3

Students' attitudes towards science and expectations of science-related careers

This chapter focuses on student engagement with science and attitudes towards science as measured through students' responses to the PISA background questionnaire. The chapter examines differences in students' career expectations, science activities, intrinsic and extrinsic motivation for learning science, and beliefs about their abilities in science. It investigates how students' attitudes towards science are associated with their expectations of future study and work in science- and technology-related fields, particularly among students who are highly proficient in science, and how students' beliefs about their abilities in science are related to performance in science.

A note regarding Israel

The statistical data for Israel are supplied by and under the responsibility of the relevant Israeli authorities. The use of such data by the OECD is without prejudice to the status of the Golan Heights, East Jerusalem and Israeli settlements in the West Bank under the terms of international law.

In recent decades, educationalists and policy makers have become more attentive to the affective dimensions of learning science. Concerns have grown that the proportions of students – particularly girls – who choose careers in science are insufficient. The assumption is that nurturing motivation and interest in science at the critical ages when students begin to think about their future careers will help increase the share of students who pursue a career in science or in science-based technology (OECD, 2008).

While educating and encouraging the next generation of scientists, engineers and health professionals is one of the goals of science education, experts in many countries – including Australia (Tytler, 2007), the European Union (Gago et al., 2004), and the United States (Holdren, Lander and Varmus, 2010; Olson and Gerardi Riordan, 2012) – have recently expressed concern about declines in enrolment and graduation rates for science-related fields or about perceived shortages of science graduates in the labour market. Beyond all this, in a world that is increasingly shaped by science-based technology, strong foundation skills in science are essential if people want to participate fully in society.

Students' current and future engagement with science is shaped by two forces: how students think about themselves – what they think they are good at and what they think is good for them – and students' attitudes towards science and towards science-related activities – that is, whether they perceive these activities as important, enjoyable and useful. Self-beliefs, identity, value judgements and affective states are shaped, in turn, by the wider social context in which students live; they are all intertwined. Together, they form the basis of major theories about motivation for learning and career choice, such as the expectancy-value theory (Wigfield and Eccles, 2000) and the social-cognitive career theory (Lent et al., 2008).

What the data tell us

- On average across OECD countries, 25% of boys and 24% of girls reported that they expect to work in an occupation that requires further science training beyond compulsory education. Boys and girls tend to think of working in different fields of science. Girls envisage themselves as health professionals more than boys do; and in almost all countries, boys see themselves as becoming information and communication technology (ICT) professionals, scientists or engineers more than girls do.
- Boys are more likely than girls to participate in science-related activities, such as watching TV programmes about science, visiting websites about science topics, or reading science articles in newspapers or magazines.
- Countries that saw increases in their students' instrumental motivation to learn science – their perception that studying science in school is useful to their future lives and careers – also saw increases between 2006 and 2015 in their students' enjoyment of learning science, on average.
- Expectations of future careers in science are positively related to performance in science and to enjoyment of learning science, even after accounting for performance. The relationship with enjoyment is stronger among higher-achieving students than among lower-achieving students. But socio-economic status also matters: in a majority of countries and economies, more advantaged students are more likely to expect a career in science – even among students who perform similarly in science and reported similar enjoyment of learning science.
- Girls often reported less self-efficacy in science than boys. Performance gaps between high-achieving boys and girls tend to be larger in countries/economies with large differences in how confident boys and girls feel in understanding scientific information, discussing scientific issues or explaining phenomena scientifically.

In 2015, PISA examined students' engagement with science and their expectations of having a science-related career. Students were asked about the occupation they expect to be working in when they are 30 years old. Students' responses were later grouped into major categories of science-related and non-science-related careers for the purpose of the analysis. Another question asked students to report their current participation in a range of (elective) science-related activities.

PISA also measured a range of aspects that relate to students' motivation to learn science through questions about their enjoyment of science (how interesting and fun students find learning science), their interest in broad science topics, and their instrumental motivation for science learning (whether they perceive school science as useful for their future study and career plans).

Science self-efficacy – the extent to which students believe in their own ability to handle science tasks effectively and overcome difficulties – was also measured in PISA. Self-efficacy is not the only aspect of students' self-image that is expected to influence their engagement in science; but while self-efficacy was the explicit focus of a question in the student questionnaire, the influence of other self-beliefs, such as whether students believe a career in science is good for them, can only be indirectly assessed by relating students' engagement and career expectations to their gender, socio-economic status, and other information available through the student and parent questionnaires. Figure I.3.1 summarises the aspects of science engagement, motivation and self-beliefs discussed in this chapter.

Figure I.3.1 ▪ **Science engagement and career expectations, science self-beliefs and motivation for learning science**

Science engagement	Motivation for learning science	Science self-beliefs
Science career expectations: A categorical variable based on students' open-entry answers to the question "What kind of job do you expect to have when you are about 30 years old?"	**Enjoyment of science:** Constructed index based on students' responses to questions about their enjoyment of doing and learning science	**Self-efficacy in science:** Constructed index based on students' responses to questions about their perceived ability to use their knowledge of science in real-world situations (e.g. to understand and analyse news reports or to participate in discussions about science topics)
Science activities: Constructed index based on students' responses to questions about their participation in a range of science-related activities	**Interest in broad science topics:** Students' reports about their interest in topics such as "the biosphere", "motion and forces", "the universe and its history", "the prevention of disease"	
	Instrumental motivation for learning science: Constructed index based on students' responses to questions about their perceptions of how useful school science is for their study and career plans	

Students' engagement with science, motivation for learning science and science self-beliefs are discussed in this chapter in the order in which they appear in Figure I.3.1. The chapter also discusses how motivation and performance help nurture the choice of a science-related study and career path.

CURRENT AND FUTURE ENGAGEMENT WITH SCIENCE AMONG 15-YEAR-OLDS

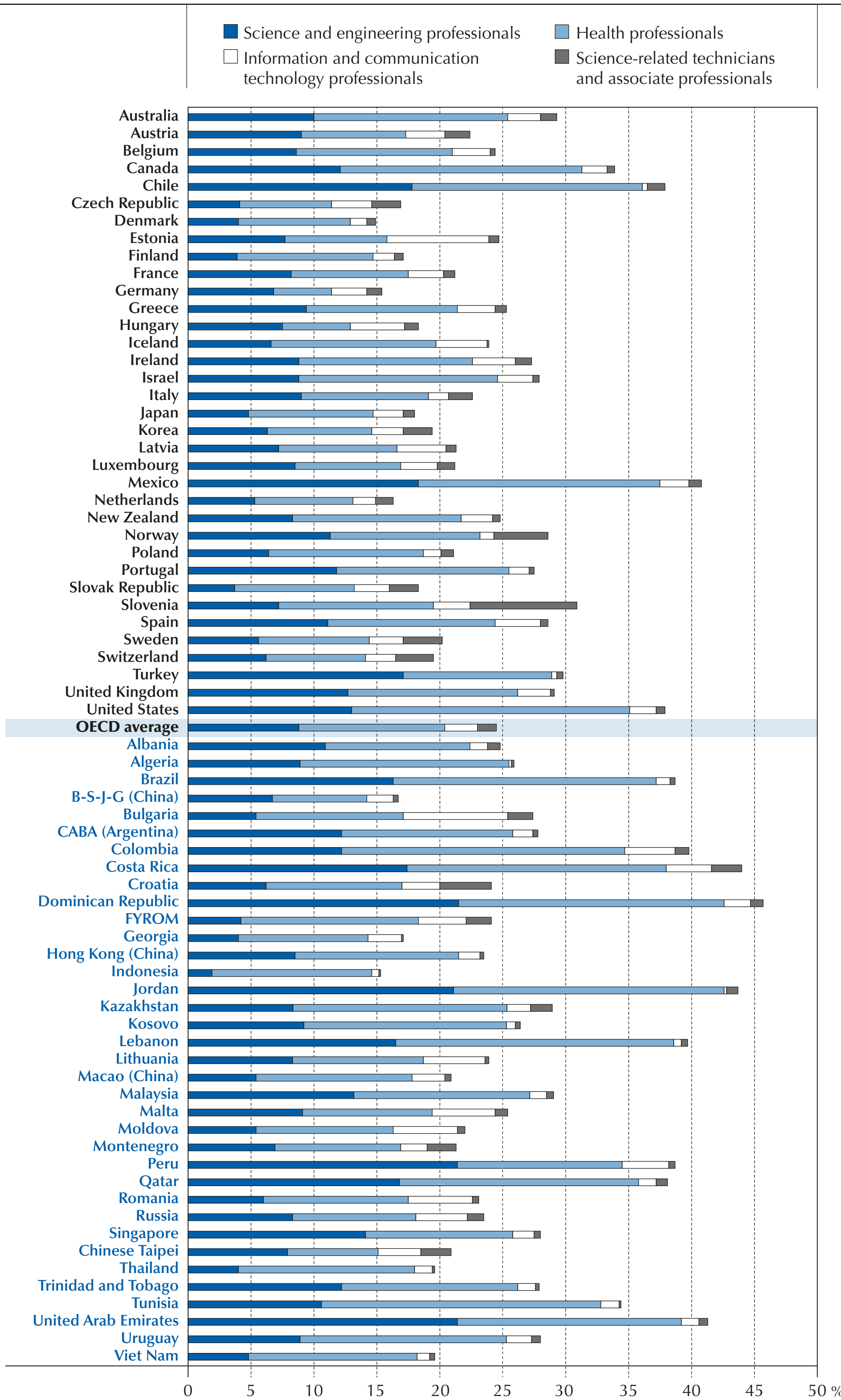
Science-related career expectations

PISA 2015 asked students what occupation they expect to be working in when they are 30 years old. Students could enter any job title or description in an open-entry field; their answers were classified according to the International Standard Classification of Occupations, 2008 edition (ISCO-08). These coded answers were used to create an indicator of science-related career expectations, defined as those career expectations whose realisation requires the study of science beyond compulsory education, typically in formal tertiary education. Within this large group of science-related occupations, the following major groups were distinguished: science and engineering professionals; health professionals; science technicians and associate professionals; and information and communication technology (ICT) professionals (see Annex A1 for details).

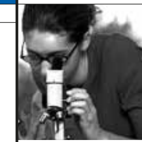
Many 15-year-old students are still undecided about their future. They may be weighing two or more options, or they may feel that they have insufficient knowledge about careers to answer this question in anything but the most general terms. In some PISA-participating countries and economies, many students did not answer the question on career expectations, gave vague answers (such as "a good job", "in a hospital") or explicitly indicated that they were undecided ("I do not know"). This chapter focuses on students with a well-defined expectation of a career in a science-related field. Among the remaining students, a distinction is made between those who expect to work in other occupations, and those whose answer about their future career is vague, missing or indecisive.

Figure I.3.2 ▪ **Students' career expectations**

Percentage of students who expect to work in science-related professional and technical occupations when they are 30



Note: Results for Belgium refer to the French and German-speaking communities only.
Source: OECD, PISA 2015 Database, Table I.3.10a.
StatLink http://dx.doi.org/10.1787/888933432284



On average across OECD countries, almost one in four students (24%) reported that they expect to work in an occupation that requires further science training beyond compulsory education. Some 57% of students reported that they expect to pursue a career outside of science-related fields, and the remaining 19% of students gave a vague answer about their expected occupation, or skipped the question entirely. Specifically, 8.8% of students expect to work as professionals who use science and engineering training (e.g. engineer, architect, physicist or astronomer), 11.6% as health professionals (e.g. medical doctor, nurse, veterinarian, physiotherapist), 2.6% as ICT professionals (e.g. software developer, applications programmer), and 1.5% as science-related technicians and associate professionals (e.g. electrical or telecommunications engineering technician) (Figure I.3.2 and Table I.3.10a).

