3

Students' Drive and Motivation

This chapter explores several indicators related to students' drive and motivation: perseverance, openness to problem solving, perceived control over success in mathematics and in school, perceived self-responsibility for failing in mathematics and intrinsic and instrumental motivation to learn mathematics. The chapter discusses how these dispositions are associated with performance in mathematics, whether and how they are related to gender and socio-economic status, and how they have evolved among students since 2003.

Raw potential and talent are only a small part of what it takes to become proficient in a skill. Students' success depends on the material and intangible resources that are invested by families, schools and education systems to develop each and every student's potential. Crucially, students' ability to perform at high levels depends on their belief that while aptitude and talent for particular school subjects can help, mastery can be achieved if students put in the hard work and perseverance that are needed. The belief that intelligence is a fixed trait and that only those who have it can succeed in school is both a myth and an obstacle to success. Students who consider themselves intelligent do not think that they need to cultivate their intelligence to make it flourish, and those who believe that they lack intelligence are not inclined to work hard to overcome initial difficulties (Rattan et al., 2012; Carr and Dweck, 2012; Dweck, 2006).

What the data tell us

- Some 44% of students reported that they tend to "continue working on a task until everything is perfect" while 63% of students reported that they tend to "put off difficult problems".
- Across OECD countries, more than three out of four students agree or strongly agree that learning mathematics will improve their career prospects.
- Some 53% of students in OECD countries, including 58% of boys but 49% of girls, agree or strongly agree that they're "interested in the things [they] learn in mathematics".
- Students who are more open to problem solving – those who feel they can handle a lot of information, are quick to understand things, seek explanations for things, can easily link facts together, and like to solve complex problems – score 30 points higher in mathematics, on average, than those who are less open to problem solving; and among high achievers, the difference between the two groups of students is even greater – an average of 38 score points.

Our actions and experiences throughout life have the potential to reshape how our brains work because brains are "plastic" and can change during a lifetime.[1] In particular, extensive practice and expertise are associated with profound changes in the connections between the neurons of those regions of the brain that are stimulated. Through practice, the brain forms new connections and the internal structure of existing synapses change, so much so that some regions of the brain grow in size and complexity.[2] Stamina, hard work and persistence are just as necessary, if not more necessary, than talent and aptitude to become proficient in any endeavour. As with all individuals, students, too, differ greatly in their capacity to persevere towards a goal despite adversity, lack of progress and failure (Duckworth et al., 2007). For example, some students persist and even work harder after failure, whereas others give up quickly (Diener and Dweck, 1978). Duckworth and Quinn's (2009) notion of "grit" captures the importance of working hard and persevering to complete tasks even when they are difficult and, sometimes, not interesting.

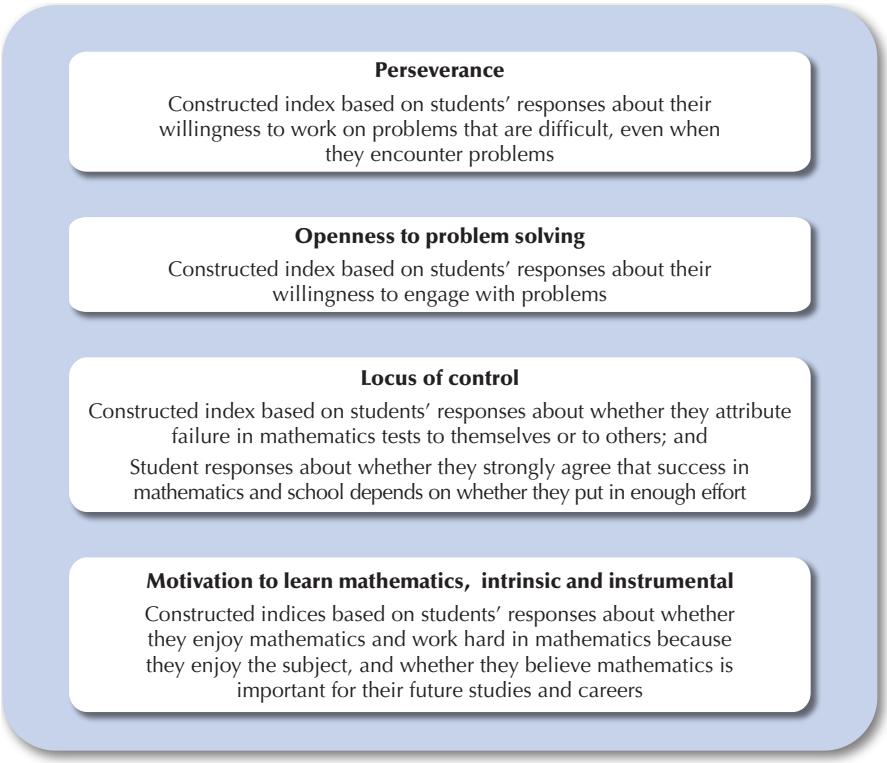
Psychologists and educators are increasingly interested in measuring students' capacity to work towards long-term goals, including their aptitude for self-discipline and perseverance in the face of difficulties and their ability to focus on clearly aligned goals and objectives (Greene, Miller, Crowson, Duke, and Aikey, 2004; Husman and Shell, 2008; Miller and Brickman, 2004; Zimmerman and Schunk, 2011). If students never encounter failure and are never challenged they will be unable to develop the stamina, perseverance and motivation that are needed to thrive in difficult conditions (Dweck, 1975; Dweck and Master, 2009). They will never discover the sense of *flow* that comes from being fully immersed in purposeful effort and the pleasure that comes from being completely and utterly focused on the task at hand (Csíkszentmihályi, 1990).

Students who have drive, stamina, perseverance and capacity for hard work do not necessarily have aptitude and talent too: talent and drive are personal attributes that are not necessarily correlated. In many cases, individuals with less raw potential, but greater stamina, perseverance and capacity for hard work are more likely to succeed than those who are talented but have little capacity to set ambitious goals for themselves and to keep focused on achieving them (Duckworth et al., 2007; Duckworth and Seligman, 2006; Duckworth et al., 2010; Zimmerman and Schunk, 2011). In fact, individuals who have talent and aptitude can, at times be less likely to develop a strong drive because they are initially at ease and are less likely to be confronted with failure, so that when they inevitably encounter difficulties, they might find themselves at a loss. This is particularly true for students who believe their abilities are fixed; such students do not believe that greater effort will improve their ability and performance.

PISA 2012 examines students' self-reports about their stamina, capacity for hard work and perception that success or failure depends on their behaviour (perceived self-responsibility for failing in mathematics and perceived control of success in school and mathematics). Advances in the understanding of what constitutes a mindset for hard work and what difference it makes for individual outcomes typically rely on a combination of both approaches – the examination of self-reports and of behaviours in controlled laboratory environments. Each approach suffers from limitations and sheds light on a different aspect of the development and deployment of an inclination towards hard work (Dweck, 2006). Self-reports can suffer from bias, particularly when comparing the responses of students from different countries (see Box III.2.2). At the same time, it is debatable whether students' behaviour when facing relatively controlled and well-defined tasks in a laboratory setting can provide valid insights into how they behave in real-world situations (Duckworth, 2013). In PISA 2012, the focus chosen was on students' self-reports.

▪ Figure III.3.1 ▪

How PISA 2012 measures students' drive and motivation



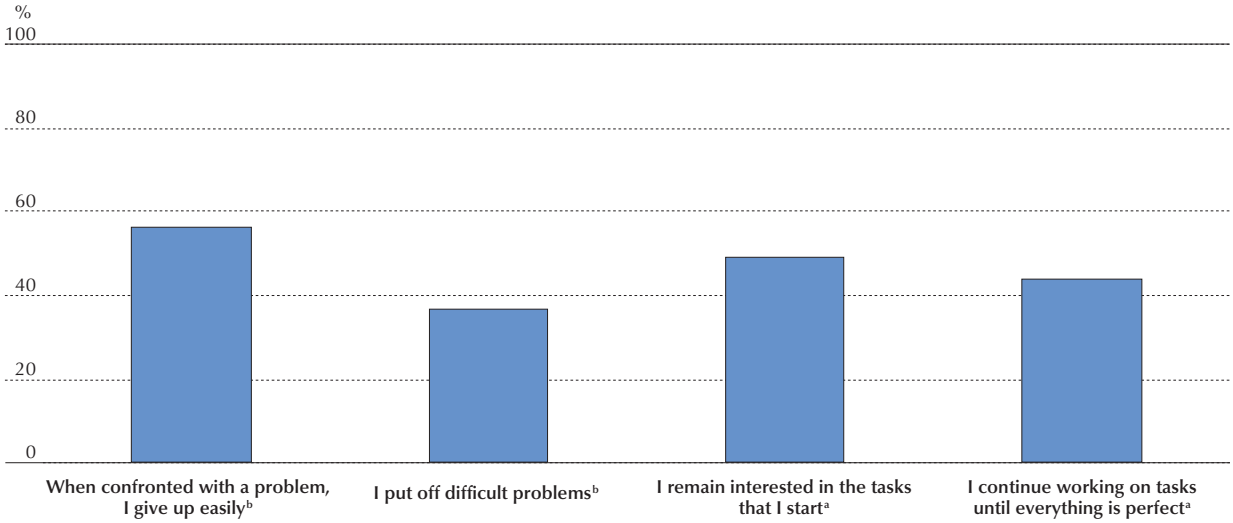
PERSEVERANCE

PISA measures students' perseverance through their responses to questions asking about the extent to which they feel they resemble someone who gives up easily when confronted with a problem, who puts off difficult problems, who remains interested in the tasks that he or she starts, who continues to work on a task until everything is perfect, and who does more than is expected of him or her when confronted with a problem. Student responses could range from: this person is "very much like me", "mostly like me", "somewhat like me", "not much like me" or "not at all like me" and were used to create the *index of perseverance*, standardised to have a mean of 0 and a standard deviation of 1 across OECD countries. Figure III.3.2 and Table III.3.1a show that across OECD countries, 56% of students indicated that they do not give up easily when confronted with a problem, 49% indicated that they remain interested in the tasks that they start, and 44% indicated that they continue working on tasks until everything is perfect. However the OECD average masks significant differences across countries and economies. For example, at least 70% of students in the Russian Federation, Kazakhstan and Poland reported that they do not give up easily when confronting problems; and in Jordan, the United Arab Emirates, Kazakhstan and Albania the same proportion of students reported that they continue to work on tasks until everything is perfect. In Japan, the Czech Republic, France, Chinese Taipei and Belgium however, fewer than one in three students reported that they continue to work on tasks until everything is perfect.

