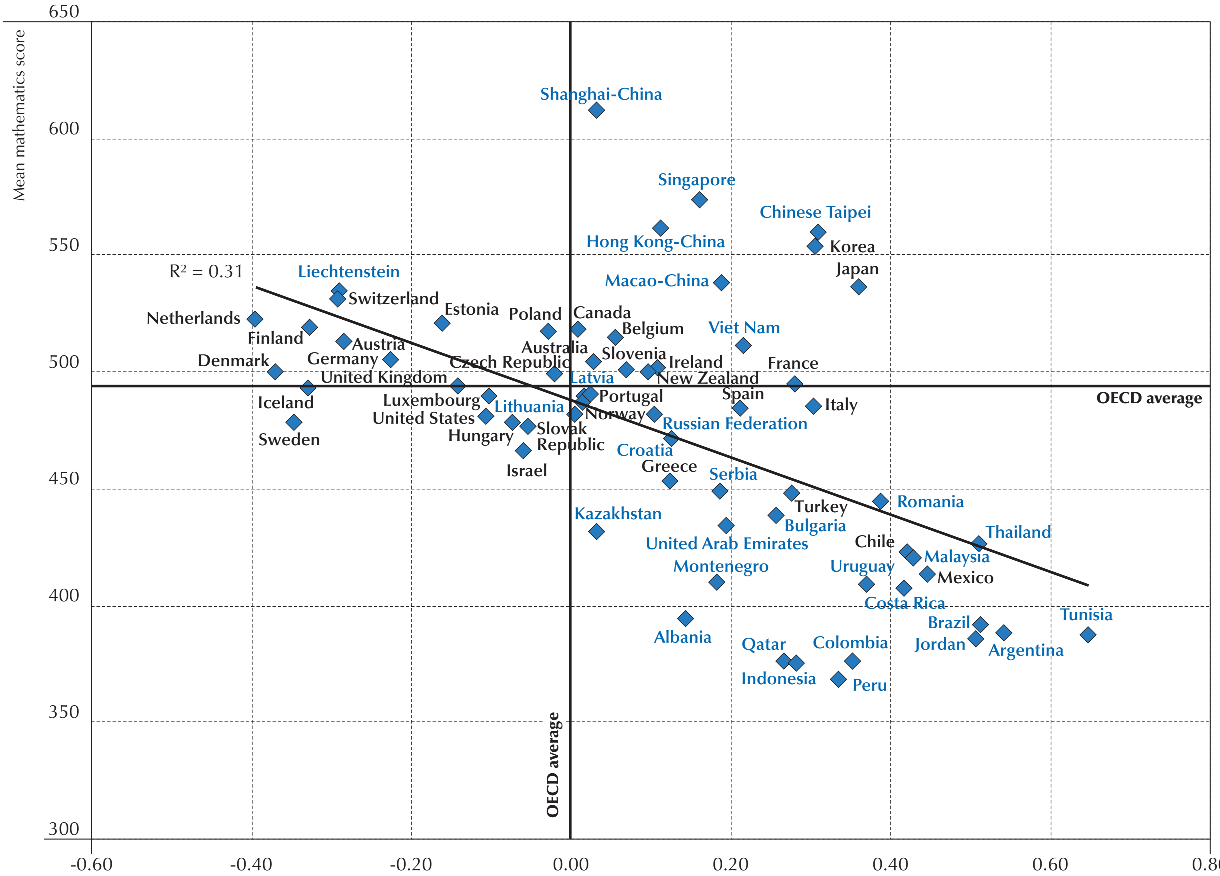
Countries where students tended to report higher levels of anxiety are also those with lower-than-average performance in mathematics: Figure III.4.14 shows how countries where students report above average levels of mathematics anxiety are also countries where students tend to perform less well in mathematics. The relationship between anxiety towards mathematics and students' mathematics performance was strong in PISA 2003 and maintained that strength through PISA 2012 among most participating countries and economies (Table III.4.9).

As Figure III.4.15 indicates, students who reported that they often worry that it will be difficult for them in mathematics classes, that they get very tense when they have to do mathematics homework, that they get very nervous doing mathematics problems, that they feel helpless when doing a mathematics problem, and that they worry that they will get poor grades in mathematics have poorer performance in mathematics than students who reported lower levels of mathematics anxiety (Table III.4.3e). As discussed in Box III.2.2, findings emerging from PISA 2012 cannot be used to establish a direct causal link between mathematics anxiety and poor mathematics performance; however, PISA can show how closely the two are associated. The blue bars in Figure III.4.15 denote the estimated difference in mathematics performance that is associated with a difference of one unit in the *index of mathematics anxiety*. This difference corresponds roughly to the difference in levels of mathematics anxiety that can be expected between the average student in OECD countries and a student that has very high levels of mathematics anxiety (only 16.5% of students, on average across OECD countries, have the highest levels of mathematics anxiety) (see Box III.2.2).