However, the share of students expecting a science-related career varies widely across countries. For instance, it is more than twice as large in Canada, Chile, Mexico and the United States as in Denmark, Germany and the Netherlands. The largest proportions of students who expect a career in a science-related occupation are found in Costa Rica, the Dominican Republic, Jordan and the United Arab Emirates; among OECD countries, Mexico tops the list, with over 40% of students expecting to work in science by the time they turn 30. (In the Dominican Republic and Mexico, however, students who sat the PISA test represent only about two in three of all 15-year-olds in the country; see Chapter 6 and Table I.6.1).

Students' expectations about their future work partly reflect their academic successes and skills; they also reflect the opportunities and support available to them, in their country and in their local environment, to turn an aspiration into reality. Box I.3.1 discusses how differences across countries and within countries in career expectations can be interpreted.

Box I.3.1. **A context for interpreting 15-year-olds' expectations of working in a science-related career**

Opportunities for pursuing a career in science-related fields do not depend solely on individual skills and preferences, but also on the social and economic resources available to students, and on employers' current and future demand for science professionals and technicians. This, in turn, depends on the wider economic context, including a country's level of development, and on broader policy responses than education policy alone.

On average across OECD countries, 24% of students reported that they expect to work in science-related occupations when they are 30 years old. This average level is close to the share of young people who, based on current enrolment patterns, can be expected to enrol in a tertiary science-related programme. Indeed, if current patterns of enrolment in tertiary education persist, about two in three of today's 15-year-olds (67%) in OECD countries can be expected to pursue tertiary education, on average; and more than one in four (i.e. 27%, or 41% of 67%) can be expected to do so in a science-related field: 7% in sciences; 11% in engineering, manufacturing and construction; 1% in agriculture; and 8% in health and welfare (OECD, 2015).

At the country/economy level, however, the variation in the share of students in PISA who reported that they expect to work in science-related occupations when they are 30 years old (expressed as a percentage of the total population of 15-year-olds) is only weakly correlated with the countries'/economies' per capita level of gross expenditure on research and development (r=-0.1) and with per capita GDP (r=0.1). It is also only weakly related to the share of tertiary graduates among 35-44 year-olds (r=0.2) and to the variation in expected rates of enrolment in tertiary science-related programmes (r=0.1). The share of students who expect a career in science is negatively related to differences in mean science performance (correlation: 0.5) and positively related to average levels of engagement and attitudes towards science, as measured in PISA (such as the index of science activities or the index of instrumental motivation to learn science) (Tables I.3.7 and I.3.12).

The lack of positive associations with country-level variables measuring educational or occupational opportunities to pursue a career in science may suggest that students' answers reflect aspirations, more than realities. But this interpretation is at odds with the evidence about within-country associations. Students with greater proficiency in science, students who come from more advantaged backgrounds, and students with tertiary-educated parents are more likely to report that they expect to work in science-related occupations (see Tables I.3.10b and I.3.13b, and the related discussion in this chapter and in Chapter 6). In virtually all countries, students' responses reflect, to some extent, the reality of the resources available to them.

...

At the country/economy level, the lack of an association may reflect differences in how well-informed students are about careers in general, with better-informed students having more realistic expectations. Indeed, in countries where the first age at selection in the education system is younger than 15, 15-year-old students are less likely to expect to work in science-related occupations (the correlation between first age at selection and the share of students expecting a career in science is 0.38 among all countries, and 0.54 among OECD countries; see Table I.3.12). Some of the variation across countries and economies could also reflect cross-cultural differences, related to social desirability, in how students answer questions about themselves (see Box I.2.4 in Chapter 2).[1] Because of the difficulty associated with interpreting the variation in students' career expectations across countries, this report focuses on comparing within-country associations.

Within countries, career expectations at age 15 have been shown to be highly predictive of actual career choices and outcomes later in life (Aschbacher, Ing, and Tsai, 2014; Tai et al., 2006). Other research has shown career interests to be relatively stable throughout upper secondary education (Sadler et al., 2012). Early adolescence, when children are between the ages of 10 and 14, has been identified as a critical time during which students are exposed to science at school and their career aspirations are formed (DeWitt and Archer, 2015). Students this age begin to think concretely about future careers and start preparing for their chosen career (Bandura et al., 2001; Riegle-Crumb, Moore and Ramos-Wada, 2011).

Although economic theory links the number of scientists and engineers to innovation and growth (e.g. Aghion and Howitt, 1992; Grossmann, 2007), the existence of such a link at the country level has been difficult to prove empirically (Aghion and Howitt, 2006; Jones, 1995). Without this proof, one is left to conclude that this link depends on contextual factors, such as the "distance to the frontier" (the relative level of economic development), or that the number of scientists and engineers is a poor measure of their quality, or perhaps that, in the absence of other policy responses, increasing the number of science and engineering graduates will do little to improve competitiveness and innovation (see OECD, 2014a for a discussion and review of the role of human resources devoted to science and technology in innovation policy).

What, then, is the optimal number of science-trained graduates? In some countries, the evidence on current and projected employment, wages and vacancy rates in science-related occupations suggests that the current supply of graduates from science-related fields may be sufficient for the needs of the economy (Bosworth et al., 2013; Salzman, Kuehn and Lowell, 2013). Where shortages are evident, they may not reliably predict the demand for scientists over the entire working life of today's 15-year-olds. Ultimately, in most countries, the argument for increasing the number of science graduates rests on the hope that this larger supply of human resources for science and technology will generate future economic growth, through new ideas and technologies that are yet to be invented, rather than on the anticipated and more predictable needs of the economy in the absence of structural changes.

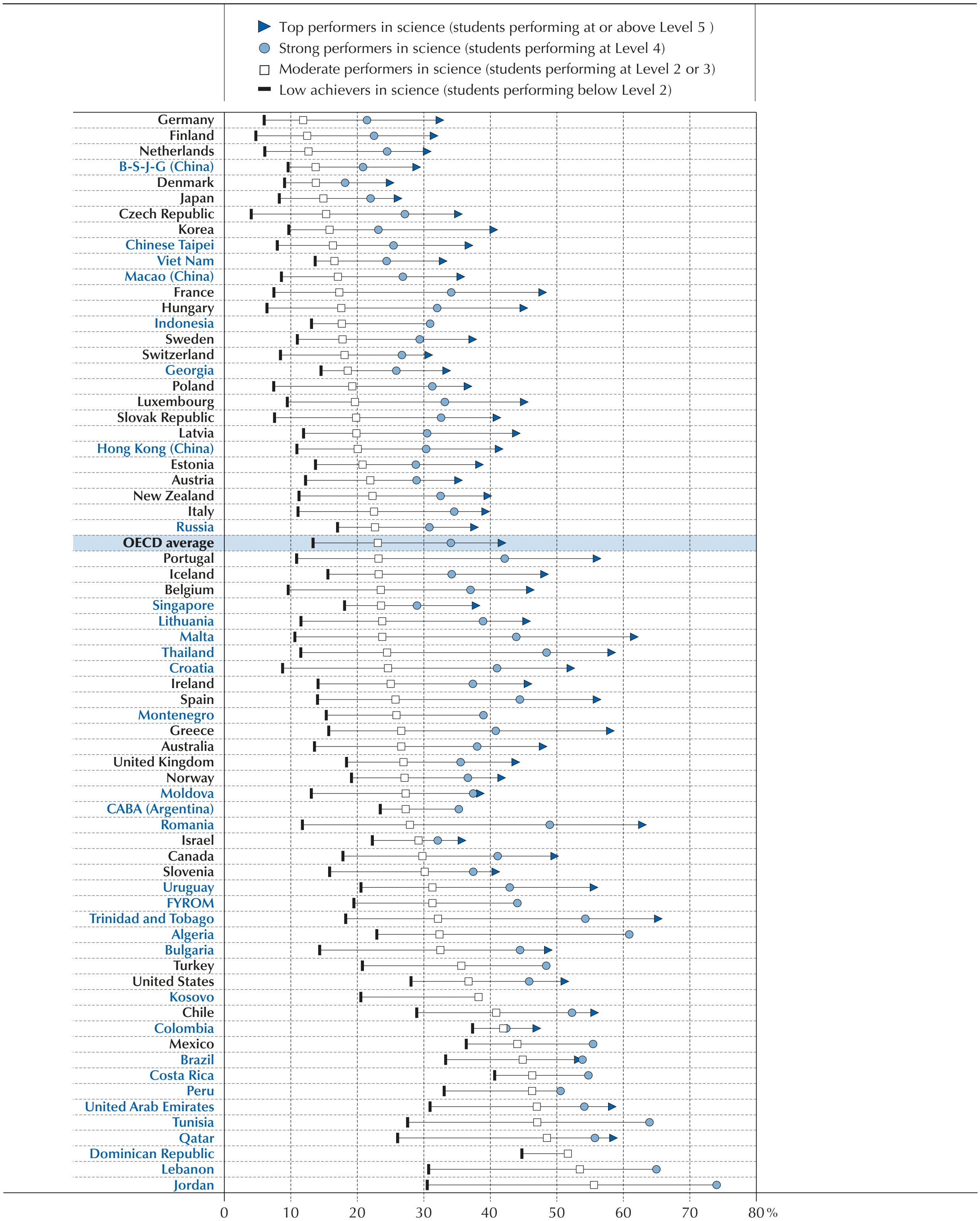
1. While the question about career expectations is less affected by issues related to the use of subjective response scales, how students report their own expectations may still depend on social desirability considerations, which vary across countries.

In almost all countries/economies, the expectation of pursuing a career in science is strongly related to proficiency in science. On average across OECD countries, only 13% of students who score below PISA proficiency Level 2 in science hold such expectations, but that percentage increases to 23% for those scoring at Level 2 or 3, to 34% among those scoring at Level 4, and to 42% among top performers in science (those who score at or above Level 5). In all countries and economies that have more than 1% of students who score at or above Level 5, these students are the most likely to expect that they will work in science-related occupations (Figure I.3.3 and Table I.3.10b).

PISA 2015 marks the second time that the question about career expectations was asked of all students, making it possible to analyse changes in students' expectations of a science-related career between 2006 and 2015.[1] On average across OECD countries, the share of students who expect to be working in a science-related occupation at age 30 increased by 3.9 percentage points between 2006 and 2015, largely because of an increase in the share of students who expect to be working as health professionals (+3 percentage points over the period). In most countries, this increase was not realised at the expense of other occupations: the percentage of students with career expectations outside of science-related occupations remained stable. Rather, the share of students who did not respond to the question other than with a vague answer shrank by 4.2 percentage points over the period, perhaps reflecting greater salience of career concerns among 15-year-olds (Table I.3.10a). In contrast to the average increase observed across OECD countries, a few countries show decreasing shares of students who expect to work in a science related career.