▪ Figure III.3.2 ▪

Students' perseverance

Percentage of students across OECD countries who reported that the following statements describe someone "very much like me" or "mostly like me" (a) or "not much like me" or "not at all like me" (b)



Note: Results for each participating country and economy can be found in Table III.3.1a.
Source: OECD, PISA 2012 Database, Table III.3.1a.
StatLink http://dx.doi.org/10.1787/888932963825

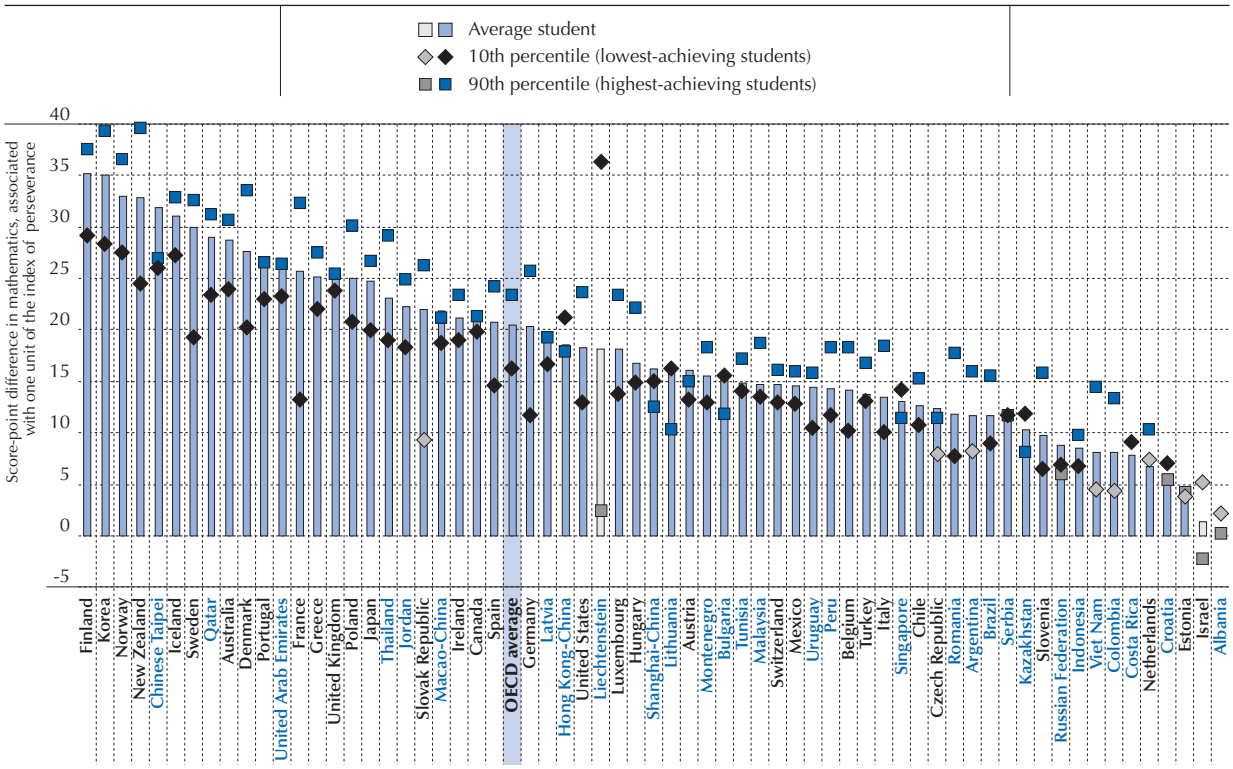
Students' self-reported levels of perseverance vary across countries: in 26 countries and economies boys reported higher levels of perseverance than girls, while in 17 countries and economies girls reported higher levels of perseverance than boys. Gender differences in favour of girls are particularly wide in Montenegro, Bulgaria and Peru while gender differences in favour of boys are particularly wide in the United Kingdom, Germany, Austria, France, Sweden, Denmark, Switzerland, Norway and Korea (Tables III.3.1b, III.3.1d and III.3.7a). In general, countries with large gender gaps in self-reported levels of perseverance are countries with above average gender gaps in mathematics performance (see Chapter 7 of this volume). Differences in students' self-reported levels of perseverance based on socio-economic status reveal that, in 25 countries and economies that participated in PISA 2012, socio-economically advantaged students reported higher levels of perseverance than less-advantaged students (Figure III.3.2) and disparities related to socio-economic status tend to be particularly wide in Finland, Kazakhstan and Liechtenstein (Table III.3.7b).

As Figure III.3.3 shows, students who reported that they continue to work on tasks until everything is perfect, remain interested in the tasks they start, do not give up easily when confronted with a problem and, in fact, when confronted with a problem, do more than is expected of them, have higher scores in mathematics than students who reported lower levels of perseverance (Table III.3.1c). The blue bar in Figure III.3.3 illustrates the estimated difference in mathematics performance that is associated with a difference of one unit in the *index of perseverance*. This difference corresponds roughly to the difference in self-reported levels of perseverance that can be expected between the average student in OECD countries and a student who reported levels of perseverance that place him or her among a group of students with comparatively high levels of perseverance (levels of perseverance that are lower than those reported by only 16.5% of students across OECD countries (see Box III.2.3).

Across OECD countries, 6% of the variation in student performance in mathematics can be explained by differences in whether students perceive themselves as someone who gives up easily when confronted with a problem, who puts off difficult problems, who remains interested in the tasks that he or she starts, who continues to work on a task until everything is perfect, and who does more than is expected of him or her when confronted with a problem (Table III.3.1d). In Norway, Finland, Iceland, Sweden and Denmark more than 10% of the variation in mathematics performance is explained by students' self-reported perseverance, while in 43 other countries and economies, less than 5% is. In most countries and economies the association between students' perseverance and mathematics performance is relatively strong: in 25 countries and economies, a difference of one unit in the *index of perseverance* is associated with a difference in performance of at least 20 score points; and in Finland, Korea, Norway, New Zealand, Chinese Taipei and Iceland, this difference is larger than 30 score points (Table III.3.1d).

▪ Figure III.3.3 ▪

Relationship between perseverance 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 one unit of the index of *perseverance.*
Source: OECD, PISA 2012 Database, Table III.3.1e.
StatLink http://dx.doi.org/10.1787/888932963825

Results presented in Figure III.3.3 indicate that the relationship between perseverance and mathematics performance is stronger among the highest-achieving students than among the lowest-achieving students. In 10 countries and economies, the magnitude of the performance gap that is associated with a one-unit change in the *index of perseverance* among the highest- and the lowest-achieving students is 10 score points or more. For example, in France, the difference in scores that is associated with a one-unit change in the *index of perseverance* is 32 points among the highest-achieving students, but only 13 points among the lowest-achieving students. Among the highest-achieving students in Germany, Viet Nam and Slovenia, that difference is at least 14 points, but among the lowest-achieving students there is no association between self-reported perseverance and performance in mathematics. Liechtenstein is an important exception to this trend, as in Liechtenstein perseverance is not associated with mathematics performance among the highest-achieving students but it is strongly associated with performance among the lowest-achieving students.

OPENNESS TO PROBLEM SOLVING

Students need to be willing to engage with problems and to be open to new challenges in order to be able to solve complex problems and situations. Proficiency in mathematics, but also other subjects, requires a mix of content knowledge and willingness to engage with new material. PISA measures students' openness to problem solving through their responses to questions asking about the extent to which they feel they resemble someone who can handle a lot of information, is quick to understand things, seeks explanations for things, can easily link facts together and likes to solve complex problems. Student responses could range from: this person is "very much like me", "mostly like me", "somewhat like me", "not much like me" or "not at all like me". Figure III.3.4 and Table III.3.2a show that across OECD countries, 53% of students indicated that they can handle a lot of information, 57% reported that they are quick to understand things, 61% reported that they seek explanation for things, 57% reported that they can easily link facts together, and only 33% that they like to solve complex problems. However, the OECD average masks significant differences across countries and economies. For example at least 70% of students in Montenegro, Jordan, Albania,

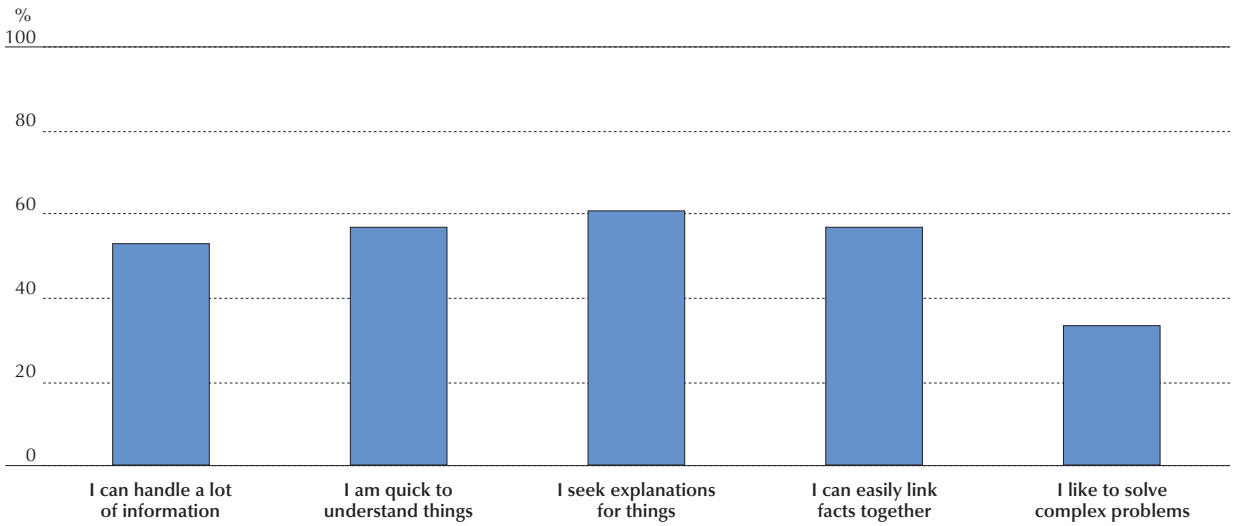
Serbia, the United Arab Emirates and Qatar reported that they can handle a lot of information. Fewer than one in four students in Viet Nam, Belgium, Korea, the Slovak Republic and Japan reported that they like to solve complex problems, while more than one in two students in Montenegro, Jordan, Kazakhstan, Albania and Qatar reported the same (Table III.3.2a).

In general, boys more than girls tended to report that they resemble a student who handles a lot of information, who is quick to understand things and seeks explanations for things. In 52 countries and economies, boys have higher values on the *index of openness to problem solving* than girls; in no country do girls have higher values on this index than boys (Table III.3.2d). Socio-economic differences in students' openness to problem solving are particularly wide – in favour of advantaged students – in 34 countries and economies, and are widest in Denmark, Latvia, Liechtenstein, Portugal and Shanghai-China (Table III.3.7b).

▪ Figure III.3.4 ▪

Openness to problem solving

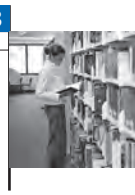
Percentage of students across OECD countries who reported "agree" or "strongly agree" with the following statements:



Note: Results for each participating country and economy can be found in Table III.3.2a.
Source: OECD, PISA 2012 Database, Table III.3.2a.
StatLink http://dx.doi.org/10.1787/888932963825

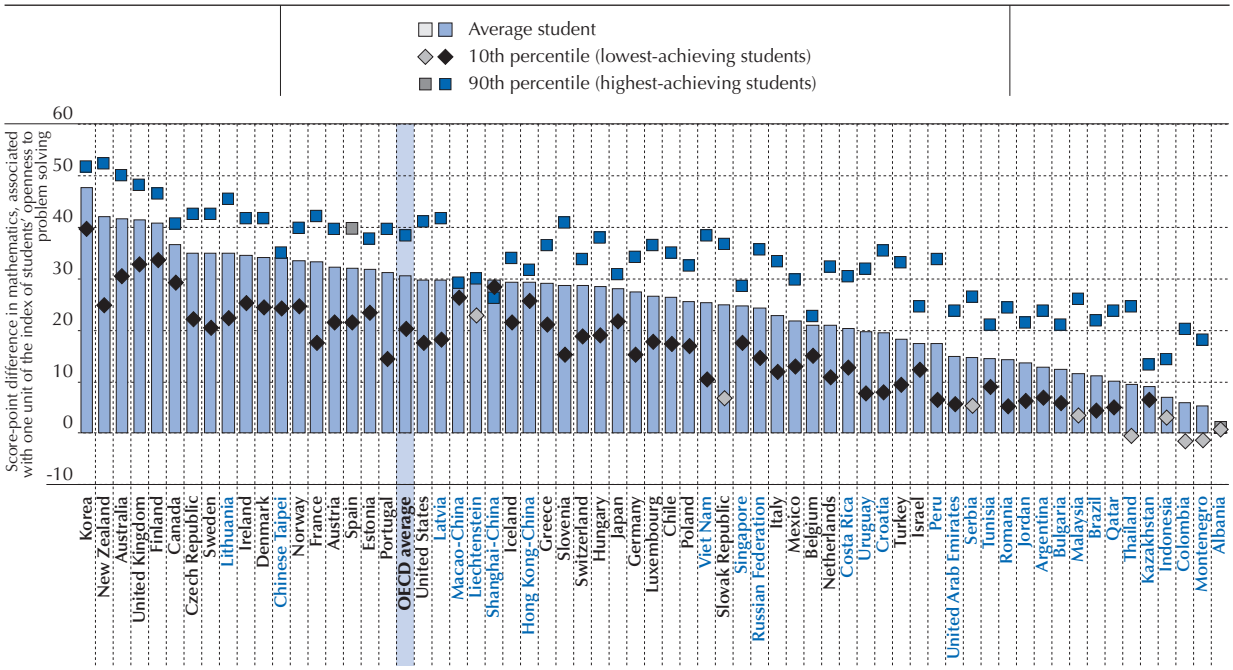
Across OECD countries, 12% of the variation in student performance in mathematics can be explained by differences in whether students perceive themselves as someone who can handle a lot of information, who is quick to understand things, who seeks explanations for things, who can easily link facts together or who likes to solve complex problems (Table III.3.2d). In Finland, Norway, Australia, Canada, Korea, the United Kingdom, Sweden, New Zealand, Denmark and Ireland more than 15% of the variation in mathematics performance is explained by students' self-reported openness to problem solving while in 45 other countries and economies, less than 10% is. In most countries and economies the association between students' openness to problem solving and mathematics performance is strong: in 44 countries and economies, a difference of one unit in the *index of openness to problem solving* is associated with a difference in performance of at least 20 score points; and in Korea, New Zealand, Australia, the United Kingdom and Finland, this difference is larger than 40 score points.