On average across OECD countries, greater mathematics anxiety is associated with a decrease in performance of 34 score points – or the equivalent of almost an additional year of school. In 13 countries and economies, the difference in mathematics performance that is associated with students' mathematics anxiety is 40 points or more, while in New

■ Figure III.4.14 ■

System-level association between mathematics performance and mathematics anxiety



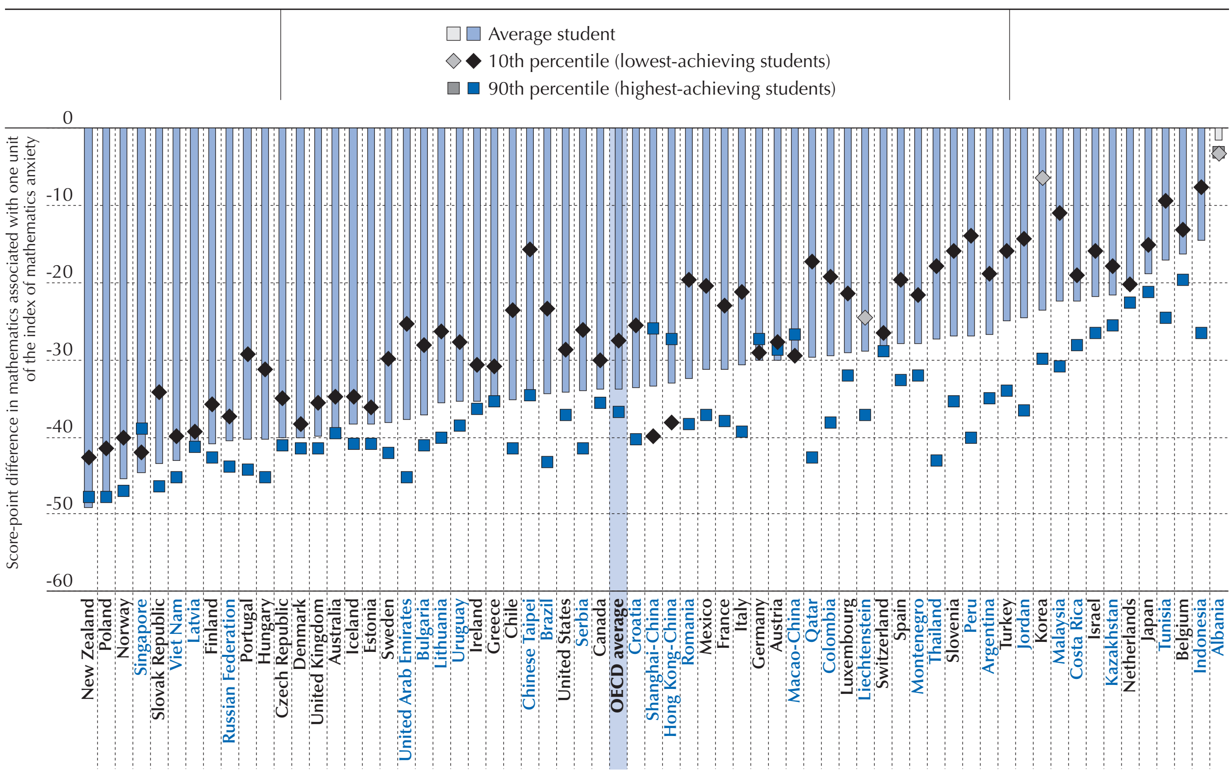
Source: OECD, PISA 2012 Database, Tables I.2.3a and III.4.3d.
StatLink http://dx.doi.org/10.1787/888932963844

Zealand, Poland and Norway the difference is particularly marked, at 45 score points or more. Albania is the only country/economy where mathematics anxiety is not associated with mathematics performance; in Indonesia, Belgium, Tunisia and Japan, the performance difference that is associated with a change of one unit in the index of mathematics anxiety is less than 20 points. Across OECD countries, 14% of the variation in students' performance in mathematics can be explained by differences in students' reported levels of mathematics anxiety. In 41 countries and economies more than 10% of the variation in student performance is explained in this way, and in Poland, Norway, Denmark, Estonia and Iceland, more than 20% of the variation is so explained. Albania, Indonesia, Belgium, Tunisia, Korea, Japan, Thailand, the Netherlands and Malaysia are the only countries where mathematics anxiety appears to have little relationship with performance. In all these countries less than 5% of the variation in student performance in mathematics is associated with students' mathematics anxiety (Tables III.4.3d and III.4.3e).

The blue bar in Figure III.4.15 represents the estimated relationship between mathematics anxiety and mathematics performance for the average student. The black diamond and the blue square in Figure III.4.15 represent the association between mathematics anxiety and mathematics performance at the two ends of the performance distribution (the 10th percentile and the 90th percentile). Figure III.4.15 reveals that the association between mathematics anxiety and mathematics performance is negative and significant across the performance distribution, but the association is weaker among the lowest-achieving students and stronger among the highest-achieving students. The performance advantage for students with low levels of mathematics anxiety is larger among the highest-achieving students than it is among the lowest-achieving students. On average across OECD countries, the performance difference that is associated with a change of one unit in the *index of mathematics anxiety* is 37 points among the highest-achieving students but only 28 points among the lowest-achieving students.