Figure I.3.3 ■ **Students' career expectations, by proficiency in science**

Percentage of students who expect to work in science-related professional and technical occupations when they are 30



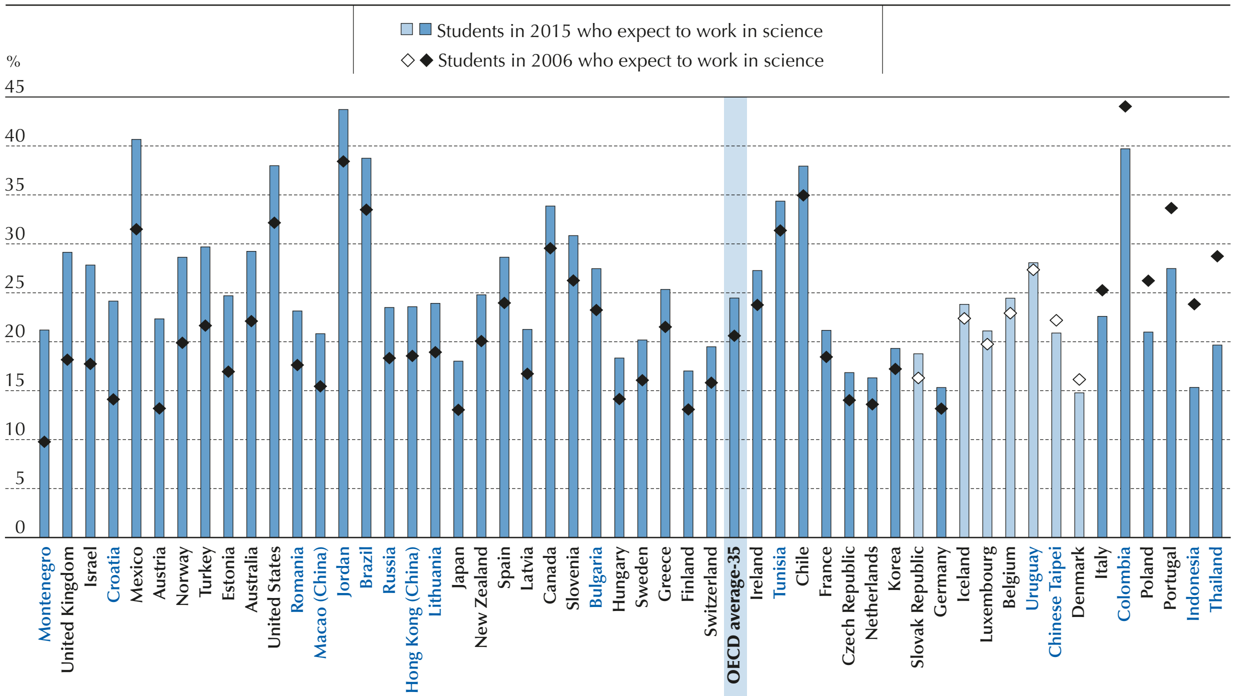
Note: Results for Belgium refer to the French and German-speaking communities only.
Countries and economies are ranked in ascending order of the percentage of moderate performers in science who expect to work in a science-related career.
Source: OECD, PISA 2015 Database, Table I.3.10b.
StatLink http://dx.doi.org/10.1787/888933432295

In Indonesia and Thailand, the share of these students shrank by nine percentage points, and in Portugal the share decreased by six percentage points. By contrast, in Croatia, Israel, Montenegro and the United Kingdom, this share increased by ten percentage points or more (Figure I.3.4 and Table I.3.10e).

On average across OECD countries, boys and girls are almost equally likely to expect to work in a science-related field – although this does not apply for all fields in the sciences. Some 25% of boys and 24% of girls expect to be working in a science-related occupation when they are 30, a small (yet statistically significant) difference. Among countries and economies participating in PISA, gender differences are most marked in Hungary, Indonesia and Thailand. In Hungary, boys are almost twice as likely (24%) as girls (13%) to report that they expect to pursue a career in science. In Indonesia and Thailand, the opposite is true: girls are significantly more likely than boys to expect to work in a science-related career. In Indonesia, 22% of girls, but 9% of boys, hold such expectations; in Thailand, 25% of girls, but only 12% of boys, do (Table I.3.10b).

Figure I.3.4 ▪ **Change between 2006 and 2015 in students' expectations of a science-related career**

Percentage of students who expect to work in science-related occupations at age 30



Notes: Statistically significant differences between 2006 and 2015 are marked in a darker tone (see Annex A3).
Results for Belgium refer to the French and German-speaking communities only.
Only countries and economies with available data since 2006 are shown.
Countries and economies are ranked in descending order of the difference in students' expectations of a science related-career between 2006 and 2015.
Source: OECD, PISA 2015 Database, Tables I.3.10b, I.3.10d and I.3.10e.
StatLink http://dx.doi.org/10.1787/888933432307

In Australia, Canada, Germany, Hungary, Singapore, Spain and Sweden, not only are there fewer girls than boys performing at or above Level 5 in science (see Chapter 2, Table I.2.6a), but girls are also less likely than boys to expect to work in a science-related occupation, including among top performers (Table I.3.10c). But in most countries, similar shares of top-performing boys and girls expect a career in a science-related field; and in Denmark and Poland, top-performing girls are significantly more likely than top-performing boys to expect a career in one of these fields.

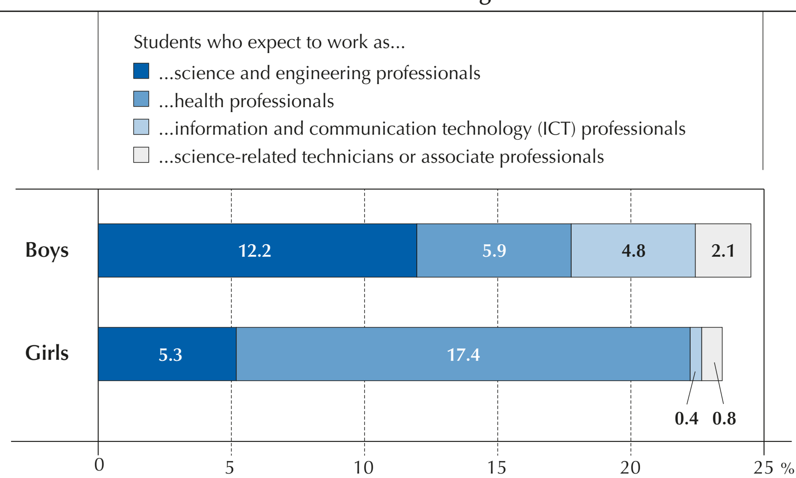
Even when the shares of boys and girls who expect a science-related career are balanced, boys and girls tend to think of working in different fields of science. In all countries, girls envisage themselves as health professionals more than boys do; and in almost all countries, boys see themselves as becoming ICT professionals, scientists or engineers more than girls do (Tables I.3.11a, I.3.11b and I.3.11c). Figure I.3.5 shows that boys are more than twice as likely as girls to expect to work as engineers, scientists or architects (science and engineering professionals), on average across OECD countries;

only 0.4% of girls, but 4.8% of boys, expect to work as ICT professionals. Girls are almost three times as likely as boys to expect to work as doctors, veterinarians or nurses (health professionals). This is consistent with recent patterns of enrolment in tertiary bachelor's degree programmes. In 2013, and on average across OECD countries, women accounted for 78% of new entrants in health and welfare programmes, but for only 30% of new entrants in science and engineering programmes (OECD, 2014b). The similarity of these findings may indicate that the career paths of boys and girls are already starting to diverge before the age of 15, and well before crucial career choices are made.

Particularly large differences between boys' and girls' expectations for their future are observed in some countries. In Norway, for example, 29% of boys and 28% of girls expect a career in a science-related occupation; but there are seven times more girls than boys (21% compared to 3%) who expect to work as doctors, nurses or other health professionals. In Finland, boys are more than four times as likely as girls to expect a career as an engineer, scientist or architect (6.2%, compared to 1.4% of girls); but girls are more than three times more likely than boys to expect a career as a health professional (17%, compared to 5% of boys) (Tables I.3.10b, I.3.11a and I.3.11b).

Figure I.3.5 ■ **Expectations of a science career, by gender**

OECD average



Source: OECD, PISA 2015 Database, Tables I.3.11a-d.

StatLink http://dx.doi.org/10.1787/888933432311

Figure I.3.6 presents a selection from the list of science-related occupations that boys and girls expect to work in as young adults. While it contains no information on where a particular occupation ranks among the choices of 15-year-olds, it shows a variety of careers that were among the five most popular science-related occupations for boys and for girls in at least one country/economy that participated in PISA 2015. It also shows the number of OECD countries, and the number of all participating countries and economies, in which each of these occupations was among the top five cited by boys and by girls.[2]

The data represented in Figure I.3.6 suggest that boys and girls generally expect careers in different science subfields and, within those subfields, in different occupations. "Medical doctors" is the only occupation that ranks among the five most frequently mentioned science-related careers by boys and girls alike in all 72 countries and economies. Careers as "architects and designers" also appear near the top in both lists. In more than 60 countries and economies, boys cite the careers of "engineers" or "software and application developers and analysts"; but in only 34 countries and economies are "engineers" among girls' top choices for a career, and in just 7 countries and economies (not including any OECD country) are "software and application developers and analysts" one of girls' top choices. Meanwhile, in almost all countries and economies, "dentists, pharmacists, physiotherapists, dieticians and other health professionals" are among the most popular science-related career expectations among girls; as are, in 45 countries and economies, "nurses and midwives" and "veterinarians". But in most countries, these health-related occupations do not appear among boys' top choices.

Figure I.3.6 ▪ **Most popular career choices in science among boys and girls**

Number of countries/economies in which a particular occupation appears among the top five science-related careers that boys and girls expect for themselves

Boys			Girls		
ISCO-08 code and occupation	Number of countries/ economies	Number of OECD countries	ISCO-08 code and occupation	Number of countries/ economies	Number of OECD countries
221-Medical doctors	72	35	**221-Medical doctors**	72	35
214-Engineers (excluding electrotechnology engineers)	66	34	**226-Dentists, pharmacists, physiotherapists, dieticians and other health professionals**	71	35
251-Software and applications developers and analysts	61	30	**216-Architects and designers**	53	22
216-Architects and designers	55	27	225-Veterinarians	45	32
226-Dentists, pharmacists, physiotherapists, dieticians and other health professionals	35	18	222-Nurses and midwives	45	22
311-Physical and engineering science technicians	21	10	**214-Engineers (excluding electrotechnology engineers)**	34	12
215-Electrotechnology engineers	17	7	213-Life science professionals (e.g. biologist)	17	10
211-Physical and earth science professionals (e.g. chemist)	12	7	211-Physical and earth science professionals (e.g. chemist)	8	3
213-Life science professionals (e.g. biologist)	11	4	321-Medical and pharmaceutical technicians	7	4
225-Veterinarians	5	2	251-Software and applications developers and analysts	7	0
252-Database and network professionals	4	1	224-Paramedical practitioners	1	0
222-Nurses and midwives	1	0			

Note: ISCO-08 refers to the International Standard Classification of Occupations; occupations are defined at the three-digit level. Occupations that appear among the most popular science occupations in at least 20 countries/economies for boys and in at least 10 countries/economies for girls are indicated in bold.
Source: OECD, PISA 2015 Database.
StatLink http://dx.doi.org/10.1787/888933432321

Students' participation in science activities

PISA 2015 asked students to report how often they participate in selected science-related activities at or outside of school. Students were asked to report the frequency with which they did the activities ("very often", "regularly", "sometimes", or "never or hardly ever"). In general, only a minority of students reported doing any of the activities "regularly" or "very often". On average across OECD countries, 23% of 15-year-old students reported watching TV programmes about science, and 19% reported visiting websites about science topics at least "regularly". But only 16% of students reported reading science magazines or science articles in newspapers and 15% reported following news of science, environmental or ecology organisations via blogs or microblogging (e.g. twitter) with similar frequency. About one in ten students, at most, reported visiting websites of ecology organisations, borrowing or buying books on science topics, using computer programs/virtual labs to simulate natural or technical processes, and attending a science club "regularly" or "very often" (Figure I.3.7).