Results presented in Figure III.3.5 indicate that the relationship between openness to problem solving and mathematics performance is stronger among the highest-achieving students than among the lowest-achieving students (Table III.3.2e). In all countries and economies but Shanghai-China, Albania, Macao-China, Hong Kong-China, Kazakhstan, Liechtenstein, Belgium and Japan, the difference in the magnitude of the performance gap that is associated with a one-unit change in the *index of openness to problem solving* among the highest- and the lowest-achieving students is larger than 10 score points. For example, in the Slovak Republic and Viet Nam the performance gap among the highest-achieving students is 30 and 28 score points, respectively, while no association is estimated among the lowest-achieving students. In as many as 10 countries and economies openness to problem solving is not associated with performance at the bottom of the performance distribution while it is strongly associated with performance differences at the top of the distribution (Table III.3.2c).



▪ Figure III.3.5 ▪

Relationship between openness to problem solving 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 one unit of the index of students' openness to problem solving.
Source: OECD, PISA 2012 Database, Table III.3.2e.
StatLink http://dx.doi.org/10.1787/888932963825

LOCUS OF CONTROL

Perceived self-responsibility for failing in mathematics

Although students differ in innate intelligence and abilities, these qualities are also influenced, to a large extent, by environmental factors. The "Flynn effect" documents large improvements in IQ scores over time (Flynn, 1987). While other explanations have been proposed and critics question the validity of the Flynn effect, the basic principle that environmental factors play a major role in how genetically determined traits are expressed is in line with a growing body of evidence (see, for example, Rutter and Silberg, 2002; Rutter, 2010). While the Flynn effect documents changes in IQ scores among populations, recent research indicates that individual IQ scores can change in the teenage years, and maps such changes to alterations in brain structures (Ramsden et al., 2011; Price, 2013).

Students who took part in the PISA 2012 assessment were asked to imagine the following scenario: "Each week your mathematics teacher gives a short quiz. Recently you have done badly on these quizzes. Today you are trying to figure out why." Students were asked to report whether they were very likely, likely, slightly likely or not at all likely to think or feel that they are not very good at solving mathematics problems; that their teacher did not explain the concepts well this week; that this week they made bad guesses on the quiz; that sometimes the course material is too hard; that the teacher did not get the students' interested in the material; and that sometimes they are just unlucky. Students' responses to this hypothetical scenario were used to construct the *index of self-responsibility for failing in mathematics*, which reflects students' perceptions of their personal responsibility for failure in mathematics. Students with high values on this index tend to attribute the responsibility for failure in solving mathematics problems to themselves, while students with low values on the index are more likely to see other individuals or factors as responsible.

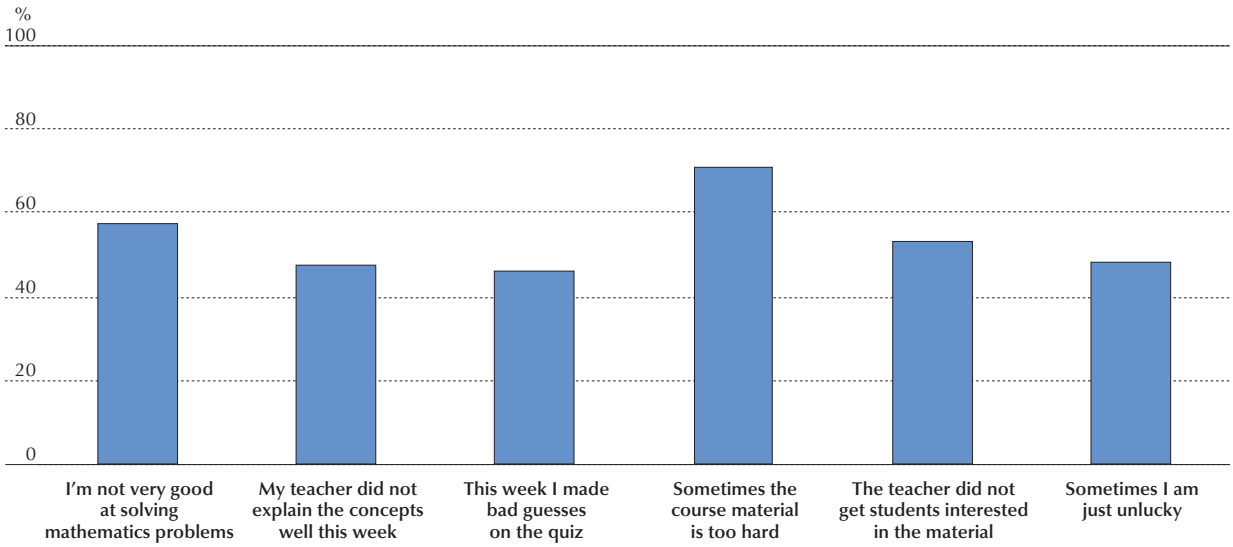
Across OECD countries, 58% of students reported that when doing badly on a teacher-administered quiz, they would think that they are not very good at solving mathematics problems; 48% would think that the teacher did not explain the concepts well; 46% would feel that they made bad guesses on the quiz; 71% would think that the course material was too hard; 53% that the teacher did not get students interested in the material; and 49% would feel that sometimes they are just unlucky (Table III.3.3a). Students in Bulgaria, Indonesia, Albania, Thailand, Spain, Viet Nam, Italy and Chile

are particularly likely to feel responsible for their failure in mathematics: in all these countries and economies more than 70% of students reported that they are just not very good at solving mathematics problems, while in Kazakhstan, the United States, Korea, Liechtenstein, Iceland, Austria, and Germany one in two students or fewer reported the same. Overall, the groups of students who tend to perform more poorly in mathematics – girls and socio-economically disadvantaged students – feel more responsible for failing mathematics tests than students who generally perform at higher levels (Tables III.3.3b and 3.3c).

▪ Figure III.3.6 ▪

Perceived self-responsibility for failing in mathematics

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



Note: Results for each participating country and economy can be found in Table III.3.3a.
Source: OECD, PISA 2012 Database, Table III.3.3a.
StatLink http://dx.doi.org/10.1787/888932963825

Perceived control of success in mathematics and at school

PISA measures students' perceived control of success in mathematics and also their perceived control of success at school through their responses as to whether they "strongly agree", "agree", "disagree" or "strongly disagree" that if they put enough effort they can succeed in mathematics (at school), that it is completely their choice whether or not they do well in mathematics (at school), that family demands or other problems prevent them from putting a lot of time into their mathematics work (school work), that if they had different teachers, they would try harder in mathematics (at school), that they could perform well in mathematics (at school) if they wanted, and that they perform poorly in mathematics (at school) whether or not they study for their exams.

Table III.3.3d shows that, across OECD countries, 92% of students reported that they agree or strongly agree that they can succeed in mathematics if they put enough effort, 83% reported that whether they do well in mathematics or not is completely up to them, 73% disagreed or strongly disagreed that family demands or other problems prevent them from putting a lot of time into their mathematics work, 83% reported that they agree or strongly agree that they could do well in mathematics if they wanted to. However, perceived control of success in mathematics differs greatly across countries and between boys and girls. For example, fewer than 85% of students agreed or strongly agreed that they can succeed in mathematics if they put enough effort in Macao-China, the Netherlands and Japan, while more than 98% of students reported the same in Singapore, Colombia and Indonesia (Table III.3.3e). Similarly, in the Netherlands, Liechtenstein, Germany, Macao-China, Switzerland and Luxembourg the difference in the proportion of boys and the proportion of girls who reported that they agree or strongly agree that they can succeed in mathematics if they put enough effort is larger than five percentage points.

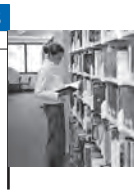
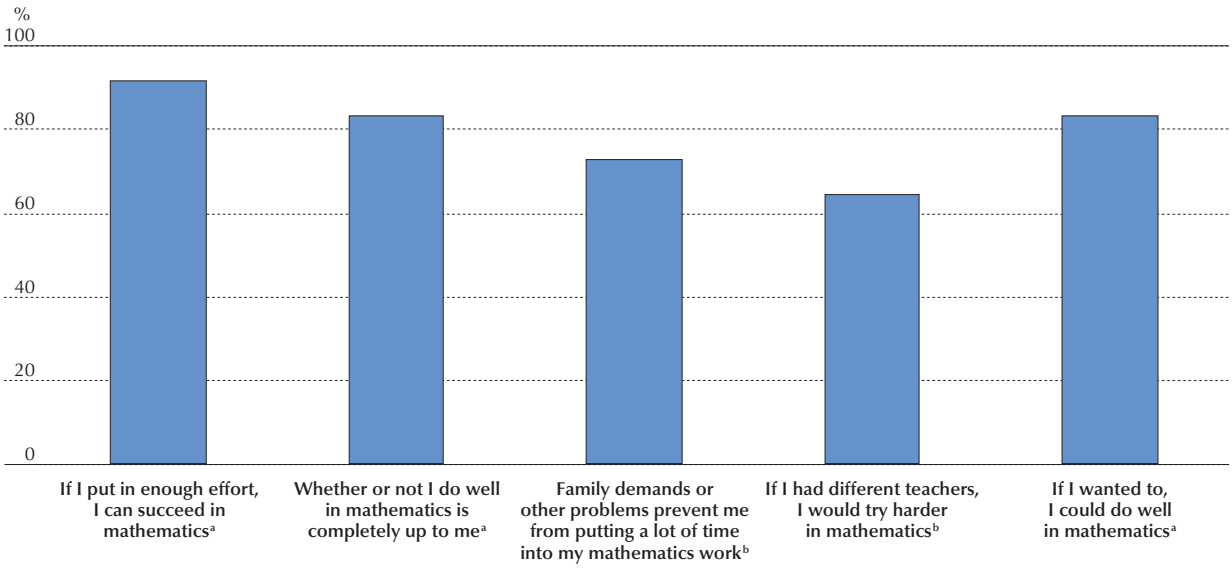


Table III.3.3h shows even more widespread agreement with statements that reflect students' perceived control of their success at school compared with their responses concerning success in mathematics. Across OECD countries, 96% of students reported that they agree or strongly agree that they can succeed in school if they put enough effort, 86% reported that whether they do well in school or not is completely up to them, 65% disagreed or strongly disagreed that family demands or other problems prevent them from putting a lot of time into their school work, 59% disagreed or strongly disagreed that they would try harder at school if they had different teachers, and 80% disagreed or strongly disagreed that they perform poorly at school whether or not they study for their exams. Large variations exist between countries in the extent to which students report feelings of control over their performance in school. For example, fewer than 70% of students in Thailand, Qatar, Argentina, Japan, the Slovak Republic, Uruguay, Lithuania disagreed or strongly disagreed that they perform poorly at school whether they study hard for their exams or not, but over 85% of students in Viet Nam, Denmark, Estonia, the United Kingdom and Liechtenstein reported the same. Differences in the extent to which boys and girls reported low levels of perceived control of success in school are smaller than those observed concerning perceived control of success in mathematics; and in many countries and for several indicators, girls reported greater feelings of control than boys (Table III.3.3i). For example, on average across OECD countries, the same percentage of boys and girls (96% and 97%) agreed or strongly agreed that they can succeed in school if they put in enough effort. Similarly, 86% of boys and girls reported that it is completely their choice whether or not they do well in school, and 65% of boys and girls disagreed or strongly disagreed that family demands or other problems prevent them from putting a lot of time into their school work.