▪ Figure III.4.15 ▪

Relationship between mathematics anxiety and mathematics performance



Note: Differences that are statistically significant at the 5% level ($p < 0.05$) are marked in a darker tone.
Countries and economies are ranked in ascending order of the change in mathematics performance that is associated with a difference of one unit in the index of mathematics anxiety.
Source: OECD, PISA 2012 Database, Table III.4.3e.
StatLink http://dx.doi.org/10.1787/888932963844

In 35 countries and economies, the performance difference associated with mathematics anxiety is greater than 10 points among the highest- and lowest-achieving students; in Peru, Qatar, Thailand, Korea and Jordan, it is 20 points or more. In Korea, for example, mathematics anxiety is associated with a performance difference of 30 points among students at the 90th percentile but with no difference in performance among students at the 10th percentile. In Peru, the performance difference related to mathematics performance is 40 points at the 90th percentile but 14 points at the 10th percentile. Shanghai-China and Hong Kong-China are notable exceptions: in these economies, the performance difference associated with mathematics anxiety is greater than 10 points among the lowest-achieving students than among the highest-achieving students. For example, in Shanghai-China the performance difference is 40 score points at the 10th percentile and 26 points at the 90th percentile (Table III.4.3e).

Box III.4.1. **Improving in PISA: Portugal**

Portugal's mathematics, reading and science scores began to improve in 2006. Mathematics scores in 2012 were 21 points higher than they were in 2003 and 2006, reading scores were around 15 points higher than they were in 2000 and 2006, and science scores were also 15 points higher than they were in 2006. The share of students who scored below Level 2 in mathematics and science shrank by about five percentage points since 2006 while the share of students performing at or above proficiency Level 5 increased in all the subjects: by 5.5 percentage points in mathematics, by 2.4 percentage points in reading, and by 3.4 percentage points in science. Both low- and high-achieving students have significantly improved their scores in all domains. In the case of mathematics, the improvement among the highest achievers (those in the 90th percentile of mathematics scores) is greater than the improvement among the lowest-achievers (those in the 10th percentile). This improvement among high-achieving students was largely observed within schools. While performance differences between schools did not change between PISA 2003 and PISA 2012, differences within schools increased. Consistent with the overall improvement in mathematics performance, students in 2012 reported higher levels of mathematics self-efficacy and self-concepts, as well as lower levels of anxiety towards mathematics when compared to their counterparts in 2003.

In the early 2000s, Portugal's performance in PISA was one of the lowest among OECD countries, prompting a wide public debate and the view that too many Portuguese students lacked the knowledge and skills needed to succeed in a modern society and economy. It was estimated that hourly productivity would be 14.4% higher if the working-age population in Portugal had the same level of education as workers in the United States (OECD, 2010a). Proposed reforms aimed to change this situation by offering children and adults from relatively disadvantaged backgrounds better learning opportunities. In addition, high rates of grade repetition were considered an obstacle to success for disadvantaged students. As part of the greater autonomy granted to schools, principals can target students who show initial signs of failure for special programmes, such as special study support, short-term ability grouping, or co-teaching in the classroom.

The government has devoted more resources to supporting students from low-income families, even though the Portuguese school system is almost entirely public, and compulsory education is free until 12th grade or when a student reaches the age of 18. In public schools, high-tech equipment, broadband Internet access and extracurricular activities are subsidised by the government; depending on the family's economic status, additional support, such as meals and books, is provided to disadvantaged students. These measures are applied from the first year of primary school until the end of secondary school. Between 2005 and 2009, the number of beneficiaries of the School Social Action programme tripled.

Encouraging students to stay in school

Official statistics show that between 2004 and 2009 there was a large decline in the repetition rate in 9th grade, from 21.5% of students to 12.8%. This, in itself, is a positive sign, given PISA's findings that grade repetition is generally associated with poorer performance and a larger impact of socio-economic status on learning outcomes (see Chapter 1 in Volume IV). Although there was a reduction in grade repetition among 9th graders, the overall rate of grade repetition remains high. In 2003 and 2012, around a third of students reported having repeated at least one grade during their time in formal education. The reduction in grade repetition rates in grade 9 implied a

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higher enrolment of students in secondary education (10th through 12th grades) and a consequent decline in the number of students dropping out of school altogether. From 2007 on, the Ministry of Education considered 12th grade to be the minimum level of educational attainment for all Portuguese citizens. In 2009, legislation extending the end of compulsory education from age 15 to age 18 was adopted.

In addition, as part of the *Novas Oportunidades* programme, secondary schools offered more vocational courses. Now, in an effort to reduce school dropout, upper secondary vocational courses are being reinforced to encourage students who do not want to continue on to university to stay in school. About half of students enrolled in 10th, 11th and 12th grades attend vocational courses, reversing the decline in enrolment that had been observed since 1995. In 2003, 90% of 15-year-old students were enrolled in schools in grade 7 or above; by 2012, all 15-year-olds in Portugal were enrolled.

Training teachers, granting more autonomy and expanding assessments

In parallel, teachers were given more training, mostly in Portuguese language, mathematics and information technologies. A new system of evaluating teachers was developed, but teachers' opposition to the system has delayed implementation. Still, a shift towards more outcome-oriented accountability has already changed the ways teachers and schools perceive external assessments, including PISA (OECD, 2010b). Whereas in 2003, around a third of students attended schools where judgements about teacher effectiveness were made using tests or assessments of student achievement, almost all students in 2012 attended such schools. The efficiency of the school system was improved by reducing teacher absenteeism and replacing absent teachers. A school evaluation system was also introduced to increase accountability. More students in 2012 than in 2003 attended schools where a higher proportion of teachers have certification and a university-level degree and schools where the school principal is less likely to report that a shortage of teachers adversely affects student learning.