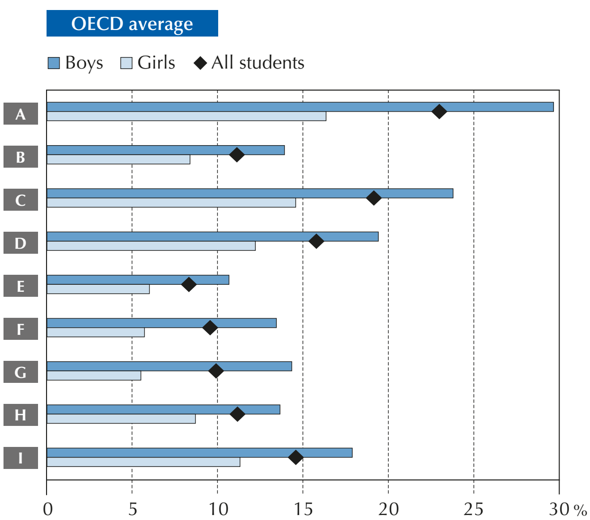
As these percentages show, while some activities tend to be more common than others among 15-year-olds, in general students seldom participate in science-related activities outside of school requirements. This underlines the critical role of science education in school, as many students do not have, or take advantage of, opportunities to learn science outside of school. But it also shows that science education in school has, in some countries at least, limited success in making science attractive enough that students choose to engage in science activities during their free time.

As shown in Figure I.3.7, the level of students' engagement with science varies considerably across countries and economies (but some caution is needed when interpreting cross-country differences in self-report scales; see Box I.2.4 in Chapter 2). Students' reports about their participation in the nine activities were also aggregated into an index of science activities. Higher values on the index indicate that students reported more frequent participation or a larger number of activities in which they participate (see Annex A1 and Box I.2.5 for details on how to interpret this and other indices discussed in this chapter). Students in Finland, Japan and the Netherlands reported among the lowest levels of engagement with science outside of school, as seen in the low average values on the index of science activities, whereas students in the Dominican Republic, Thailand and Tunisia reported more regular and varied activities (Table I.3.5a).

Figure I.3.7 ■ **Students' science activities, by gender**

Percentage of students who reported doing these things "very often" or "regularly"

- A Watch TV programmes about <broad science>
- B Borrow or buy books on <broad science> topics
- C Visit web sites about <broad science> topics
- D Read <broad science> magazines or science articles in newspapers
- E Attend a <science club>
- F Simulate natural phenomena in computer programs/virtual labs
- G Simulate technical processes in computer programs/virtual labs
- H Visit web sites of ecology organisations
- I Follow news of science, environmental or ecology organisations via blogs and microblogging



		A	B	C	D	E	F	G	H	I
OECD	Australia	17	7	19	9	4	6	6	7	13
	Austria	18	8	15	14	6	8	9	11	17
	Belgium	29	11	17	16	6	8	8	9	12
	Canada	22	12	21	15	6	9	10	11	18
	Chile	34	13	27	17	9	12	12	15	18
	Czech Republic	17	9	12	13	7	7	8	8	8
	Denmark	22	6	20	15	4	6	7	7	14
	Estonia	30	11	25	24	11	11	11	12	12
	Finland	12	5	7	10	3	4	4	5	5
	France	21	10	23	15	5	8	8	9	13
	Germany	18	9	16	13	6	8	8	11	17
	Greece	27	18	26	22	14	15	15	21	21
	Hungary	30	16	22	19	15	14	15	15	14
	Iceland	19	8	21	16	4	5	6	8	16
	Ireland	17	6	14	9	2	6	7	5	13
	Israel	30	20	25	22	16	17	18	18	21
	Italy	29	14	28	19	11	13	14	16	23
	Japan	11	5	10	7	3	3	3	3	3
	Korea	8	9	7	10	13	4	4	5	10
	Latvia	24	11	19	18	9	11	11	13	14
	Luxembourg	23	13	21	18	7	11	11	14	15
	Mexico	40	22	33	29	13	17	18	22	24
	Netherlands	26	6	11	11	4	6	7	6	11
	New Zealand	17	9	18	10	5	6	7	8	13
	Norway	22	8	21	15	8	9	9	12	14
	Poland	40	13	24	20	15	11	11	15	17
	Portugal	34	13	21	22	8	12	12	13	17
	Slovak Republic	24	15	19	19	12	13	13	14	15
	Slovenia	28	10	16	16	10	9	9	8	10
	Spain	16	7	14	12	6	8	9	9	12
	Sweden	14	6	13	11	5	6	7	8	11
	Switzerland	17	8	14	15	8	8	8	11	15
	Turkey	30	27	32	29	22	26	24	25	24
	United Kingdom	18	11	20	10	8	6	6	6	13
	United States	19	10	18	13	8	11	11	12	16
Partners	Brazil	41	26	35	29	19	22	22	24	27
	B-S-J-G (China)	29	19	16	23	10	12	12	13	26
	Bulgaria	48	25	39	29	21	24	24	26	30
	Chinese Taipei	22	9	17	15	7	6	6	7	10
	Colombia	52	26	34	30	19	22	22	27	31
	Costa Rica	44	18	26	25	12	15	16	21	25
	Croatia	27	10	17	15	7	10	10	11	11
	Dominican Republic	49	35	41	38	25	31	31	34	36
	Hong Kong (China)	21	14	15	15	12	10	10	12	13
	Lithuania	31	18	31	26	13	17	16	16	17
	Macao (China)	19	10	14	13	7	8	7	9	14
	Montenegro	52	31	39	38	22	25	25	29	31
	Peru	48	30	34	33	15	21	21	26	29
	Qatar	37	30	36	31	22	27	27	28	30
	Russia	33	22	36	24	18	18	19	21	25
	Singapore	21	11	22	19	7	9	9	11	18
	Thailand	33	23	26	23	27	21	20	24	23
	Tunisia	53	40	48	42	31	32	33	39	41
	United Arab Emirates	40	31	39	34	25	29	29	29	34
	Uruguay	30	16	21	17	12	13	13	16	20

Note: All gender differences are statistically significant (see Annex A3).
Source: OECD, PISA 2015 Database, Tables I.3.5a and I.3.5c.
StatLink http://dx.doi.org/10.1787/888933432336

In most countries and economies, the most popular activity among those listed is watching TV programmes about science, perhaps reflecting the fact that TV programmes (in contrast to other activities) are often readily available to all students. In Bulgaria, Colombia, the Dominican Republic, Montenegro, Peru and Tunisia, about half of all students reported watching science-related TV programmes regularly (in Finland, Japan, Korea and Sweden, less than 15% of students so reported). But there are notable exceptions. In Korea, for instance, only a small minority of students (around 8%) reported that they watch science programmes on TV, but 13% of students – one of the largest shares among OECD countries – attend a science club. Meanwhile, in some countries – most notably Australia, France, the Russian Federation (hereafter "Russia") and the United Kingdom – more students visit websites about science topics than watch TV programmes about science (Figure I.3.7 and Table I.3.5a).

Figure I.3.8 ▪ **Gender differences in students' science activities**

Note: All gender differences are statistically significant (see Annex A3).
Countries and economies are ranked in descending order of gender differences in the index of science activities.
Source: OECD, PISA 2015 Database, Tables I.3.5a and I.3.5c.
StatLink http://dx.doi.org/10.1787/888933432343

As Figures I.3.7 and I.3.8 show, boys are more likely than girls to participate in science-related activities. On average, boys reported almost twice as often as girls that they regularly engage in each of the listed science activities. Across OECD countries, 11% of boys, but only 6% of girls, reported that they regularly attend a science club. Some 24% of boys, but 15% of girls, reported visiting websites about science topics regularly; and 30% of boys, but 16% of girls, reported watching TV programmes about science. Gender differences in favour of boys are observed across all nine activities and in all 57 countries and economies that included this question as part of the student questionnaire (the question was not included in the paper-based version of the questionnaire). The gender difference is statistically significant in all but a few countries/economies (Table I.3.5c).

Students in 2015 reported participating more in science activities than their counterparts in 2006 did. For example, in 43 out of 49 countries with comparable data, more students in 2015 reported that they regularly attend a science club than did their counterparts in 2006. On average across OECD countries, only 5% of students reported regularly attending a science club in 2006; in 2015, 8% of students so reported. And while the proportion of students who reported reading science magazines or science articles in newspapers has shrunk, this decrease may largely reflect disengagement from the medium, rather than from the content. In many countries, the percentage of students who reported visiting websites about science topics, or even borrowing or buying books on science topics, increased over the same period (Tables I.3.5a, I.3.5e and I.3.5f).

Countries that saw increases in the shares of students engaging in science activities outside of school often also saw increases in students' intrinsic motivation to learn science (students' enjoyment of doing and learning science; see below) and their sense of self-efficacy in science (students' beliefs in their own science abilities). At the country/economy level, the correlation between changes in students' engagement with science activities and changes in enjoyment of science learning over the nine-year period is 0.4, and the correlation with changes in science self-efficacy is 0.5 (Table I.3.8). Canada, Sweden and the United Kingdom, for instance, saw relatively large improvements in both students' engagement with science and their enjoyment of science (Tables I.3.1f and I.3.5f).

MOTIVATION FOR LEARNING SCIENCE

Motivation can be regarded as a driving force behind engagement, learning and choice of occupation in all fields. To nurture students' engagement with science, school systems need to ensure that students have not only the basic knowledge that is necessary to engage with complex scientific issues, but also the interest and motivation that will make them want to do so. PISA distinguishes between two forms of motivation to learn science: students may learn science because they enjoy it (intrinsic motivation) and/or because they perceive learning science to be useful for their future plans (instrumental motivation). These two constructs are central in expectancy-value theory (Wigfield and Eccles, 2000) and in self-determination theory, which emphasises the importance of intrinsic motivation (Ryan and Deci, 2009).