▪ Figure III.3.7 ▪

Perceived control of success in mathematics

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



Note: Results for each participating country and economy can be found in Table III.3.3d.
Source: OECD, PISA 2012 Database, Table III.3.3d.
StatLink http://dx.doi.org/10.1787/888932963825

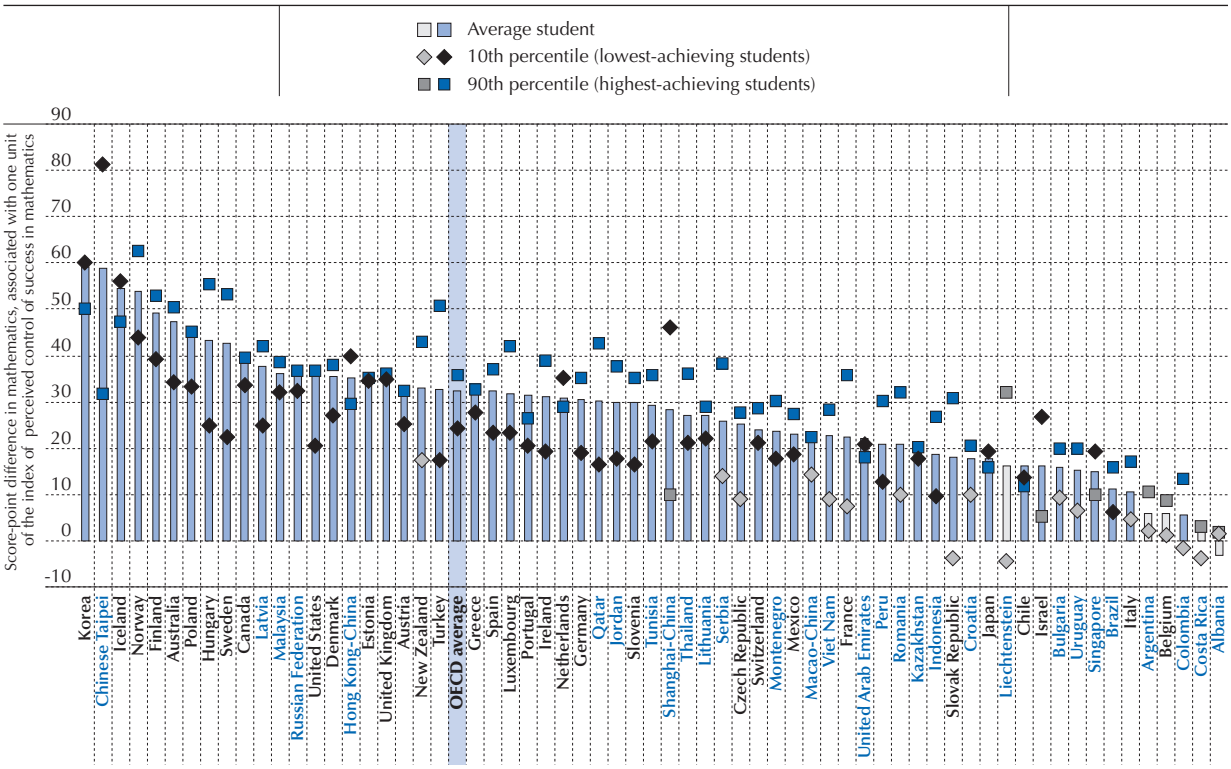
On average across OECD countries, students who reported that they strongly agree that they can succeed in mathematics and in school if they put in enough effort perform at higher levels than other students (Tables III.3.3g and III.3.3k). The difference in mathematics performance that is associated with students strongly agreeing that they can succeed in mathematics if they put in enough effort is 32 score points, while the difference in mathematics performance that is associated with students strongly agreeing that they can succeed in school if they put enough effort is 13 score points. Albania, Belgium, Argentina, Costa Rica and Liechtenstein are the only countries where perceived control of success in mathematics is not associated with mathematics performance, and the score-point change in mathematics performance that is associated with students strongly agreeing that they can succeed in mathematics if they put in enough effort is 50 points or larger in Korea, Chinese Taipei, Iceland and Norway. The relationship between perceived control of success

in school and mathematics performance is weaker only in Iceland, Korea, Australia, Norway, Chinese Taipei and Thailand where the score point difference is 25 points or larger (Table III.3.3k).

The relationship between perceived control of success in mathematics and mathematics performance is stronger at the top of the performance distribution than at the bottom of the distribution. Across OECD countries, students at the 90th percentile of performance who strongly agree that they can succeed in mathematics if they put in enough effort have a performance advantage of 36 score points over students who did not report that they strongly agree with the same statement. This difference is only 24 score points at the 10th percentile of performance. In 24 countries and economies the difference is 15 score points or more, and it is particularly large, at 30 score points or more, in the Slovak Republic, Turkey, Hungary and Sweden. Singapore, Israel and Shanghai-China are notable exceptions: in all these countries and economies, perceived control of success in mathematics is associated with mathematics performance at the bottom of the distribution but not at the top; and in Chinese Taipei perceived control of success in mathematics is more strongly associated with mathematics performance at the bottom than at the top of the performance distribution (Table III.3.3g).

▪ Figure III.3.8 ▪

Relationship between perceived control of success in mathematics and mathematics performance

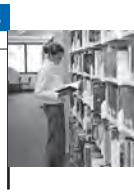


Note: Differences that are statistically significant at the 5% level ($p < 0.05$) are marked in a darker tone.
Countries and economies are ranked in descending order of the average score-point difference in mathematics that is associated with students strongly agreeing that they can succeed in mathematics if they put enough effort.
Source: OECD, PISA 2012 Database, Table III.3.3g.
StatLink http://dx.doi.org/10.1787/888932963825

MOTIVATION TO LEARN MATHEMATICS

Intrinsic motivation to learn mathematics

Motivation and engagement can be regarded as the driving forces behind learning. Given the importance of mathematics for students' future lives, school systems need to ensure that students have not only the knowledge that is necessary to continue learning mathematics beyond formal schooling, but also the interest and motivation that will make them want to do so. PISA distinguishes two forms of motivation to learn mathematics: students may learn mathematics because they enjoy it and find it interesting and/or because they perceive learning mathematics as useful. These two constructs are central in self-determination theory (Ryan and Deci, 2009) and expectancy-value theory (Wigfield, Tonks and Klauda, 2009).



Intrinsic motivation refers to the drive to perform an activity purely for the joy gained from the activity itself. Students are intrinsically motivated to learn mathematics when they want to do so because they find learning mathematics interesting and enjoyable and because it gives them pleasure, not because of what they will be able to achieve upon mastering mathematical concepts and solving mathematics problems (Gottried, 1990; Ryan and Deci, 2009). Interest and enjoyment affects both the degree and continuity of engagement in learning and the depth of understanding reached (Schiefele, 2009). Intrinsic motivation affects the degree of student engagement, the learning activities in which students enrol, student performance, and the types of careers students aspire to and choose to pursue (Reeve, 2012). Generally, intrinsic motivation dissipates from elementary school to higher education (Gottfried, Fleming and Gottfried, 2001; Gottfried et al., 2013; Jacobs et al., 2002) because as students grow older their interests become increasingly differentiated (OECD, 2004). Students' intrinsic motivation for mathematics also declines because of the increasing difficulty of mathematics, and because of teaching practices that undermine, rather than foster, motivation for learning mathematics (Midgley, Feldlaufer and Eccles, 1989). However, students' enjoyment of, and interest in, mathematics can be shaped by what teachers do, by students' peers, by classroom instruction and dynamics, and by parents' attitudes and behaviour (see Wigfield et al., 2006 and Chapters 5 and 6 of this volume).

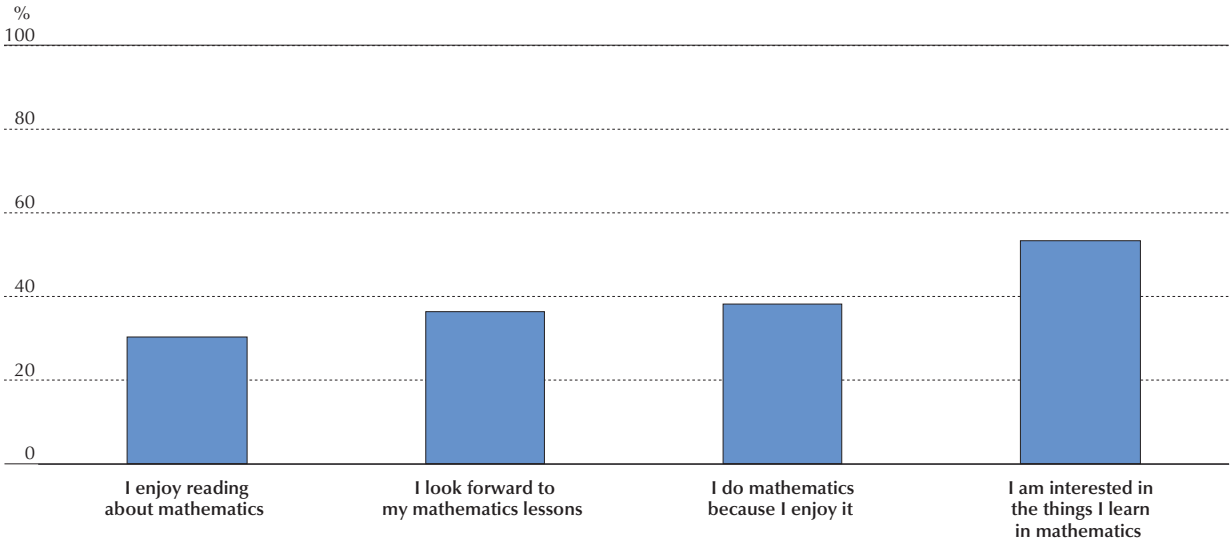
PISA measures students' intrinsic motivation to learn mathematics through students' responses as to whether they "strongly agree", "agree", "disagree" or "strongly disagree" that they enjoy reading about mathematics; that they look forward to mathematics lessons; and that they do mathematics because they enjoy it and that they are interested in the things they learn in mathematics. As Figure III.3.9 and Table III.3.4a show, across OECD countries 38% of students reported that they agree or strongly agree that they do mathematics because they enjoy it and 53% reported that they are interested in the things they learn in mathematics. However, the OECD average masks significant differences across countries and economies. For example, at least 70% of students in Indonesia, Malaysia, Kazakhstan, Thailand and Albania reported enjoying mathematics; and at least 80% of students in Albania, Thailand, Colombia, Peru, Mexico, Kazakhstan, Jordan and Malaysia reported being interested in the things they learn in mathematics. In Croatia, Austria, Serbia, Slovenia, Hungary, the Slovak Republic, Finland and Belgium, however, only 30% of students, at most, enjoy mathematics, while in the Slovak Republic, Croatia, Slovenia and Japan, fewer than 40% of students reported being interested in the things they learn in mathematics.