Portugal has had one of the lowest mean values, among OECD countries, on the *index of school responsibility in resource allocation* and on the *index of school responsibility for curriculum and assessment* (see Volume IV, and especially Tables IV.4.1 and IV.4.2). The policies that are now being implemented give greater autonomy to leaders of "school clusters". A school cluster is an organisational unit comprising several schools from kindergarten to 9th or 12th grade, vertically structured under a single education project that is led by a director. The director is elected by a council of teachers, parents, students, municipal leaders, institution representatives, and relevant community members. The vast majority of school clusters are now led by an elected director who has the autonomy to pursue a proposed education project. In the initial phases of the consolidation of school clusters, pre-primary and primary schools were combined; but from 2010 secondary schools began to be included in school clusters. This policy was accompanied by major investments in the physical infrastructure; but because of budgetary constraints, those investments had stopped by 2013.

As part of the reforms implemented in the 2000s, all students in 4th, 6th and 9th grades participated in annual national assessments, known as the Educational Progress Tests, in the Portuguese language and mathematics. By 2013, however, the 4th- and 6th-grade assessments, which previously had no direct consequences for students, were replaced with high-stakes national examinations (OECD, 2012). Students who fail the 4th-grade examination can benefit from extra three weeks of preparation before taking a second round of the exam (starting in 2014, this extra preparation time will be available for students who fail the 6th-grade exam). The expansion of assessments and examinations in the school system is reflected in the fact that students who participated in PISA 2012 were 52 percentage points more likely than students who participated in PISA 2003 to attend schools where the principal reported that assessment data is used to compare the school's performance with national benchmarks.

Mathematics had always been considered the most difficult subject for students in Portugal. PISA 2003 results showed that almost one-third of students performed below Level 2 in mathematics. Following the PISA results and the 2005 results in the 9th grade mathematics examinations, the Ministry of Education promoted a broad debate on the subject. The Action Plan for Mathematics, which was launched in 2005 and involves some 78 000 teachers and 400 000 students, has six components: implementing a mathematics plan in each school; training teachers in basic and secondary schools; reinforcing mathematics in initial teacher training; readjusting the mathematics curriculum throughout the compulsory education system; creating a resource bank specifically devoted to mathematics;

...

and evaluating textbooks on mathematics. At the same time, more mathematics teachers were trained and hired. Students in 2012 spent one-and-a-half hours more per week in mathematics lessons than students in 2003 did. Whereas students in 2003 reported 195 minutes of mathematics instruction per week, students in 2012 reported 288 minutes of mathematics instruction per week, but they spend around an hour less in after-school study than students in 2003 did.

Following the success of the Action Plan for Mathematics, in 2012 the initiatives that showed the greatest impact – collaboration between teachers and co-teaching in the classroom – were extended to all schools and all subjects. Mathematics and Portuguese standards and curricular goals were established and implemented in 2013 in primary and secondary schools with the aim of creating such standards for upper secondary schools and for other subjects, like science, history and geography. The implementation of these standards is being accompanied by teacher training to ensure that teachers have the tools to incorporate these changes into their practice.

More recently, the National Plan for Reading, launched in 2006 as a joint initiative involving the Ministry of Education, the Ministry of Culture and the Ministry of Parliamentary Affairs, aims to improve reading proficiency among children and foster good reading habits. More than one million children in all school clusters and secondary schools are involved in the programme.

Sources:

OECD (2010a), *OECD Economic Surveys: Portugal 2010*, OECD Publishing.
http://dx.doi.org/10.1787/eco_surveys-prt-2010-en.

OECD (2010b), *PISA 2009 Results: Learning Trends: Changes in Student Performance Since 2000 (Volume V)*, PISA, OECD Publishing.
http://dx.doi.org/10.1787/9789264091580-en.

Santiago, P. et al. (2012), *OECD Reviews of Evaluation and Assessment in Education: Portugal 2012*, OECD Reviews of Evaluation and Assessment in Education, OECD Publishing.
http://dx.doi.org/*10.1787/9789264117020-en.*

PARTICIPATION IN MATHEMATICS ACTIVITIES, MATHEMATICS INTENTIONS AND NORMS

PISA 2012 asked students to report how often they participate in mathematics-related activities at or outside of school. Mathematics-related activities considered in PISA 2012 included: talking about mathematics problems with friends; helping friends with mathematics; doing mathematics as an extracurricular activity; taking part in mathematics competitions; doing mathematics for more than two hours a day outside of school; playing chess; programming computers; and participating in a mathematics club. Students could report engaging "always or almost always", "often", "sometimes" or "never or rarely".