Enjoyment of science

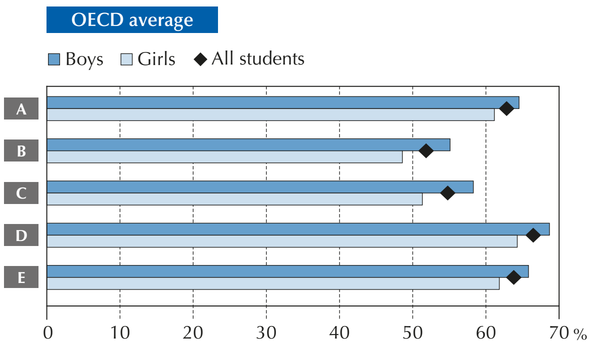
Intrinsic motivation refers to the drive to perform an activity purely for the joy gained from the activity itself. Students are intrinsically motivated to learn science when they want to do so not because of what they will be able to achieve upon mastering new science concepts, but because they find learning science and working on science problems enjoyable (Ryan and Deci, 2009). Enjoyment of science affects students' willingness to spend time and effort in science-related activities, the choice of electives, students' self-image, and the type of careers students aspire to and choose to pursue (Nugent et al., 2015).

Among young children, enjoyment of science has been found to predict participation in science-related activities, whereas the opposite is not true: more opportunities to learn about science do not, in themselves, stimulate enjoyment of science (Alexander, Johnson and Kelley, 2012). Generally, students' enjoyment of science declines from elementary to high school (Archer et al., 2010). Results from the 2011 Trends in Mathematics and Science Study (TIMSS), for instance, show that in all 21 countries that teach science as an integrated subject in eighth grade, and for which there are comparable data for fourth-grade students, the percentage of students who "agreed a lot" with the statement "I enjoy learning science" was lower among eighth-grade students (43%, on average) than among fourth-grade students (68%, on average) (Martin et al., 2012). This may reflect the fact that as students grow older, their interests become increasingly differentiated and specialised. The decline in or durability of enjoyment has also been linked to teaching practices that can either undermine or nurture students' natural motivation to learn science (Hampden-Thompson and Bennett, 2013; Krapp and Prenzel, 2011; Logan and Skamp, 2013).

Figure I.3.9 ▪ **Students' enjoyment of learning science, by gender**

Percentage of students who reported that they "agree" or "strongly agree" with the following statements

- **A** I generally have fun when I am learning <broad science> topics
- **B** I like reading about <broad science>
- **C** I am happy working on <broad science> topics
- **D** I enjoy acquiring new knowledge in <broad science>
- **E** I am interested in learning about <broad science>



		A	B	C	D	E
OECD	Australia	65	53	67	72	67
	Austria	53	38	42	47	49
	Belgium	62	49	60	64	69
	Canada	75	63	69	79	79
	Chile	67	53	57	68	67
	Czech Republic	53	40	35	61	42
	Denmark	65	54	64	64	70
	Estonia	71	59	58	77	63
	Finland	64	56	50	50	61
	France	69	45	45	68	72
	Germany	59	40	43	50	56
	Greece	65	56	58	73	72
	Hungary	47	47	51	59	52
	Iceland	66	58	62	70	63
	Ireland	64	56	71	78	74
	Israel	62	55	60	69	67
	Italy	58	55	64	66	69
	Japan	50	35	35	55	48
	Korea	59	43	48	60	54
	Latvia	69	59	64	74	64
	Luxembourg	66	52	53	65	68
	Mexico	86	70	59	84	80
	Netherlands	40	36	30	50	46
	New Zealand	66	52	71	76	72
	Norway	64	53	63	70	66
	Poland	61	60	51	72	58
	Portugal	74	66	63	84	78
	Slovak Republic	57	43	39	60	51
	Slovenia	48	43	34	52	50
	Spain	62	50	57	65	71
	Sweden	65	57	46	66	63
	Switzerland	66	47	48	63	64
	Turkey	62	62	61	70	70
	United Kingdom	67	52	72	72	69
	United States	72	57	69	76	73
Partners	Albania	84	81	78	90	85
	Algeria	76	76	70	83	79
	CABA (Argentina)	47	47	31	64	72
	Brazil	67	64	65	80	77
	B-S-J-G (China)	81	79	70	81	77
	Bulgaria	74	68	65	79	75
	Chinese Taipei	66	52	50	59	53
	Colombia	76	65	66	79	79
	Costa Rica	74	67	65	80	78
	Croatia	55	55	49	69	57
	Dominican Republic	75	76	72	83	84
	FYROM	76	77	76	82	79
	Georgia	76	73	73	82	71
	Hong Kong (China)	76	66	61	78	75
	Indonesia	90	88	82	95	89
	Jordan	77	75	74	80	78
	Kosovo	86	88	85	92	89
	Lebanon	70	65	71	80	79
	Lithuania	73	66	61	79	74
	Macao (China)	77	64	58	76	74
	Malta	68	52	64	73	70
	Moldova	66	78	60	87	85
	Montenegro	65	63	59	68	66
	Peru	80	73	73	81	79
	Qatar	74	68	73	78	76
	Romania	50	55	50	74	74
	Russia	66	58	49	66	66
	Singapore	84	77	81	86	83
	Thailand	85	77	81	88	85
	Trinidad and Tobago	67	56	64	74	71
	Tunisia	75	74	72	88	86
	United Arab Emirates	76	73	77	82	79
	Uruguay	59	47	48	64	64
	Viet Nam	89	87	88	84	87

Note: All gender differences are statistically significant (see Annex A3).
Source: OECD, PISA 2015 Database, Tables I.3.1a and I.3.1c.
StatLink http://dx.doi.org/10.1787/888933432354

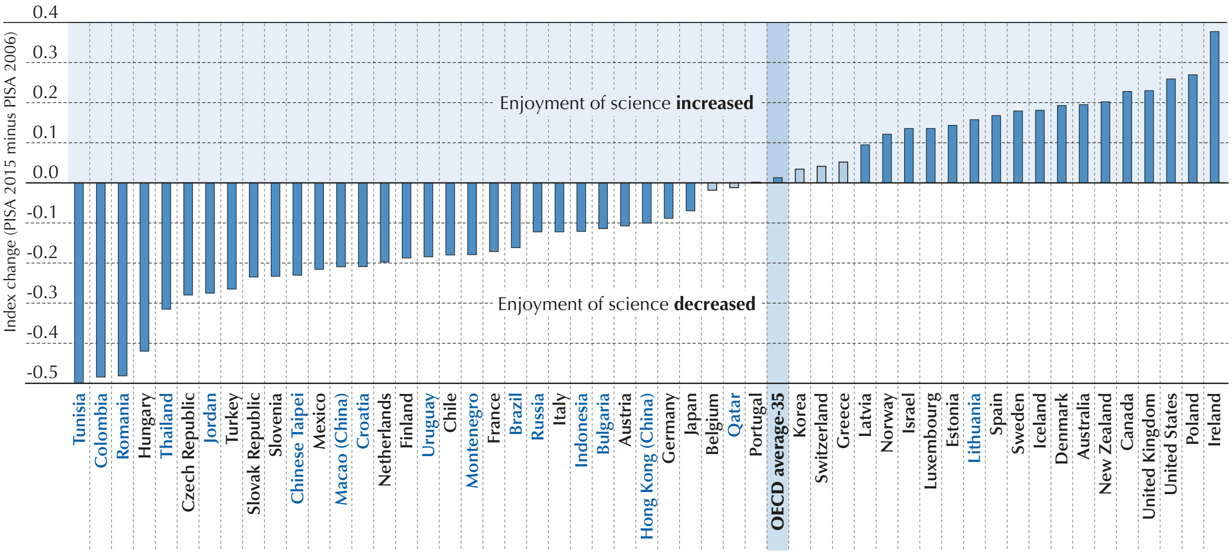
PISA measures students' enjoyment of learning science through students' responses ("strongly agree", "agree", "disagree" or "strongly disagree") to statements affirming that they generally have fun when learning science topics; that they like reading about science; that they are happy working on science topics; that they enjoy acquiring new knowledge in science; and that they are interested in learning about science. The index of enjoyment of science was constructed to summarise students' answers; the scale of the index was set to allow for comparisons with the corresponding index in PISA 2006. The difference between a student disagreeing with all statements, and a student disagreeing with only the statement "I am happy working on science topics", but agreeing with all four remaining statements, corresponds approximately to a one-unit increase (0.97) in the value of this index.

As Figure I.3.9 shows, across OECD countries, 66% of students reported that they agree or strongly agree that they enjoy acquiring new science knowledge, and 64% reported that they are interested in learning about science. However, the OECD average masks significant differences across countries and economies. For example, at least 90% of students in Indonesia and Kosovo reported that they enjoy acquiring new knowledge in science. In Austria and the Netherlands, by contrast, only 50% of students, at most, enjoy acquiring new knowledge in science, and a similarly small proportion is interested in learning about science (Figure I.3.9).

Between 2006 and 2015, students' enjoyment of science improved in 17 countries and economies.[3] In Ireland and Poland, for example, the index of enjoyment of science increased by around 0.4 and 0.3 unit, respectively. Indeed, the share of students who agreed that they enjoy acquiring new knowledge in science grew by more than 10 percentage points during the period, and similar, if not larger, increases were found across all statements used to construct this index (Figure I.3.10 and Table I.3.1f).

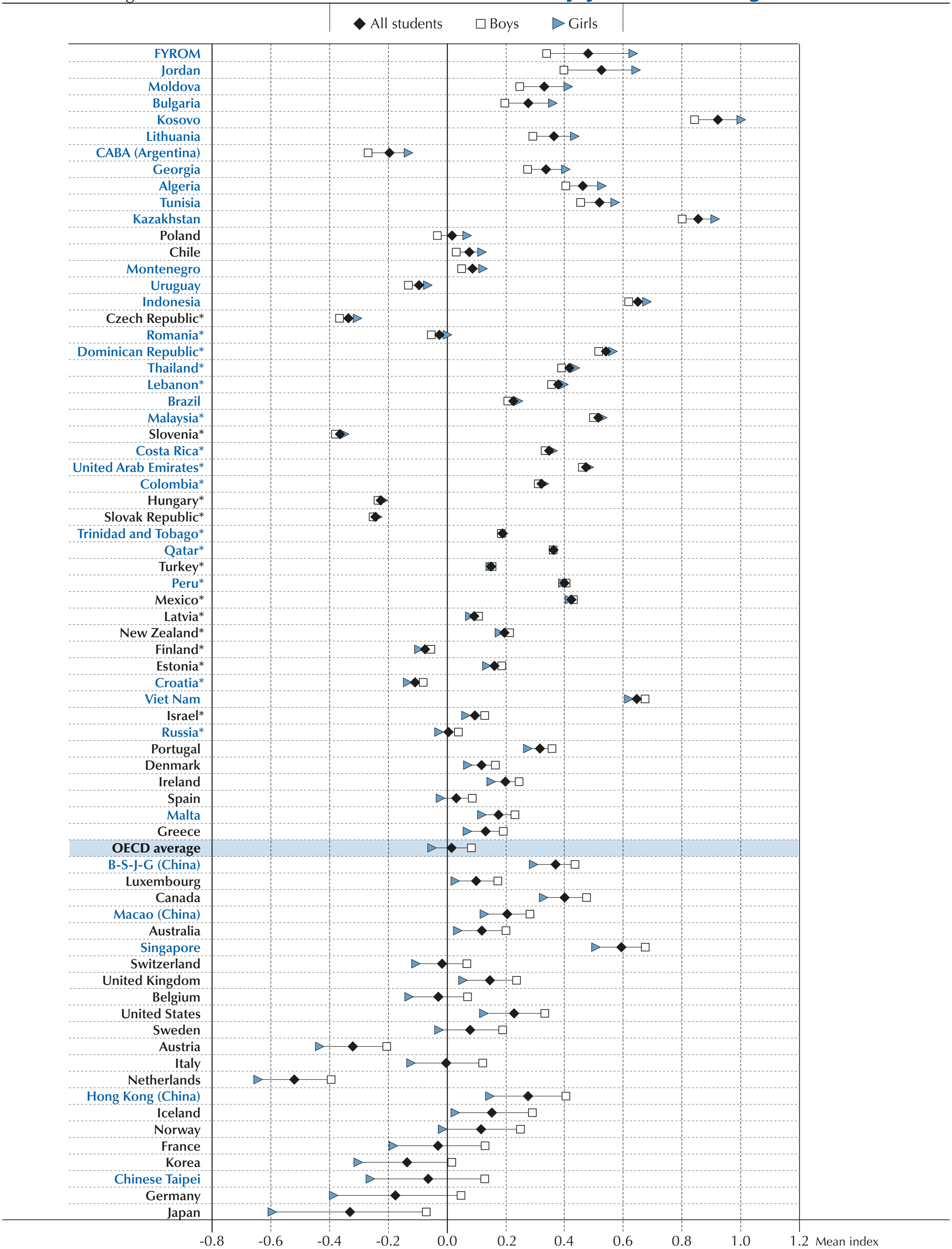
Similarly, in Australia, Canada, Denmark, Iceland, New Zealand, Spain, Sweden, the United Kingdom and the United States, more students reported greater intrinsic motivation to learn science, and the index of enjoyment of science increased by more than 0.17 unit. In the United Kingdom and the United States, for example, the percentage of students who reported having fun when learning science topics increased by about ten percentage points between 2006 and 2015, from 55% to 67% in the United Kingdom, and from 62% to 72% in the United States. In 2006, 54% of students in Canada, and only about 43% in Australia and New Zealand, reported that they like reading about science topics; by 2015, all of these shares had increased by about nine percentage points. In Denmark, Iceland and Sweden, among other countries, the proportion of students interested in learning about science increased by at least six percentage points over this period (Figure I.3.10 and Tables I.3.1a, I.3.1e and I.3.1f).