Between 2003 and 2012, students' intrinsic motivation to learn mathematics improved in 17 countries and economies.[3] In Iceland, for example, the *index of intrinsic motivation to learn mathematics* increased by around 0.3 units. Specifically, this means that the share of students reporting that they look forward to their mathematics lessons increased by

▪ Figure III.3.9 ▪

Students' intrinsic motivation to learn mathematics

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

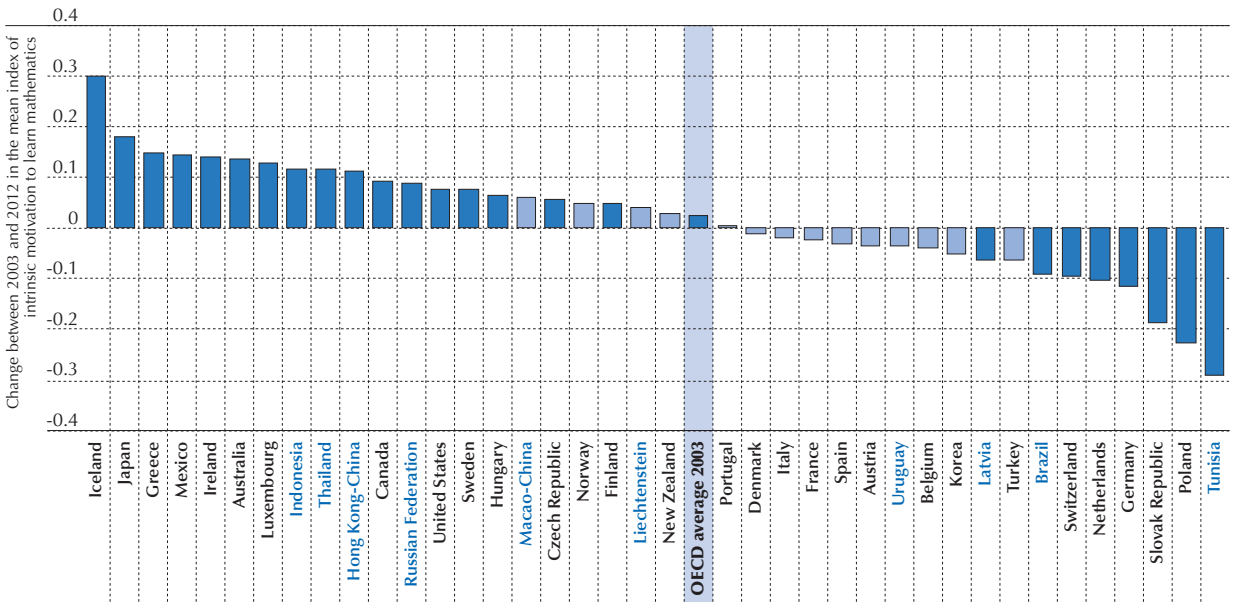


Note: Results for each participating country and economy can be found in Table III.3.4a.
Source: OECD, PISA 2012 Database, Table III.3.4a.
StatLink http://dx.doi.org/10.1787/888932963825

16 percentage points, the share of students doing mathematics because they enjoy it grew by 10 percentage points, the share of students interested in the things they learn in mathematics increased by 9 percentage points, and the share of students who enjoy reading about mathematics grew by 5 percentage points during the period. Similarly, in Japan, Greece, Mexico, Ireland, Australia, Luxembourg, Indonesia, Thailand and Hong Kong-China, more students showed greater intrinsic motivation to learn mathematics as the *index of intrinsic motivation to learn mathematics* increased by more than 0.1 units (Japan's improvement in PISA and recent educational policies and programmes is outlined in Box III.3.1[4]). More concretely, in Mexico, while half of students in 2003 reported looking forward to their mathematics classes, 70% of students in 2012 reported so. Similarly, in Greece, the percentage of students who reported being interested in the things that they learn in mathematics increased by 14 percentage points during the period. By contrast, the *index of intrinsic motivation to learn mathematics* fell by more than 0.1 units in Tunisia, Poland, the Slovak Republic, Germany and the Netherlands. In Poland, for example, a smaller share of students in 2012 than in 2003 reported that they enjoy learning mathematics (15 percentage-point decline), look forward to mathematics lessons (9 percentage-point decline), study mathematics because they enjoy it (9 percentage-point decline), and are interested in the things learned in mathematics (6 percentage-point decline) (Figure III.3.10 and Table III.3.4f).

▪ Figure III.3.10 ▪

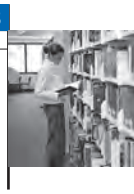
Change between 2003 and 2012 in students' intrinsic motivation to learn mathematics



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 intrinsic motivation to learn mathematics since 2003.
Countries and economies are ranked in descending order of the index of intrinsic motivation to learn mathematics *in PISA 2012.*
Source: OECD, PISA 2012 Database, Table III.3.4f.
StatLink http://dx.doi.org/10.1787/888932963825

Improvements in students' intrinsic motivation to learn mathematics between 2003 and 2012 were observed in countries and economies where improvements in students' instrumental motivation to learn mathematics, mathematics self-concept and sense of belonging were also observed (correlations of the changes in these indices over the period, at the country/economy level, of 0.5, 0.4 and 0.4, respectively, see Table III.4.10). Mathematics self-concept is, as described in more detail in Chapter 4, students' beliefs in their own mathematics abilities while instrumental motivation to learn mathematics is the drive to learn mathematics because students perceive it as useful to them and to their future studies and careers.

In general, as noted above, students who participated in PISA 2012 have relatively low levels of enjoyment of mathematics and intrinsic motivation to learn mathematics, but this is particularly true among girls and socio-economically disadvantaged students (Tables III.3.4b, III.3.4c, III.3.7a and III.3.7b). Across OECD countries, the difference in the proportion of boys and girls who are interested in the things they learn in mathematics is nine percentage points: 58% of

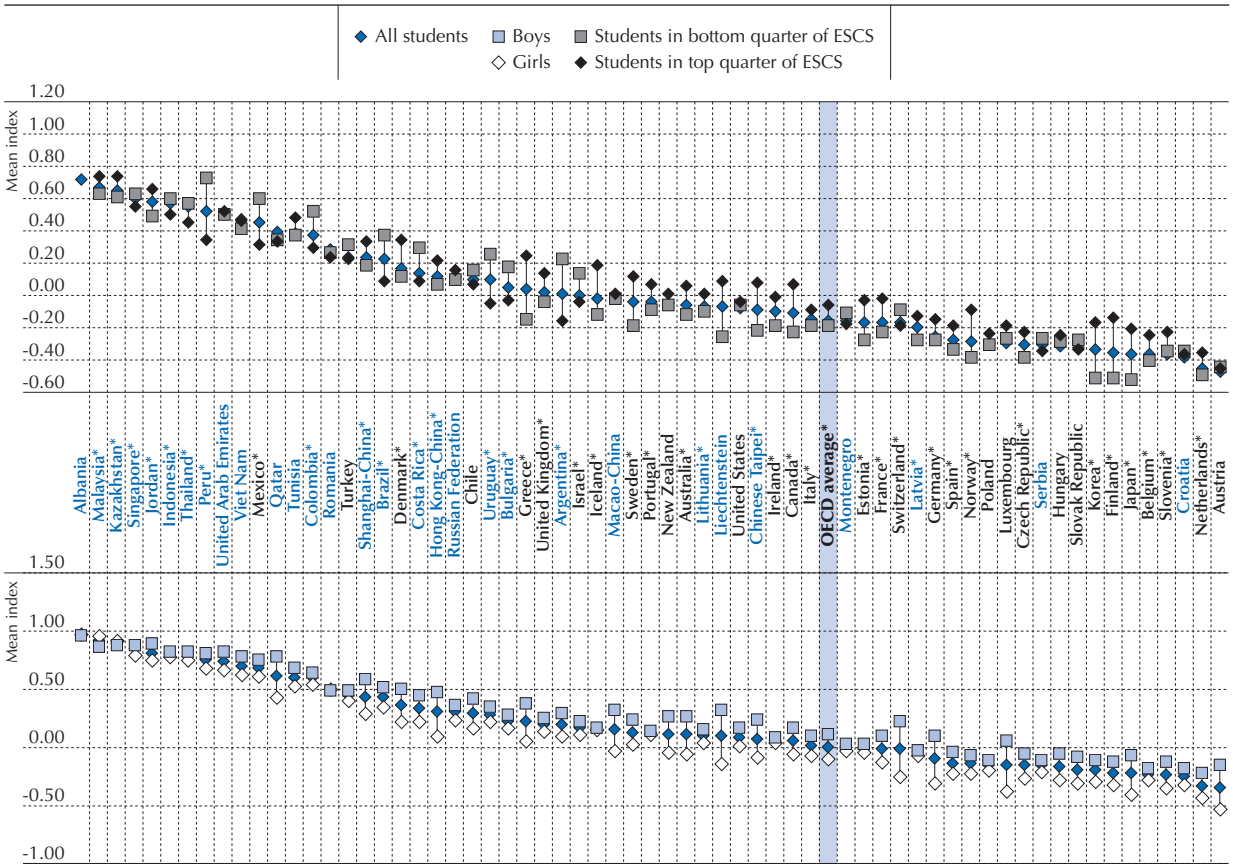


boys, but only 49% of girls, reported being interested in the things they learn in mathematics (Table III.3.4a). Similarly, 42% of boys, but only 35% of girls across OECD countries reported doing mathematics because they enjoy it. Gender differences in intrinsic motivation to learn mathematics are especially wide in Switzerland, Liechtenstein, Luxembourg and Germany; and in as many as 52 countries and economies boys have higher levels of intrinsic motivation to learn mathematics than girls (Table III.3.4d).

In general, and on average across OECD countries with comparable data from PISA 2003 and PISA 2012, intrinsic motivation has remained stable for boys and girls, but socio-economic disparities in intrinsic motivation – favouring advantaged students – widened slightly in the period. In the Russian Federation, Hong Kong-China, Hungary and Australia, boys' *index of intrinsic motivation to learn mathematics* improved to a greater extent than girls'; only in Finland and Norway was the improvement in intrinsic motivation among girls greater than that among boys. On average across OECD countries, advantaged students' motivation improved while that of disadvantaged students remained stable. This difference is particularly marked in Iceland, Australia, Ireland, Canada, Hong Kong-China, Mexico, the Russian Federation and Greece. In Uruguay, Thailand and Norway, intrinsic motivation to learn mathematics improved for disadvantaged students while there was no concurrent change among advantaged students; therefore the gap narrowed (Figures III.3.12a and b).

▪ Figure III.3.11 ▪

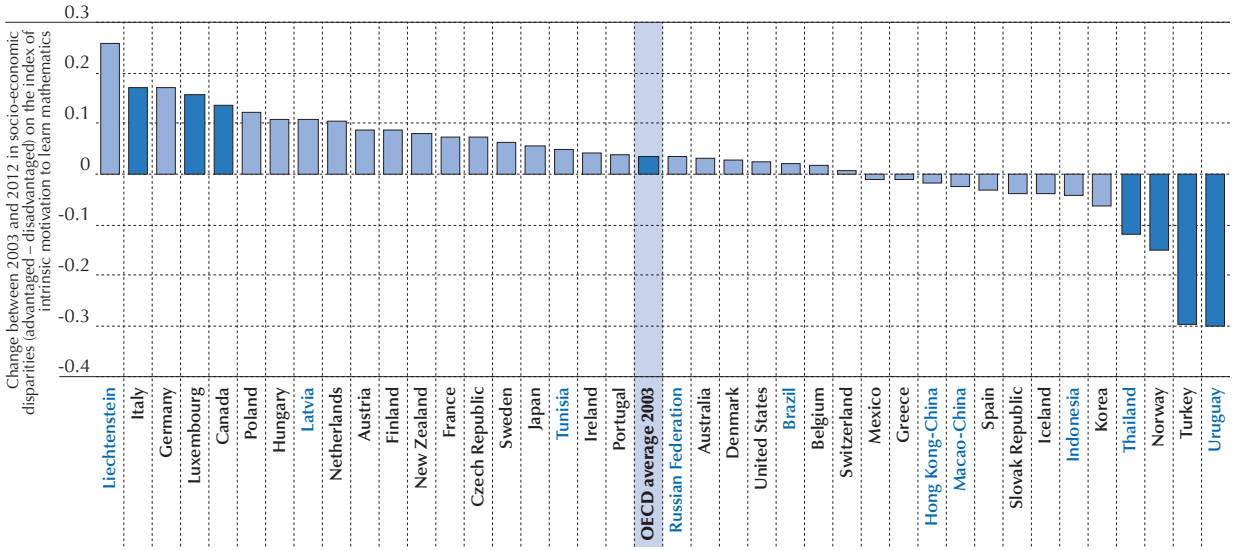
Gender and socio-economic differences in students' intrinsic motivation to learn mathematics