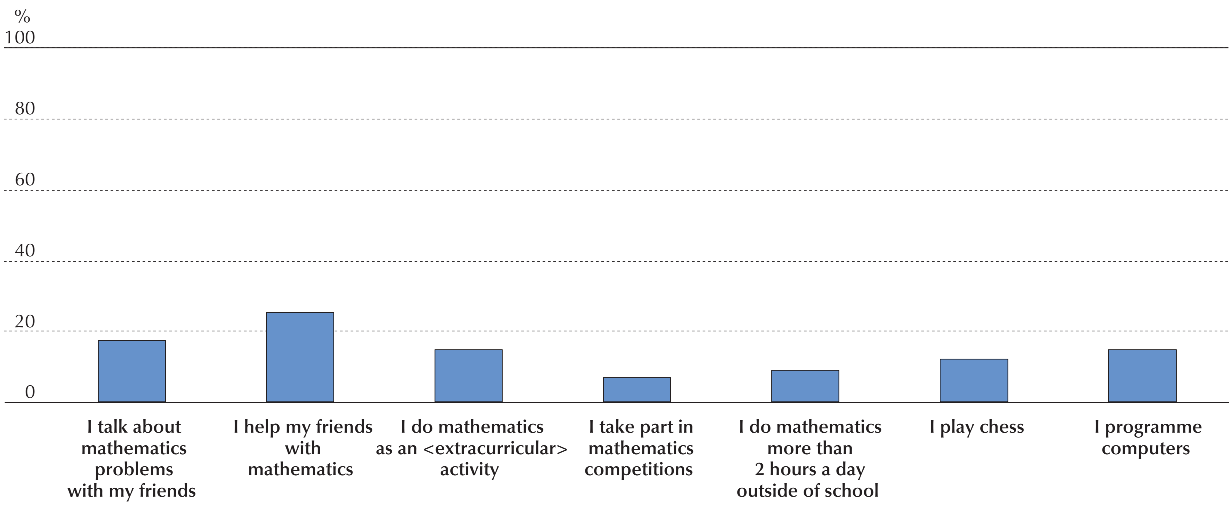
Across OECD countries, around 25% of students reported that they regularly help their friends with mathematics, where "reported regularly" corresponds to reporting that they always, almost always or often help. Similarly, only 18% of students reported that they regularly talk about mathematics problems with their friends; 15% reported regularly doing mathematics as an extracurricular activity; 7% reported regularly taking part in mathematics competitions; 9% reported regularly doing more than two hours a day of mathematics outside of school; 12% reported that they regularly play chess; 15% reported that they regularly programme computers; and 4% reported that they regularly participate in mathematics clubs. While some activities tend to be more common among 15-year-olds, in general students seldom participate in mathematics-related activities outside of school requirements. However, there are some notable exceptions, particularly when certain kinds of mathematics-related activities are considered. For example, 37% of students in Turkey play chess regularly, while in Poland, 20% of students participate in mathematics clubs (Figure III.4.16 and Table III.4.4a).

As Figure III.4.17 shows, boys are more likely than girls to participate in mathematics-related activities. Across OECD countries 16% of boys, but only 14% of girls, do mathematics as an extracurricular activity; 9% of boys, but 5% of girls, take part in mathematics competitions; and 5% of boys, but 3% of girls, participate in a mathematics club. Gender differences are particularly pronounced with respect to playing chess and programming computers: 19% of boys, but only 6% of girls, play chess, and 22% of boys, but 8% of girls, programme computers (Table III.4.4b). Similarly, results shown in Figure III.4.18 suggest that socio-economically disadvantaged students are less likely to participate in

▪ Figure III.4.16 ▪

Students' participation in activities related to mathematics

Percentage of students across OECD countries who reported that they "agree" or "strongly agree" with the following statements:



Note: Results for each participating country and economy can be found in Table III.4.4a.
Source: OECD, PISA 2012 Database, Table III.4.4a.
StatLink http://dx.doi.org/10.1787/888932963844

mathematics-related activities. However, PISA cannot determine whether disparities in participation are due to lower interest among disadvantaged students or less access to these activities because their families lack the resources or because these activities are not available in their communities.