Figure I.3.10 ▪ **Change between 2006 and 2015 in students' enjoyment of learning science**



Note: Statistically significant differences are shown in a darker tone (see Annex A3).
Countries and economies are ranked in ascending order of the change in the index of students' enjoyment of learning science between 2006 and 2015.
Source: OECD, PISA 2015 Database, Table I.3.1f.
StatLink http://dx.doi.org/10.1787/888933432362

Figure I.3.11 ■ **Gender differences in students' enjoyment of learning science**



Note: Gender differences that are not statistically significant are marked with an asterisk next to the country/economy name (see Annex A3).
Countries and economies are ranked in ascending order of the difference between boys' and girls' enjoyment of learning science.
Source: OECD, PISA 2015 Database, Tables I.3.1a and I.3.1c.

StatLink http://dx.doi.org/10.1787/888933432373

By contrast, the index of enjoyment of science decreased by more than 0.17 unit in 20 countries/economies. In Finland and Chinese Taipei, for example, the proportion of students who reported that they enjoy acquiring new knowledge in science shrank by more than 20 percentage points, to about 60% in Chinese Taipei and to about 50% in Finland. In the Czech Republic and Hungary, the proportion of students who reported being interested in learning about science was 20 percentage points smaller in 2015 than in 2006 (Figure I.3.10 and Table I.3.1f).

As discussed above, increases in students' intrinsic motivation to learn science are related to more frequent participation in science activities in 2015, compared to 2006 (correlation across all countries/economies: 0.4). Greater intrinsic motivation also tends to be observed more often in countries and economies where students' instrumental motivation (the drive to learn science because students perceive it as useful to their future studies and careers; see below) increased between 2006 and 2015 (correlation: 0.5; Table I.3.8), indicating, perhaps, that intrinsic and extrinsic motivation need not be in opposition to each other (Hidi and Harackiewicz, 2000).

A majority of students who participated in PISA 2015 reported that they enjoy and are interested in learning science, but boys tended to report so more than girls. On average across OECD countries, boys were more likely than girls to agree with each of the statements that make up the index of enjoyment of science. For instance, boys were four percentage points more likely than girls to agree with the statements, "I enjoy acquiring new knowledge in science" and "I am interested in learning about science", on average across OECD countries. Gender differences in intrinsic motivation to learn science are especially wide, in favour of boys, in France, Germany, Japan, Korea and Chinese Taipei. These gender differences in enjoyment of science are found in 29 countries and economies. But in 18 countries and economies, the opposite pattern is found: girls were more likely than boys to report enjoying and being interested in science, particularly so in the Former Yugoslav Republic of Macedonia (hereafter "FYROM") and Jordan (Figure I.3.11 and Table I.3.1c).

Interest in broad science topics

Interest is one of the components of intrinsic motivation and one of the reasons why students may enjoy learning. What distinguishes it from other sources of enjoyment is that an interest is always directed towards an object, activity, field of knowledge or goal. Having an interest means being interested *in something* (Krapp and Prenzel, 2011). Interest in science can be defined generally (interest in science) or specifically (interest in science topics, be it a broader discipline or school subject, such as biology, or a more specific domain or research question, such as bacterial infections).

PISA measures the extent to which students are interested in five broad science topics, or subjects, through students' responses ("not interested", "hardly interested", "interested" or "highly interested") to topics related to the biosphere (e.g. ecosystem services, sustainability); to motion and forces (e.g. velocity, friction, magnetic and gravitational forces); to energy and its transformation (e.g. conservation, chemical reactions); to the universe and its history; and in how science can help us prevent disease. A fifth response offered students the possibility to report that "[they] don't know what this is".

Current theories of how children develop interests emphasise that interests are not developed in isolation. While an "interesting" or "curious" first contact with an object, activity or field of knowledge may trigger an initial, transitory interest, in order for this "situational" interest to become a more stable disposition, it must be supported and sustained (Hidi and Renninger, 2006; Krapp, 2002). Individual differences in interests may stem both from differences in opportunities to access the object or activity (one cannot be interested in things one does not know about; and without repeated interaction with the object, it is unlikely that one can develop a durable interest) and from differences in the support received to develop an initial attraction or curiosity into a more stable motivational state. These differences may also be a by-product of the process through which students, particularly during adolescence, critically review their abilities and interests as they try to define and shape their identity. All interests that do not appear compatible with the ideal self-concept are then devalued (Krapp and Prenzel, 2011).

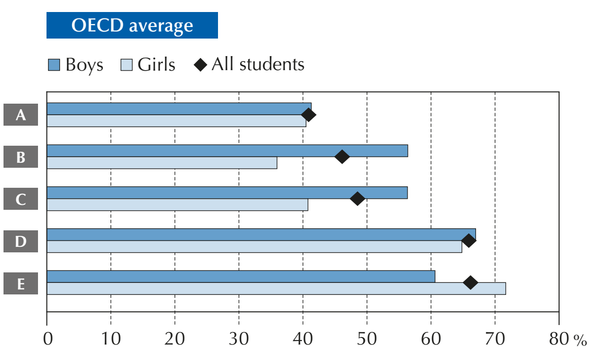
On average across OECD countries, two out of three students (66%) reported being interested in "how science can help us prevent disease", and a similar percentage (66%) reported interest in "the universe and its history". Less than half of all students reported interest in energy and its transformation (49%), motion and forces (46%), and in topics related to the biosphere (41%). Across most countries and economies, students preferred the topics of disease prevention and astronomy (the universe and its history) to the remaining three topics. In Thailand, however, the topic of biosphere attracted the highest percentage of students among all the proposed topics. The Czech Republic is the only PISA-participating country in which the share of students who reported interest in a topic was below 50% in all five topics (Figure I.3.12).

PISA data show that boys are more interested than girls in physics and chemistry ("motion and forces", "energy and its transformation"), while girls tend to be more interested in health-related topics ("how science can help us prevent disease"). Gender differences are narrower with respect to the topic of biosphere, or to the topic of the universe and its history. In all countries and economies, more boys than girls reported being interested in the topics of motion and forces (e.g. velocity, friction, magnetic and gravitational forces); but in the Dominican Republic, the difference is not significant. Similarly, in all countries and economies except the Dominican Republic and Thailand, more boys than girls reported being interested in the topics of energy and its transformation (e.g. conservation, chemical reactions). In the Dominican Republic and Thailand, the difference between boys and girls is not significant. Meanwhile, in all countries and economies, girls were more likely than boys to report being interested in how science can help us prevent disease. In Chinese Taipei, this gender difference is not significant (Figure I.3.12 and Table I.3.2c).

Figure I.3.12 ▪ **Students' interest in broad science topics, by gender**

Percentage of students who reported that they are "interested" or "highly interested" in the following topics

- **A** Biosphere (e.g. ecosystem services, sustainability)
- **B** Motion and forces (e.g. velocity, friction, magnetic and gravitational forces)
- **C** Energy and its transformation (e.g. conservation, chemical reactions)
- **D** The Universe and its history
- **E** How science can help us prevent disease



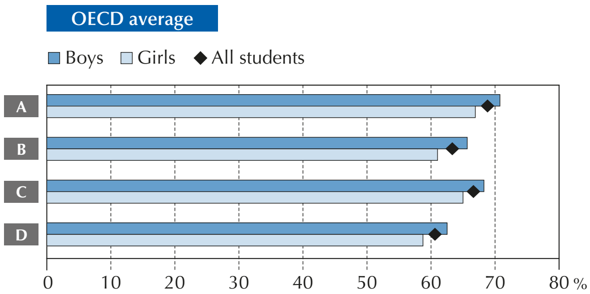
		A	B	C	D	E
OECD	Australia	43	48	53	67	69
	Austria	50	46	47	66	61
	Belgium	42	52	52	66	73
	Canada	53	55	63	69	74
	Chile	41	46	48	68	68
	Czech Republic	16	20	23	44	36
	Denmark	45	57	55	73	71
	Estonia	30	45	49	71	65
	Finland	27	45	45	65	63
	France	36	43	47	67	69
	Germany	54	43	41	61	68
	Greece	34	51	52	66	65
	Hungary	28	38	37	59	58
	Iceland	51	62	58	74	75
	Ireland	37	47	54	69	78
	Israel	23	41	42	55	60
	Italy	48	48	57	75	78
	Japan	55	37	38	72	54
	Korea	56	39	41	64	61
	Latvia	37	53	55	73	70
	Luxembourg	47	53	56	68	71
	Mexico	63	62	68	75	80
	Netherlands	32	40	38	54	60
	New Zealand	39	53	57	66	66
	Norway	41	53	54	69	66
	Poland	22	34	37	59	59
	Portugal	62	55	57	75	79
	Slovak Republic	29	38	40	57	52
	Slovenia	27	29	33	63	57
	Spain	49	46	50	72	75
	Sweden	42	44	45	64	61
	Switzerland	49	49	53	70	70
	Turkey	38	47	49	54	58
	United Kingdom	38	45	50	71	73
	United States	44	48	54	67	73
Partners	Brazil	51	56	61	71	73
	B-S-J-G (China)	65	68	63	80	79
	Bulgaria	57	56	59	75	75
	Colombia	59	59	63	76	79
	Costa Rica	53	49	53	72	75
	Croatia	33	37	41	69	64
	Dominican Republic	70	78	79	86	87
	Hong Kong (China)	64	57	59	68	69
	Lithuania	35	50	51	73	70
	Macao (China)	53	49	45	67	61
	Montenegro	44	38	44	58	65
	Peru	60	63	67	82	85
	Qatar	54	58	63	71	73
	Russia	39	44	46	67	63
	Singapore	48	57	61	71	77
	Chinese Taipei	60	38	36	64	66
	Thailand	90	77	78	78	85
	Tunisia	48	55	57	67	73
	United Arab Emirates	49	52	56	67	71
	Uruguay	44	42	49	64	69