Notes: ESCS refers to the *PISA index of economic, social and cultural status*.
Countries/economies where the gender/socio-economic gap is statistically significant at the 5% level ($p < 0.05$) are indicated with an asterisk.
Countries and economies are ranked in descending order the mean index of intrinsic motivation to learn mathematics *of all students.*
Source: OECD, PISA 2012 Database, Tables III.3.4c and III.3.4d.
StatLink http://dx.doi.org/10.1787/888932963825

▪ Figure III.3.12a ▪

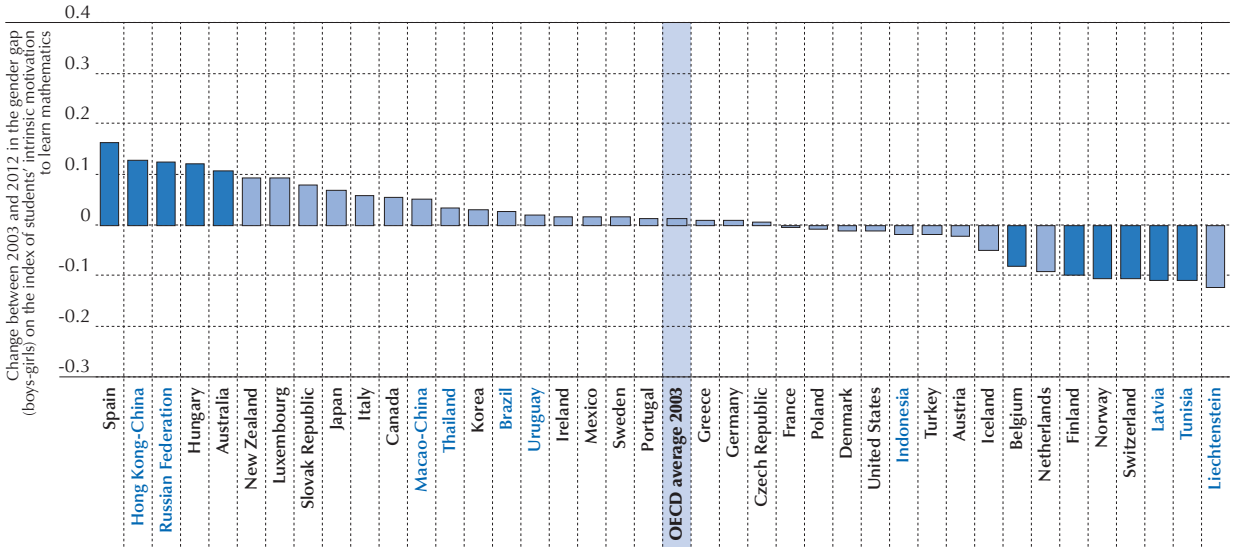
Change between 2003 and 2012 in socio-economic disparities in students' intrinsic motivation to learn mathematics



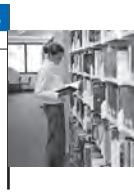
Notes: Statistically significant changes at the 5% level ($p < 0.05$) between PISA 2003 and 2012 are marked in a darker tone.
Advantaged/disadvantaged students are students in the top/bottom quarter of the *PISA index of economic, social and cultural status*.
Only countries and economies with comparable data from PISA 2003 and PISA 2012 are shown.
OECD average 2003 compares only OECD countries with comparable indices of intrinsic motivation to learn mathematics since 2003.
Countries and economies are ranked in descending order of the change in the socio-economic disparities on the index of intrinsic motivation to learn mathematics *between PISA 2003 and PISA 2012.*
Source: OECD, PISA 2012 Database, Table III.3.4g.
StatLink http://dx.doi.org/10.1787/888932963825

▪ Figure III.3.12b ▪

Change between 2003 and 2012 in the gender gap in students' intrinsic motivation to learn mathematics



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 intrinsic motivation to learn mathematics since 2003.
Countries and economies are ranked in descending order of the change in the gender gap on the index of students' intrinsic motivation to learn mathematics *between PISA 2003 and PISA 2012.*
Source: OECD, PISA 2012 Database, Table III.3.4g.
StatLink http://dx.doi.org/10.1787/888932963825

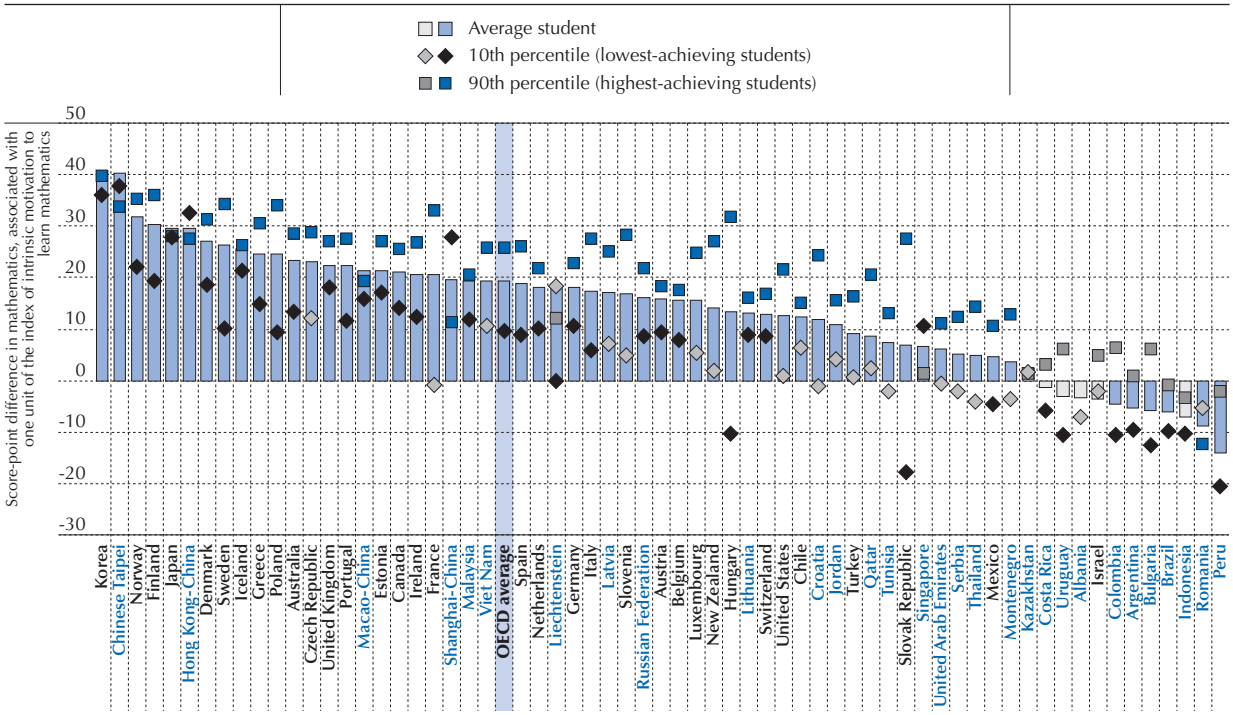


As Figure III.3.13 indicates, students who reported low levels of interest in and enjoyment of mathematics, who do not look forward to mathematics lessons, and who reported not being interested in the things they learn in mathematics generally do not score as high in mathematics as those who reported that they enjoy mathematics and that they are interested in mathematics lessons. On average across OECD countries, a change in one unit in the *index of intrinsic motivation to learn mathematics* translates into a 19 score-point difference in mathematics performance. However, the strength of this association varies greatly across countries. In Korea and Chinese Taipei, the difference is greater than 40 score points, and in 21 countries and economies it is larger than 20 score points, while in Peru, Romania, Brazil, Bulgaria, Argentina and Colombia, students with higher levels of intrinsic motivation to learn mathematics perform less well in mathematics than students with lower levels (Table III.3.4d). Across OECD countries, 5% of the variation in students' mathematics performance can be explained by differences in students' intrinsic motivation to learn mathematics; in six countries and economies, more than 10% of the variation is so explained. The strength of the relationship between students' levels of intrinsic motivation to learn mathematics and their mathematics performance observed in PISA 2012 is similar to that observed in PISA 2003 across OECD countries with comparable data, and for all countries and economies (Table III.3.9).

The relationship between students' motivation and mathematics performance is significantly stronger among the highest-achieving students than among the lowest-achieving students. While greater motivation can give the highest-achieving students an edge in performance, among the lowest-achieving, motivation seems to have little relationship with performance. On average across OECD countries, the performance difference that is associated with a change of one unit in the *index of intrinsic motivation to learn mathematics* is 26 score points among the highest-achieving students but only 10 points among the lowest-achieving students. As Figure III.3.13 shows, the difference in the strength of the association between intrinsic motivation to learn mathematics and mathematics performance among the highest- and lowest-achieving students is more than 10 score points in 40 countries and is larger than 20 points in the Slovak Republic, Hungary, France, Croatia and New Zealand. Shanghai-China is an important exception: in Shanghai-China, a change of one unit in the *index of intrinsic motivation to learn mathematics* is associated with a performance difference of 28 points among the lowest-achieving students but a difference of only 11 score points among the highest-achieving students. However, in Shanghai-China, the lowest-achieving students are high achievers in comparison with students in other countries (Table I.2.3a)

▪ Figure III.3.13 ▪

Relationship between intrinsic motivation to learn mathematics 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 that is associated with one unit of the index of intrinsic motivation *to learn mathematics.*
Source: OECD, PISA 2012 Database, Table III.3.4e.
StatLink http://dx.doi.org/10.1787/888932963825

Instrumental motivation to learn mathematics

Instrumental motivation to learn mathematics refers to the drive to learn mathematics because students perceive it as useful to them and to their future studies and careers (see Eccles and Wigfield, 2002; Miller and Brickman, 2004). PISA measures the extent to which students feel that mathematics is relevant to their own lives through students' responses as to whether they "strongly agree", "agree", "disagree" or "strongly disagree" that making an effort in mathematics is worth it because it will help them in the work that they want to do later on; because learning mathematics can improve their career prospects and chances; because they need mathematics for what they want to study later on; and because learning many things in mathematics will help them get a job.

As shown in Figure III.3.14 and Table III.3.5a, students who participated in PISA 2012 recognise the value of mathematics in the labour market and as a way to improve their career prospects. Students' appreciation of the instrumental value of mathematics is reflected in the very high percentage of students who agree or strongly agree that learning mathematics will improve their career prospects: across OECD countries, 78% of students responded this way. Similarly, on average across OECD countries, 70% of students believe that learning many things in mathematics will help them get a job, and 75% of students reported that making an effort in mathematics is worth it because it will help them in the work that they want to do later on in life.

Between 2003 and 2012, instrumental motivation to learn mathematics has remained relatively stable among students, on average across OECD countries with comparable data on the period. The share of students who reported that learning mathematics is worthwhile because it will help them in the work that they want to do later on, it will improve their career prospects, because it is needed for what they want to study later on, or because it will help them get a job decreased by less than one percentage point. Reductions in instrumental motivation to learn are significant in eight countries and economies, particularly in the Slovak Republic, Macao-China, Poland and the Czech Republic, where students' value on the index slipped by at least 0.1 points. In the Slovak Republic, for example, the percentage of students who reported that they will learn things that will be useful to get a job decreased by 14 percentage points; in Poland, the share of students who reported that they will learn many things in mathematics that will help them get a job shrank by 13 percentage points. By contrast, the *index of instrumental motivation to learn mathematics* increased in 17 countries and economies, particularly in Sweden, Liechtenstein, Japan, Luxembourg, Greece, Latvia, Austria and Hungary. In these countries, it increased by at least 0.1 point (Figure III.3.15 and Table III.3.5f).

Instrumental motivation to learn mathematics tended to increase among those countries that also observed improvements in intrinsic motivation to learn mathematics and improved attitudes toward school (correlations at the country level of 0.5 in both cases, see Table III.4.10).