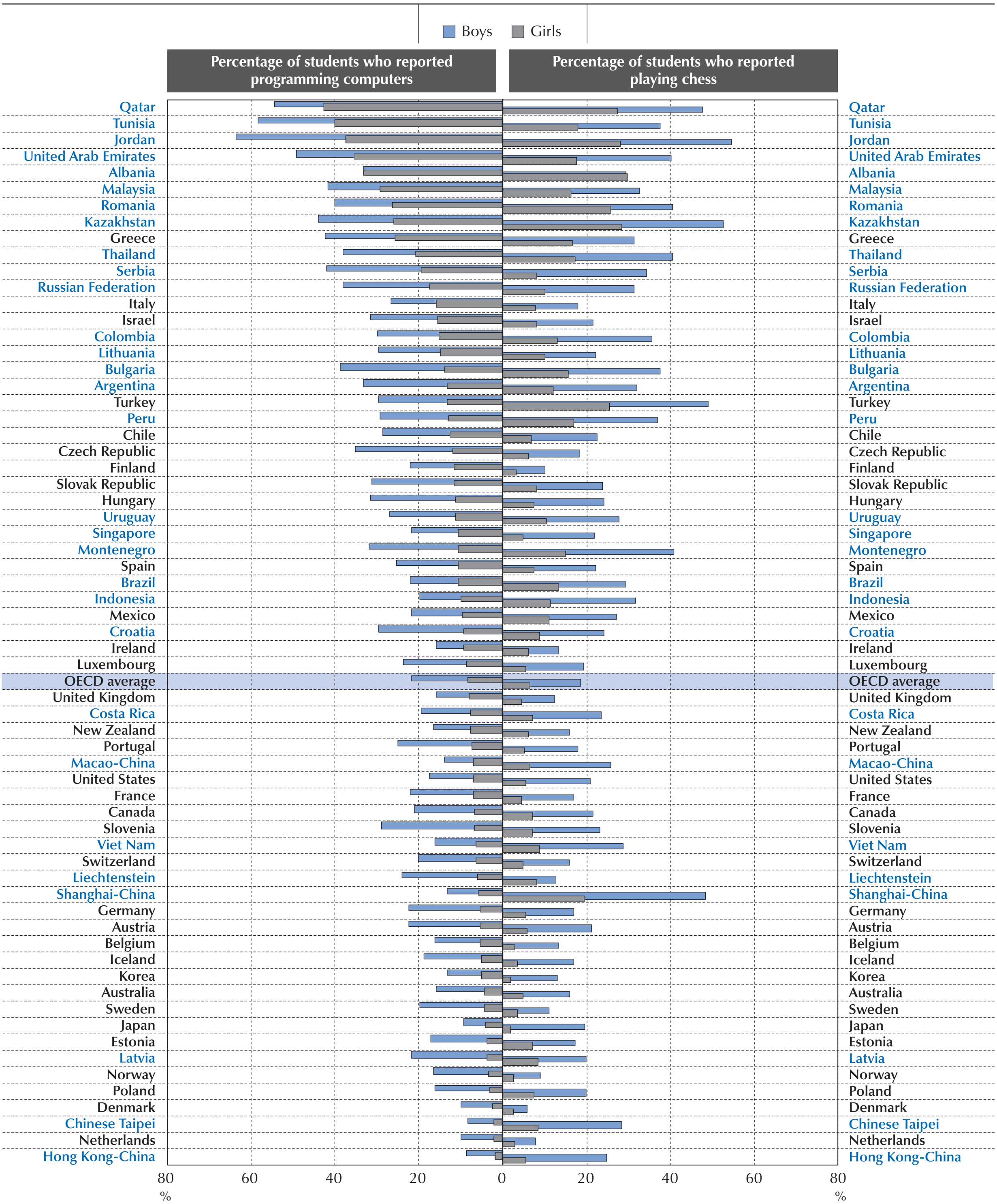
PISA 2012 also asked students to report about their intentions to use mathematics in their future studies and careers. Students were presented with five pairs of statements and were asked to choose the one of each pair that best described their intentions and desires for their future lives. Students were first asked whether they intend to take additional mathematics courses or additional <test language> courses after their compulsory schooling ends.[1] On average, across OECD countries, 57% of students reported intending to take additional mathematics courses, and 45% of students intend to major in a subject at university that requires mathematics skills compared to 55% who intend to major in a subject that requires science skills (Table III.4.5a). Overall, in all but six countries and economies boys tend to have greater intention to pursue mathematics in their studies and careers than other subjects. Turkey is the only country where girls have more positive intentions than boys of continuing mathematics study (Table III.4.5b).

PISA 2012 also asked students to report on how people who are important to them, such as their parents and friends, view mathematics. Specifically, students were asked to report whether they strongly agree, agree, disagree or strongly disagree that most of their friends do well in mathematics, that most of their friends work hard at mathematics, that their friends enjoy taking mathematics tests, that their parents believe it is important that the student studies mathematics, that their parents believe that mathematics is important for the student's career, or that their parents like mathematics. Students' responses were used to create *the index of subjective norms in mathematics*, reflecting the extent to which a student's social environment promotes mathematics and the study of mathematics. The index was standardised to have a mean of 0 and a standard deviation of 1 across OECD countries so that positive index values indicate that the student encounters more positive social norms towards mathematics than the average student across OECD countries, while negative values indicate that the student encounters more negative social norms towards mathematics than the average student across OECD countries.

On average across OECD countries, 60% of students agreed or strongly agreed that most of their friends do well in mathematics; 51% reported that most of their friends work hard at mathematics; 13% reported that most of their friends enjoy taking mathematics tests; 90% reported that their parents believe that it is important for their child to study mathematics; 80% reported that their parents believe that mathematics is important for their career; and 58% reported that their parents like mathematics (Table III.4.6a). Gender differences in these subjective norms – in favour of boys – are more pronounced than socio-economic disparities: they tend to be larger and observed in more countries and economies (Tables III.4.7a and III.4.7b).