Note: All gender differences are statistically significant (see Annex A3).
Source: OECD, PISA 2015 Database, Tables I.3.2a and I.3.2c.
StatLink http://dx.doi.org/10.1787/888933432380

Figure I.3.13 ▪ **Students' instrumental motivation to learn science, by gender**

Percentage of students who reported that they "agree" or "strongly agree" with the following statements

- **A** Making an effort in my <school science> subject(s) is worth it because this will help me in the work I want to do later on
- **B** What I learn in my <school science> subject(s) is important for me because I need this for what I want to do later on
- **C** Studying my <school science> subject(s) is worthwhile for me because what I learn will improve my career prospects
- **D** Many things I learn in my <school science> subject(s) will help me to get a job



		A	B	C	D
OECD	Australia	70	62	67	61
	Austria	53	47	50	45
	Belgium	66	56	63	53
	Canada	81	74	80	74
	Chile	76	70	75	68
	Czech Republic	57	51	52	48
	Denmark	60	61	62	53
	Estonia	74	73	71	61
	Finland	65	71	66	64
	France	63	57	64	50
	Germany	54	46	49	44
	Greece	74	72	72	62
	Hungary	68	58	57	53
	Iceland	70	67	68	66
	Ireland	78	68	76	71
	Israel	70	64	71	64
	Italy	69	66	73	64
	Japan	61	56	57	52
	Korea	66	57	63	64
	Latvia	68	65	60	59
	Luxembourg	61	55	59	53
	Mexico	85	81	85	80
	Netherlands	55	48	55	47
	New Zealand	79	71	76	72
	Norway	69	64	67	60
	Poland	68	60	70	58
	Portugal	73	72	75	72
	Slovak Republic	65	59	64	57
	Slovenia	72	66	63	57
	Spain	68	65	71	68
	Sweden	74	67	74	65
	Switzerland	54	48	53	43
	Turkey	80	79	75	71
	United Kingdom	80	68	77	71
	United States	81	72	74	70
Partners	Albania	93	91	90	88
	Algeria	82	82	80	76
	Brazil	82	79	85	76
	B-S-J-G (China)	91	87	88	82
	Bulgaria	71	65	71	62
	CABA (Argentina)	71	60	72	59
	Colombia	82	77	79	72
	Costa Rica	79	74	80	74
	Croatia	70	66	67	62
	Dominican Republic	84	81	85	79
	FYROM	85	81	80	75
	Georgia	71	64	76	68
	Hong Kong (China)	73	72	75	69
	Indonesia	95	95	94	91
	Jordan	91	85	85	83
	Kosovo	92	89	88	85
	Lebanon	83	81	80	77
	Lithuania	81	77	70	68
	Macao (China)	75	69	77	65
	Malta	70	60	65	64
	Moldova	74	77	75	74
	Montenegro	82	75	72	69
	Peru	89	85	87	77
	Qatar	86	82	82	79
	Romania	76	76	76	74
	Russia	77	77	70	67
	Singapore	88	83	86	79
	Chinese Taipei	76	70	77	72
	Thailand	92	91	90	90
	Trinidad and Tobago	81	74	79	78
	Tunisia	88	86	84	78
	United Arab Emirates	86	82	82	79
	Uruguay	80	70	71	66
	Viet Nam	91	88	85	72

Note: All gender differences are statistically significant (see Annex A3).
Source: OECD, PISA 2015 Database, Tables I.3.3a and I.3.3c.
StatLink http://dx.doi.org/10.1787/888933432397

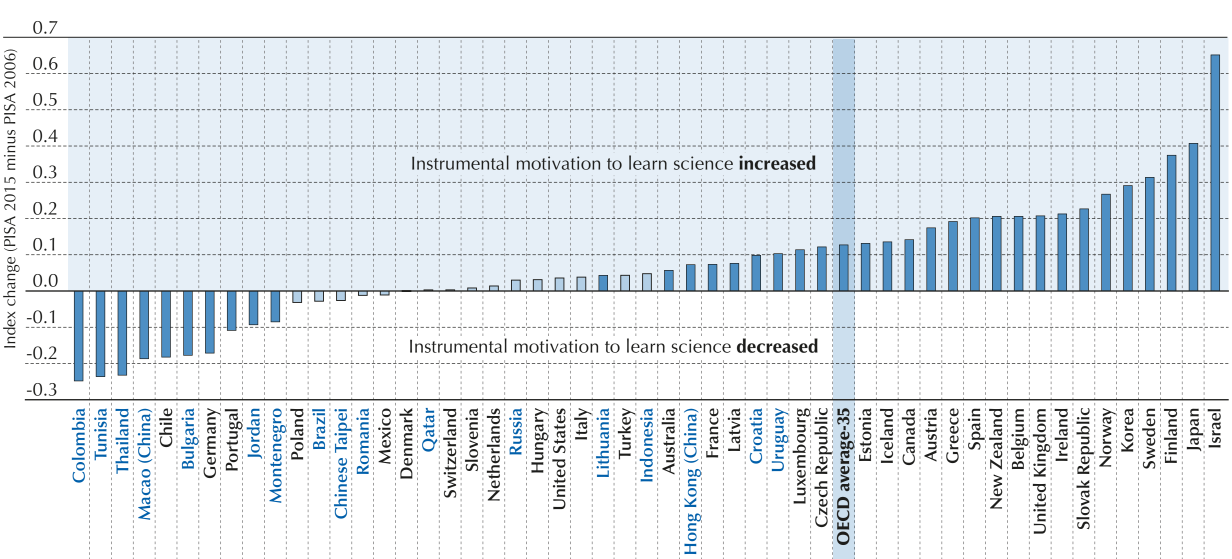
Instrumental motivation to learn science

Instrumental motivation to learn science refers to the drive to learn science because students perceive it to be useful to them and to their future studies and careers (Wigfield and Eccles, 2000). PISA measures the extent to which students feel that science is relevant to their own study and career prospects through students' responses ("strongly agree", "agree", "disagree" or "strongly disagree") to statements that affirm that making an effort in their school science subject(s) is worthwhile because it will help them in the work they want to do later on; that what they learn in school science subject(s) is worthwhile because they need it for what they want to do later on; that studying science at school is worthwhile because what they learn will improve their career prospects; and that many things they learn in their school science subject(s) will help them get a job. The index of instrumental motivation to learn science was constructed to summarise students' answers; the scale of this index was set to allow for comparisons with the corresponding index in PISA 2006. The difference between a student who agrees with all four statements, and a student who disagrees with the statements, corresponds to 1.15 points on this scale, or about the average standard deviation in OECD countries (which equals 0.98).

In general, a majority of students recognises the instrumental value of studying science as a way to improve their career prospects and work in their desired field. On average across OECD countries, 69% of students agreed or strongly agreed that making an effort in science subjects at school is worth it because it will help them in the work they want to do later on; 67% of students agreed that studying science subjects at school is worthwhile because what they learn will improve their career prospects. These percentages are somewhat lower than those observed in response to similar questions about mathematics in PISA 2012. In 2012, 78% of students, on average across OECD countries, agreed or strongly agreed that learning mathematics is worthwhile because it will improve their career prospects (OECD, 2013). Nevertheless, these data reveal that at least two out of three students appreciate the value of science in their future studies and careers (Figure I.3.13).

Two of the four items used in PISA 2015 to measure students' instrumental motivation to learn science are identical to those included in the PISA 2006 questionnaires. Both of these items reveal that instrumental motivation to learn science has increased among students, on average across OECD countries. The share of students who agreed or strongly agreed that making an effort in science subjects at school is worth it because it will help them in the work they want to do later on, and the proportion who agreed that studying science subjects at school is worthwhile because what they learn will improve their career prospects, both increased between five and six percentage points between 2006 and 2015. This is reflected in an OECD average increase of 0.12 unit on the index of instrumental motivation to learn science (Table I.3.3f).[4]

Figure I.3.14 ▪ **Change between 2006 and 2015 in students' instrumental motivation to learn science**



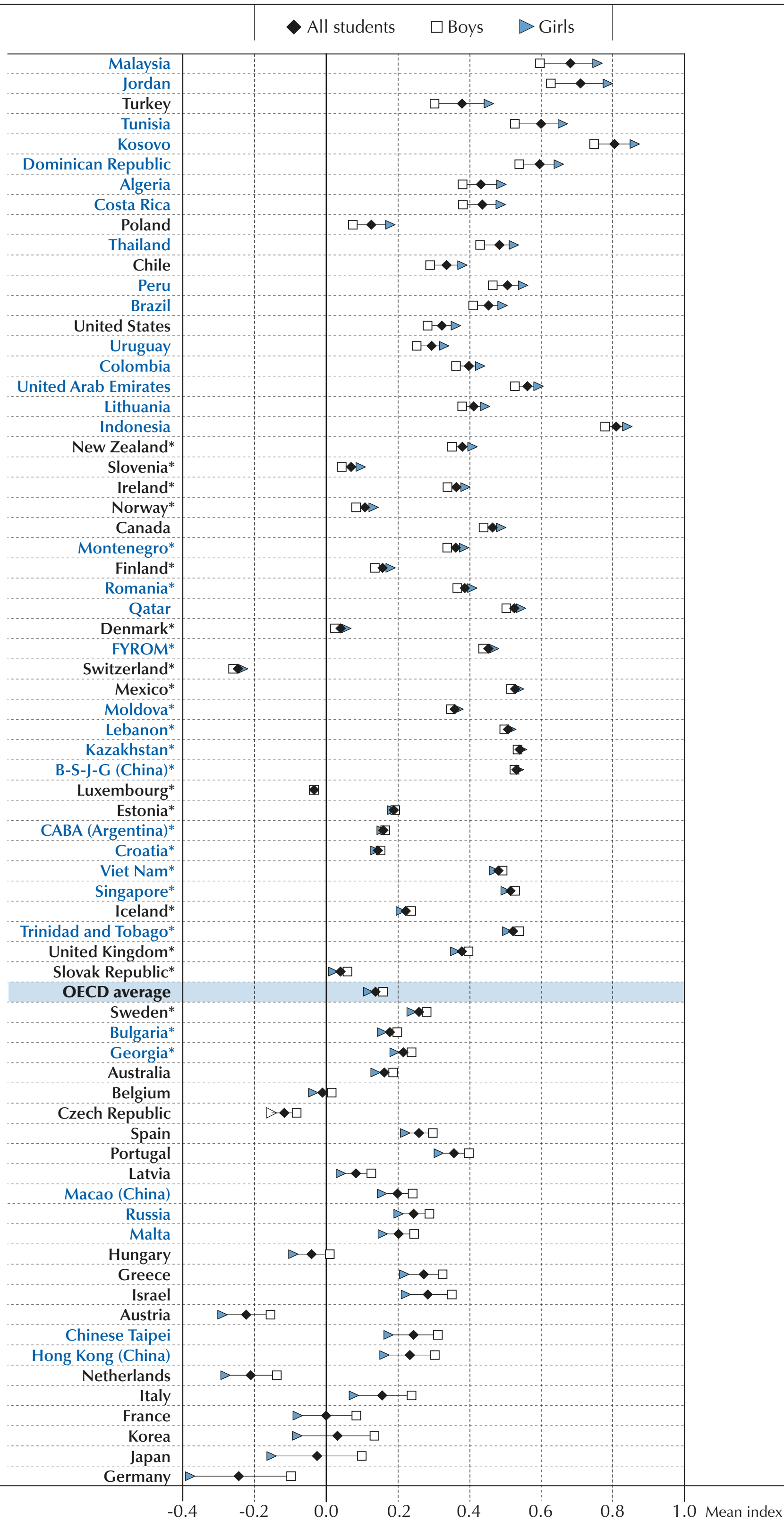
Note: Statistically significant differences are marked in a darker tone (see Annex A3).