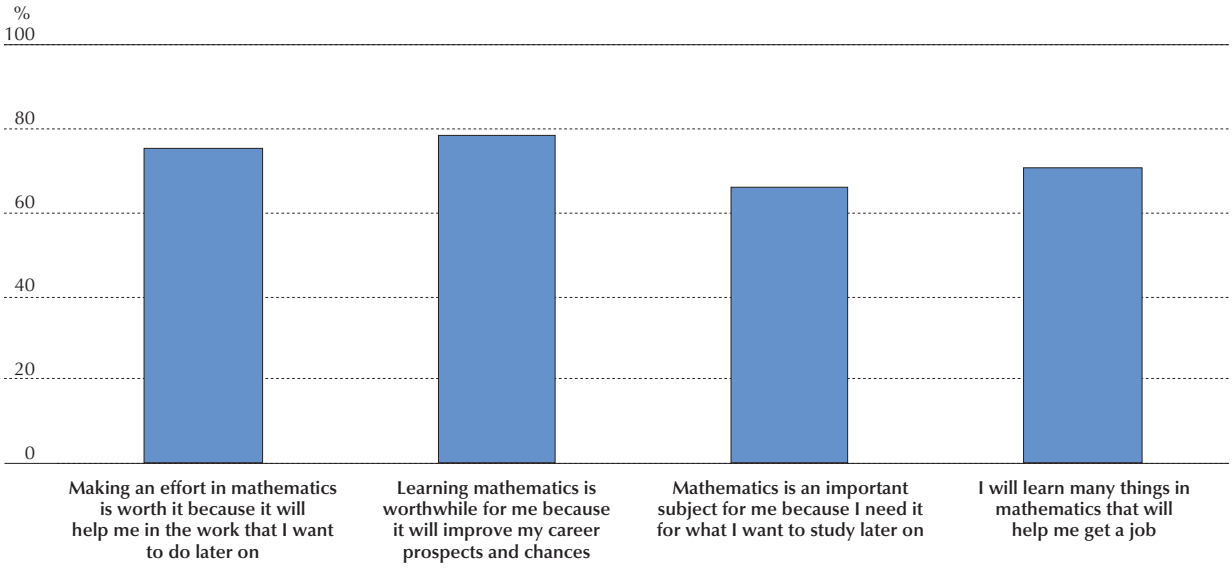
Boys tend to be more conscious than girls of the value mathematics in the labour market and as a way to improve career prospects (Figure III.3.16). Table III.3.5b indicates that, on average across OECD countries, 78% of boys, but only 72% of girls, believe that making an effort in mathematics is worth it because it will help them in the work they want to do later on in life. Similarly, across OECD countries, 71% of boys, but only 61% of girls, agree that mathematics is an important subject because they will need it for what they want to study later on. These gender differences partly reflect differences in mathematics performance; but, in 45 countries and economies, boys and girls with similar performance in mathematics still do not have similar views about mathematics as instrumental to their education and career plans (see Table III.7.2a in Chapter 7 of this volume). In 45 countries and economies, boys were more likely than girls to report higher levels of instrumental motivation to learn mathematics; only in Malaysia, Thailand and Jordan did girls report higher levels than boys. Gender differences in favour of boys are largest in Switzerland, Austria, Luxembourg and Liechtenstein (Table III.3.5d). Gender differences in instrumental motivation to learn mathematics reflect differences in the expectations students have to enter fields of study and have careers in occupations that require strong mathematical skills (Sikora and Pokropek, 2011).

As Figure III.3.17 indicates, students who reported low levels of instrumental motivation to learn mathematics generally do not score as high in mathematics as those who reported that learning many things in mathematics will help them get a job or that learning mathematics is worthwhile because it will improve their career prospects and chances. On average across OECD countries, a change of one unit in the *index of instrumental motivation to learn mathematics* translates into a 17 score-point difference (Table III.3.5d). However, the strength of this association varies greatly across countries. In Korea, Chinese Taipei and Norway, the difference is greater than 30 score points, and in 16 countries and economies it is larger than 20 score points, while in Romania, Brazil, Colombia and Uruguay students with higher levels of instrumental motivation to learn mathematics perform less well in mathematics than students with lower levels (Table III.3.5d). Across

▪ Figure III.3.14 ▪

Students' instrumental motivation to learn mathematics

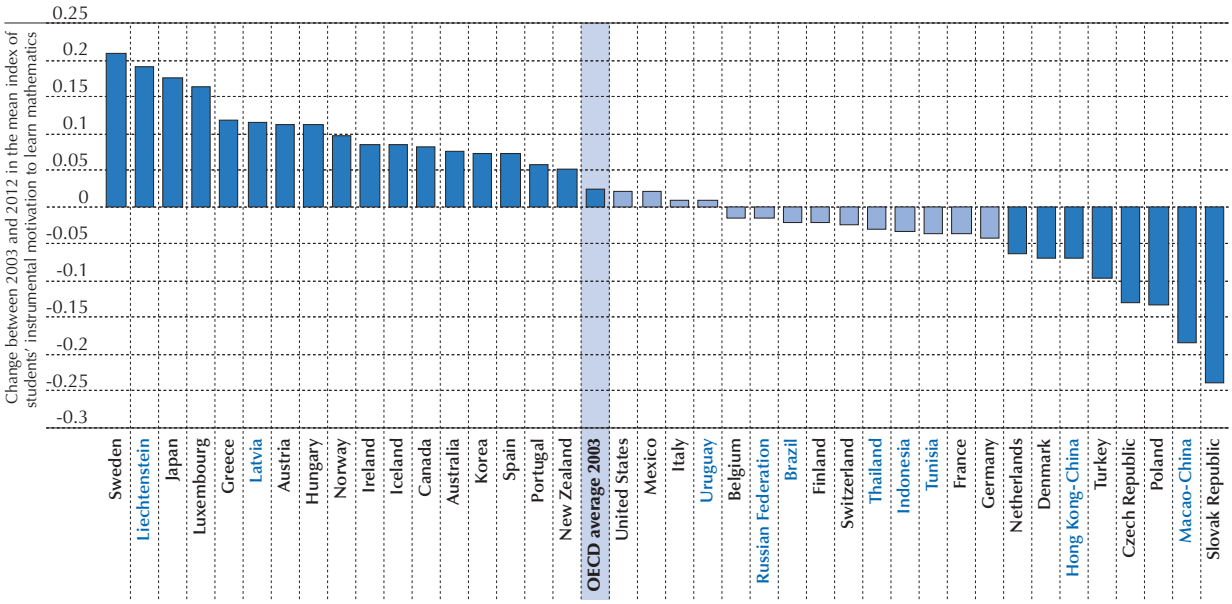
Percentage of students across OECD countries who reported "agree" or "strongly agree" with the following statements:



Note: Results for each participating country and economy can be found in Table III.3.5a.
Source: OECD, PISA 2012 database, Table III.3.5a.
StatLink http://dx.doi.org/10.1787/888932963825

▪ Figure III.3.15 ▪

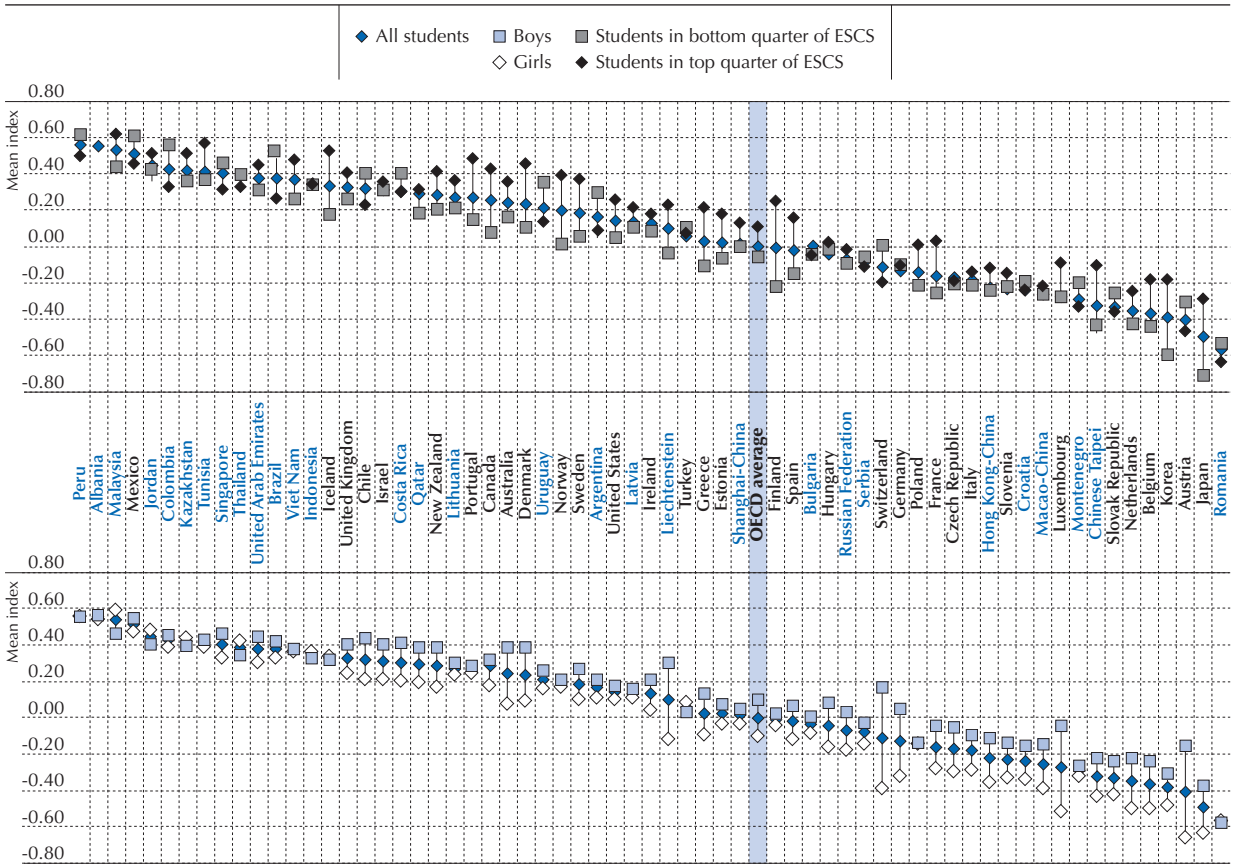
Change between 2003 and 2012 in students' instrumental motivation to learn mathematics



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 instrumental motivation to learn mathematics since 2003.
Countries and economies are ranked in descending order of the change in the index of instrumental motivation to learn mathematics *between PISA 2003 and PISA 2012.*
Source: OECD, PISA 2012 Database, Table III.3.5f.
StatLink http://dx.doi.org/10.1787/888932963825

▪ Figure III.3.16 ▪

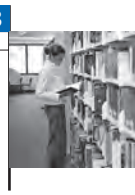
Gender and socio-economic differences in students' instrumental motivation to learn mathematics



Note: ESCS refers to the *PISA index of economic, social and cultural status*.
Countries and economies are ranked in descending order the mean index of instrumental motivation to learn mathematics *of all students.*
Source: OECD, PISA 2012 Database, Tables III.3.5c and III.3.5d.
StatLink http://dx.doi.org/10.1787/888932963825