▪ Figure III.4.17 ▪

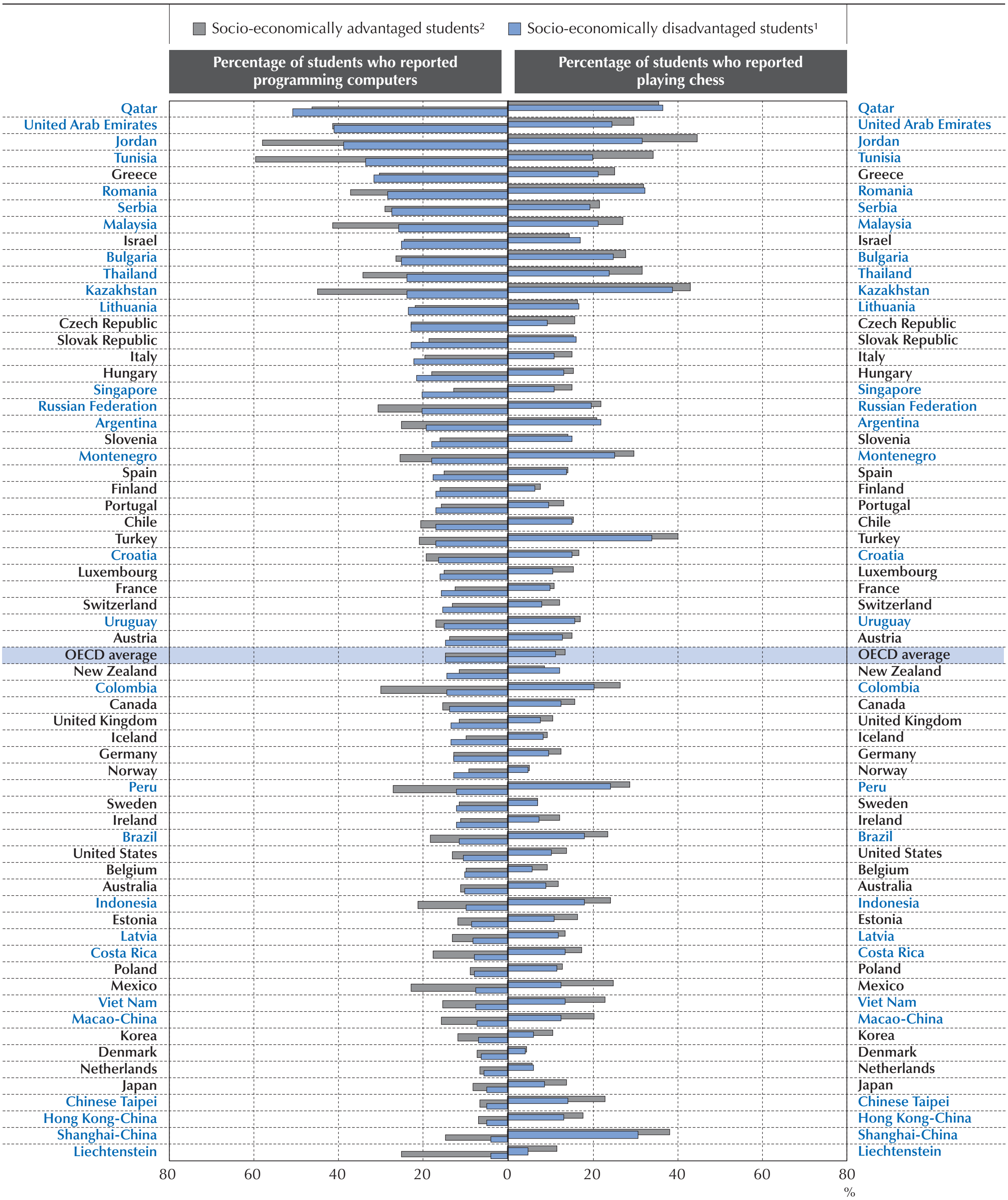
Gender differences in students' participation in mathematics-related activities



Countries and economies are ranked in descending order of the percentage of girls who reported programming computers.
Source: OECD, PISA 2012 Database, Table III.4.4b.
StatLink http://dx.doi.org/10.1787/888932963844

■ Figure III.4.18 ■

Socio-economic differences in students' participation in mathematics-related activities



1. Socio-economically disadvantaged students are students in the bottom quarter of the *PISA index of economic, social and cultural status* (ESCS).
2. Socio-economically advantaged students are students in the top quarter of the *PISA index of economic, social and cultural status* (ESCS).
Countries and economies are ranked in descending order of the percentage of socio-economically disadvantaged students who reported programming computers.
Source: OECD, PISA 2012 Database, Table III.4.4c.
StatLink http://dx.doi.org/10.1787/888932963844