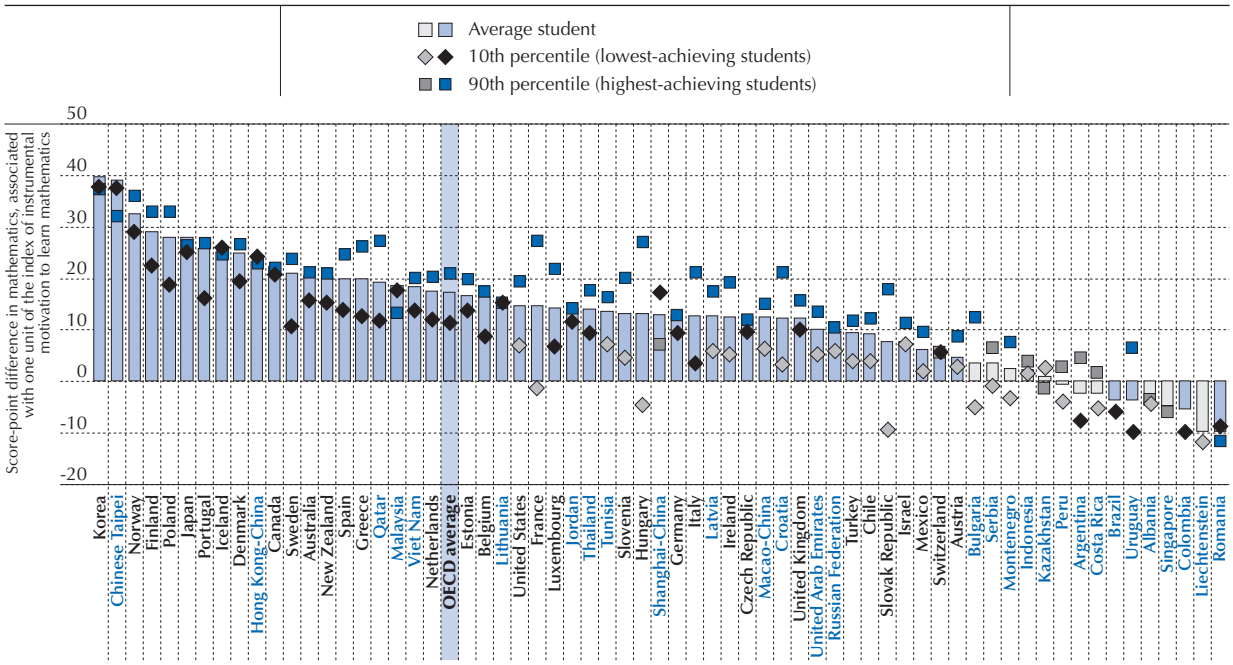
OECD countries, 4% of the variation in students' mathematics performance can be explained by differences in students' instrumental motivation to learn mathematics. As with intrinsic motivation to learn mathematics, the relationship between instrumental motivation to learn mathematics and students' mathematics performance was moderately strong in 2003 and remained so in 2012, both on average across OECD countries with comparable data and among individual countries and economies (Table III.3.8).

The relationship between students' instrumental motivation and mathematics performance is significantly stronger among the highest-achieving students than among the lowest-achieving students. Figure III.3.17 indicates that while greater motivation can give the highest-achieving students an edge in performance, among the lowest-achieving, motivation seems to be less related to performance. On average across OECD countries, the performance difference that is associated with a change of one unit in the *index of instrumental motivation to learn mathematics* is 21 score points among the highest-achieving students but only 11 points among the lowest-achieving students (Table III.3.5e).



▪ Figure III.3.17 ▪

Relationship between instrumental motivation to learn mathematics 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 *that is associated with one unit of the* index of instrumental motivation to learn mathematics.
Source: OECD, PISA 2012 Database, Table III.3.5e.
StatLink http://dx.doi.org/10.1787/888932963825

Box III.3.1. **Improving in PISA: Japan**

Japanese students are consistently among the top performers in PISA. Japan's mean score in reading in both 2000 (520 points) and 2009 (522 points) placed the country among the top ten performers in the world. Between PISA 2009 and PISA 2012, average reading scores improved to 538 points, showing that improvements are possible even among top-performing countries. In science, similar improvement was observed between PISA 2006 and PISA 2012 as average scores improved from 531 to 547 points, at an average rate of 2.6 points per year.[5]

Despite these high levels of performance, PISA results prompted wide discussion of policy reforms to offer equal opportunities to all children and a curriculum appropriate for the 21st century. In 2006, Japan amended the Basic Act on Education, which had regulated education services for the previous 60 years. The amendment modified the legal framework, the stated objectives of education, introduced a system for renewing educational personnel certificates and revised the administration of local education authorities to improve the role of the local boards of education. These changes implied moving towards an education model that emphasised a good balance between cognitive and non-cognitive knowledge and skills. The implementation of these policies shed light on possible sources of Japan's improvement in PISA; further study is required to assess the extent of the contribution of each policy to explain Japan's positive PISA trends.

The Course of Study is Japan's national standard that guides schools' curricula and classroom times, ensuring the common content is taught and the common educational level is assured across the country. It is revised almost every ten years; the latest revisions were made in 2008 and implemented universally in 2011 and 2012. These revisions reoriented the basic objectives of Japanese education to ensure not only that children learn basic fundamental knowledge and skills, but that child learn how to think, make decisions, and express themselves. The new course of study balances specific knowledge and skills with their practical use. As a result of these changes, course content is now in line with PISA's concepts of competencies, literacy and proficiency.

…

The new course of study adds learning time in Japanese language, social studies, arithmetic, science, and physical education by two classes per week in the lower grades, and one class per week in the middle and upper grades. This can be seen as a rebalancing effort, following a significant reduction in curricular content early in the 2000s. In lower secondary schools, it adds one class per week in each grade in Japanese language, social studies, arithmetic, science, foreign language, and health/physical education. In line with these changes, PISA results show that students in 2012 spent an average of 18 more minutes per week in mathematics classes per week compare to students in PISA 2003 (see Table IV.84 in Volmue IV). More important than the increase in learning time in absolute terms, the reform reshaped how that time is used to give students more time to think, judge and discuss the subject content. Many schools also allotted a short time each day for students to read, which seems to have fostered greater enjoyment of reading and led to improvements in reading skills.

Previous PISA results highlighted comparatively low levels of engagement, motivation and mathematics self-beliefs among Japanese students. When compared to students in 2003, however, Japanese students in 2012 reported a stronger sense of belonging, lower rates of tardiness, better attitudes towards school, and higher levels of intrinsic and instrumental motivation to learn mathematics. In the past decade, the student experience and the relationship between schools and the community also changed. School-community co-operation has become indispensable. For example, parents and community members now take some responsibilities for managing schools and help in teachers' lessons to encourage the connection between school and the outside world. Coincidentally, students in 2009 were more likely to enjoy reading and perform better in open-ended constructed tasks than their counterparts in 2000 (OECD, 2010).

With the introduction of the system for renewing educational personnel certificates, teachers have to attend 30 hours of training every ten years and pass an examination in the certificate renewal course at a university for the acquisition of the latest knowledge and skills. Assessment and accountability measures were also introduced in 2007 in the form of the National Assessment of Academic Ability in mathematics and Japanese. Results of this assessment of students in the sixth year of elementary school and the third year of lower secondary school give local policy makers and administrators information about student achievement and are used by teachers to improve learning.

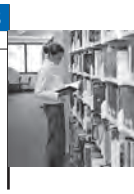
Source:

OECD (2010), *PISA 2009 Initial Report: Learning Trends (Volume V)*, PISA, OECD Publishing.

THE ROLE OF GENDER AND SOCIO-ECONOMIC DIFFERENCES IN IN THE RELATIONSHIP BETWEEN STUDENTS' DRIVE AND MOTIVATION AND PERFORMANCE

In order to examine whether the results presented above reflect differences in the composition of the highest-achieving and lowest-achieving students, results presented in Tables III.3.1c, III.3.2c, III.3.3c, III.3.3e, III.3.3g, III.3.4e and III.3.5e illustrate two sets of models. The first set, which is used in previous sections of this chapter, reports results with the key factor of interest as the only independent variable. The second set reports results that control for students' socio-economic status and gender in addition to the key factor of interest. Therefore, they represent the difference in performance that is associated with students' drive and motivation among the highest- and lowest-achieving students of the same gender and with similar socio-economic status.

Tables III.3.1e and III.3.4e show results for self-reported intrinsic motivation to learn mathematics among the highest-achieving and lowest-achieving students and how these change when controlling for students' socio-economic status and gender. Results indicate that, in the majority of countries, relationships are relatively unaffected both at the top and at the bottom of the performance distribution. Among the lowest-achieving students, results indicate that, on average across OECD countries, relationships remain relatively stable. However, among this group of students in the United States, Poland, New Zealand, Finland, Luxembourg, France, Turkey, Sweden, Portugal, Mexico, Latvia, Thailand, Bulgaria, Jordan, the United Arab Emirates, Argentina, Peru, Costa Rica, Montenegro, Tunisia, Qatar, Colombia, Liechtenstein and Serbia, the relationship between intrinsic motivation and mathematics performance is stronger when comparing students with similar socio-economic and demographic characteristics (Table III.3.4e). At the top of the performance distribution, the relationship between perseverance and mathematics performance is relatively stable, but it is grows weaker in all countries and economies except Costa Rica when comparing students with the same socio-economic status and of the same gender. In New Zealand, Korea and Portugal, controlling for gender and socio-economic status reduces the score-point difference among high-performing students by more than seven points (Table III.3.1e).



Notes

1. Brain plasticity refers to the brain's ability to change during an individual's life. Changes occur because human babies are born with an immature brain, but also because the brain is able to reorganise itself following traumatic events, such as brain injury, and to adapt to the environment individuals experience. Human babies have a particularly underdeveloped brain compared to infants of other species: human newborn brains on average are only 30% of the average adult size brain (altriciality), but, thanks to neuroplasticity continue to mature after birth. Two hypotheses have been proposed to explain this unique human characteristic. The anthropological hypothesis suggests that the main constraint to gestation length and fetal growth is the pelvic morphology that allows for upright locomotion. The metabolic hypothesis suggests that the main constraint to gestation length and fetal growth is maternal metabolism (see Lovejoy, 1981; Dunsworth et al., 2012).

2. For example, Gaser and Schlaug (2003) found that the volume of the cerebral cortex in the motor regions, anterior superior parietal areas and inferior temporal (areas that are known to be involved in playing music) is largest in professional musicians, medium-sized in amateur musicians, and smallest in non-musicians. Draganski et al. (2006) showed that extensive learning of abstract information can also trigger changes in specific regions of the brain. Medical students' brains underwent profound changes in the parietal cortex and in the posterior hippocampus regions (areas that are known to be involved in memory retrieval and learning) when studying for their medical exams. Similarly, Mechelli et al. (2004) document brain plasticity in the brains of bilingual individuals: compared to people who speak only one language, bilingual individuals have larger left inferior parietal cortex than monolingual individuals. Finally Maguire, Woollett, and Spiers (2006) document that the posterior region of the hippocampus is larger among London taxi drivers than it is among London bus drivers. This region of the hippocampus is specialised in acquiring and using complex spatial information and while bus drivers follow a limited set of routes when travelling in the city traffic, taxi drivers do not follow specific navigation patterns. The study was conducted before the advent of cheap and reliable Global Positioning System (GPS) devices which are aiding the work of taxi drivers in large cities, but also reducing the stimulation their brains undergo with practice.

3. The *index of intrinsic motivation to learn mathematics* was called the *index of interest and enjoyment in mathematics* in PISA 2003 (see OECD, 2004). Only the name changes, while the construct and measurement in the context of the PISA student background questionnaire remains the same.

4. Chapter 4 of this volume and other volumes of this series highlight other country's improvements in PISA and outline their recent policy trajectories (e.g. Portugal in Chapter 4 of this volume, Brazil, Turkey, Korea and Estonia in Volume I, Mexico and Germany in Volume II, and Colombia, Israel, Poland and Tunisia in Volume IV).

5. Between PISA 2000 and PISA 2003 Japan's reading scores declined from 522 to 498 points. In PISA 2000, reading was a major domain, while in PISA 2003 reading was a minor domain. As a result, only a subset of the reading items used in PISA 2000 were included in the PISA 2003 reading assessment. These items (known as "link items" because they allow for a link between PISA 2000 scores and future assessments) were particularly difficult in Japan. The observed decline influenced by the choice of reading items included in the PISA 2003 and PISA 2006. In PISA 2009 reading was again a major domain and Japan's reading performance can be more confidently compared to PISA 2000 results.

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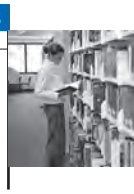

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