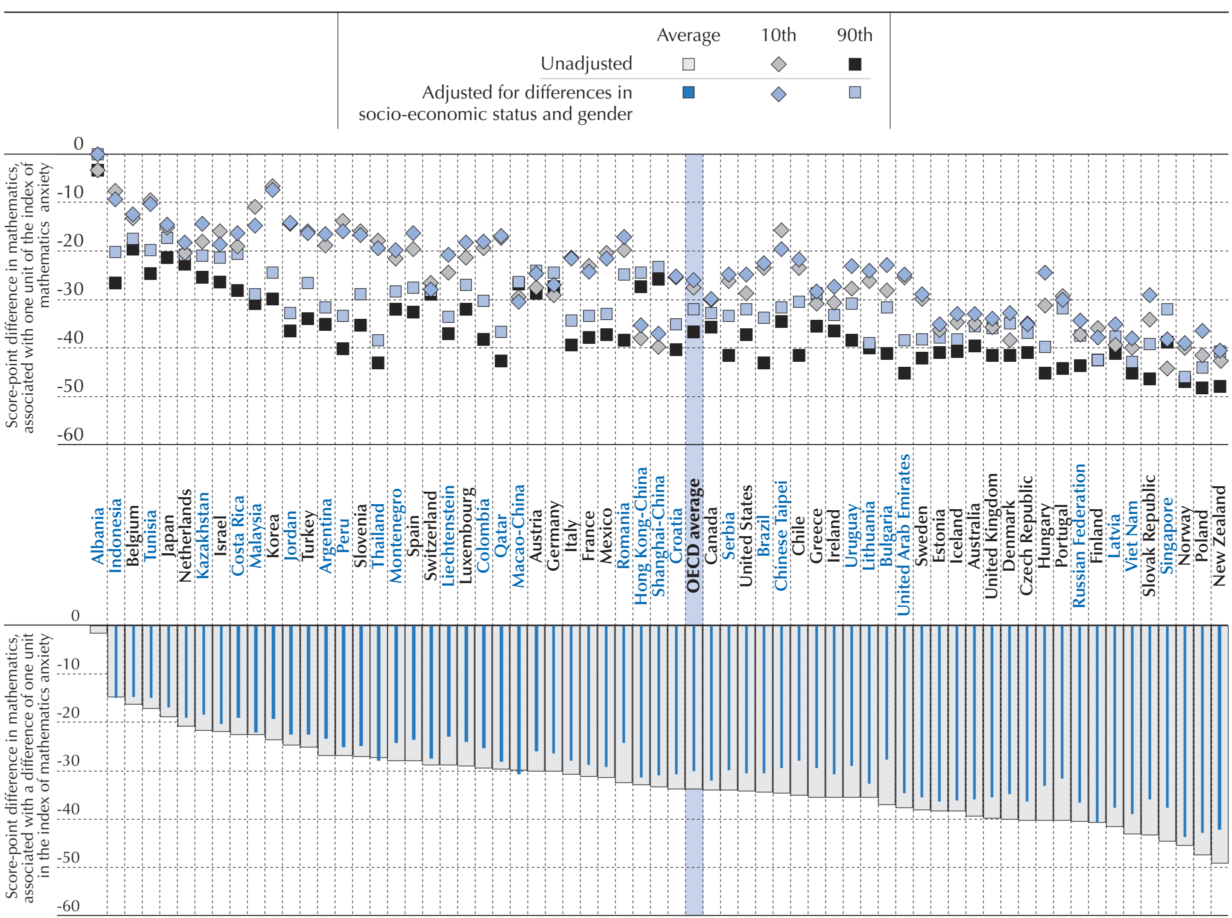
THE ROLE OF GENDER AND SOCIO-ECONOMIC DIFFERENCES IN THE RELATIONSHIP BETWEEN DISPOSITIONS TOWARDS MATHEMATICS AND PERFORMANCE

In order to examine whether the results presented in previous sections reflect differences in the profiles of the highest-achieving and lowest-achieving students, Tables III.4.1e, III.4.2e, III.4.3e and III.4.4e, present two sets of regression models. The first set – defined as unadjusted in the Tables – used earlier, reports regression results with the key factor of interest as the only independent variable. The second set – defined as adjusted in the tables – reports results from regression models that control for students' socio-economic status and gender as well as for the key factor of interest. Thus, they represent the differences in performance that are associated with students' dispositions, behaviours and self-beliefs at the high and low ends of the performance distribution between students of the same gender and with similar socio-economic status.

Figure III.4.19 shows the association between mathematics anxiety and mathematics performance among the highest-achieving and lowest-achieving students, and how this changes when controlling for students' socio-economic status and gender. Among the highest-achieving students, results indicate that the relationship between mathematics anxiety and mathematics performance generally remains unaffected when controlling for whether the student is a girl and socio-economic status. Among the highest-achieving students across OECD countries, the difference in mathematics performance that is associated with a one-unit change in the *index of mathematics anxiety* is 37 score points when not controlling for students' gender and socio-economic status and 32 points after accounting for these factors. This slight weakening of the

▪ Figure III.4.19 ▪

Relationship between mathematics anxiety and mathematics performance among the highest- and lowest-achieving students: The role of socio-economic and gender differences



Countries and economies are ranked in descending order of the unadjusted score-point difference in mathematics associated with mathematics anxiety, for the average student.

Source: OECD, PISA 2012 Database, Table III.4.3e.

StatLink http://dx.doi.org/10.1787/888932963844

relationship occurs because girls are less likely than boys to be among the highest-achieving students in mathematics and are more likely than boys to be anxious about mathematics (Table III.4.3e). When controlling for gender and socio-economic differences, the association between mathematics anxiety and mathematics performance at the top of the performance distribution remains strong – much stronger than the association found among the lowest-achieving students.

Notes

1. The item "I plan on <taking> as many mathematics classes as I can during my education" and "I plan on <taking> as many science classes as I can during my education" might work differently across different education systems depending on the ability students have to adapt their course schedule. To reflect such differences, in some countries these items were, for example, translated along the following lines "I plan to engage as much as possible with mathematics/science during school time".

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