Countries and economies are ranked in ascending order of the change in the index of students' instrumental motivation to learn science between 2006 and 2015.

Source: OECD, PISA 2015 Database, Table I.3.3f.

StatLink http://dx.doi.org/10.1787/888933432403

Figure I.3.15 ■ **Gender differences in students' instrumental motivation to learn science**



Note: Gender differences that are not statistically significant are marked with an asterisk next to the country/economy name (see Annex A3).
Countries and economies are ranked in ascending order of the difference between boys' and girls' instrumental motivation to learn science.
Source: OECD, PISA 2015 Database, Tables I.3.3a and I.3.3c.
StatLink http://dx.doi.org/10.1787/888933432417

In Finland, Israel, Japan and Sweden, the proportion of students who responded positively to each of these two items increased by more than 10 percentage points; the index of instrumental motivation to learn science increased by at least 0.3 point in these four countries. In Belgium, Ireland, New Zealand, Norway, the Slovak Republic and the United Kingdom, the index increased by between 0.2 and 0.3 point. By contrast, in ten countries and economies, including OECD countries Chile, Germany and Portugal, instrumental motivation to learn science was lower in 2015 than in 2006 (Figure I.3.14 and Table I.3.3f).

As noted above, improvements between 2006 and 2015 in students' instrumental motivation to learn science are related to improvements in students' enjoyment of science. At the country level, changes in students' instrumental motivation to learn science over the period are unrelated to changes in science performance, engagement with science or self-efficacy (all correlations are between -0.4 and 0.4) (Table I.3.8).

In 21 countries/economies, as well as on average across OECD countries, the index of instrumental motivation to learn science is significantly higher among boys than among girls (Figure I.3.15). Table I.3.3c shows that, in Germany, 56% of boys, but only 43% of girls, agreed that studying science subjects at school is worthwhile because what they learn will improve their career prospects; similarly, in Japan and Korea, the share of boys who reported so exceeds the corresponding share of girls by more than ten percentage points. By contrast, in 21 other countries/economies, the index of instrumental motivation to learn science is significantly higher among girls than among boys. At the country level, gender differences in instrumental motivation to learn science are related to differences in the shares of boys and girls who expect to have careers in occupations that require further science studies. The correlation between these two gender gaps is 0.4 (Table I.3.9).

Instrumental motivation to learn science and expectations of a science career

By comparing levels of instrumental motivation for learning science across students with different career expectations, it is possible to explore the breadth of students' views concerning the usefulness of school science. Are students equally likely to perceive science as useful when they expect to work in science-related occupations as when they expect to work in occupations requiring similar levels of qualifications but that are not science-related?

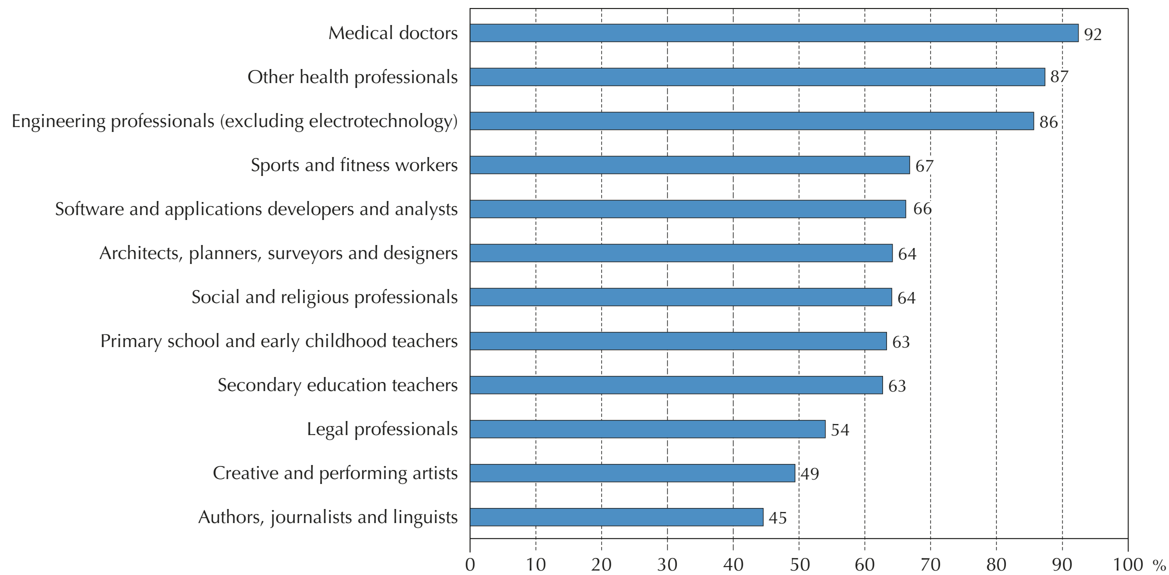
Figure I.3.16 shows, for 12 major professional or technical occupations (chosen among those that students most frequently cited when asked what occupation they expect to work in when they are 30), the corresponding share of students who agreed that making an effort in science subjects at school is worth it because this will help them in the work they want to do later on. On average across OECD countries, more than 90% of students who expect to work as medical doctors perceived efforts in school science as useful for what they want to do later in life, as did 87% of students who expect to work as dentists, pharmacists, physiotherapists or dieticians, and 86% of prospective engineers. But only about two in three of the students who expect to work as software and applications developers or as architects and designers perceived such efforts as useful – a similar proportion as among prospective sports and fitness workers, school teachers, and social and religious workers. Only 54% of students who expect to work as legal professionals reported that they think that school science is useful for their future career, as did less than 50% of students who expect to work as creative and performing artists, or as authors and journalists.

The significant differences in students' perceptions about the usefulness of school science, including among those students who were classified as having science-related career expectations, indicate that many students may have somewhat narrow views of the utility of school science. Perhaps, when prompted to think about what they learn in science at school, students mainly refer to content knowledge – the facts and theories learned in biology, chemistry, physics or earth science classes – rather than to procedural or epistemic knowledge that can be applied outside of science-related careers too (e.g. "What constitutes a valid argument based on data?", "How can experiments be used to identify cause and effect?").

But students' perceptions about how useful school science is for specific careers also differ across countries. For instance, in Finland, Germany and Switzerland, less than half of all students who expect to work as "software and applications developers and analysts" agreed that making an effort in school science is useful for the work they want to do later on, a similar percentage as among students who expect to work as lawyers or journalists ("legal professionals", "authors, journalists and linguists"). Meanwhile, in Canada, France, Greece, Hong Kong (China) and Macao (China), among others, more than 80% of students who expect to work as software developers perceive school science to be useful for their career – a significantly higher percentage than among students who expect to work as lawyers or journalists (Table I.3.11f). Such differences may partly reflect disparities in which science content is emphasised in school. They may also reflect country differences in tertiary studies that lead to these careers.

Figure I.3.16 ▪ **Students' expectations of future careers and instrumental motivation to learn science**

Percentage of students who "agree"or "strongly agree" that "making an effort in my <school science> subject(s) is worth it because this will help [them] in the work [they] want to do later on", by expected occupation



Source: OECD, PISA 2015 Database, Table I.3.11f.
StatLink http://dx.doi.org/10.1787/888933432425

NURTURING FUTURE SCIENTISTS: THE ROLE OF SKILLS AND MOTIVATION

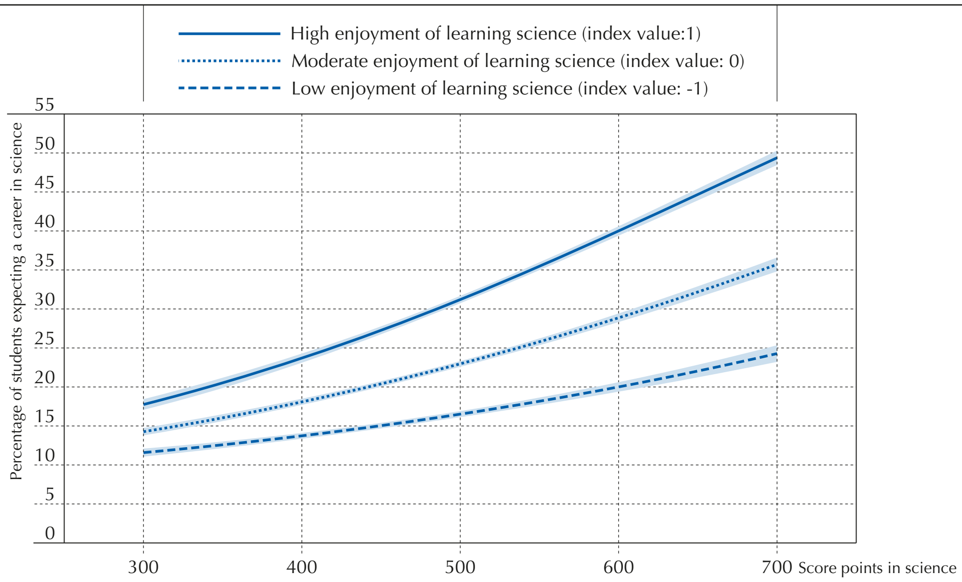
Knowledge of and about science does not automatically translate into the ability to apply scientific knowledge in real-life situations, nor into an interest in pursuing a career in science. Assuming otherwise gives little or no recognition to the range of interests, attitudes, beliefs and values that influence personal decisions (Bybee and McCrae, 2011).

As Figure I.3.17 shows, the likelihood that a student expects to pursue a career in science increases as his or her performance in science improves, and this association is positive among both students who do not value science as something particularly interesting and enjoyable (those who are one standard deviation below the OECD average on the index of enjoyment of science) and students who do (those who are one standard deviation above the OECD average on that index). But the association with performance depends on the degree to which students enjoy science. Among students with a value of 0 (or close to the mean) on the index of enjoyment of science, an estimated 23% expect a career in a science-related occupation if they score about 500 points on the science scale (or slightly above the OECD average score); that share increases to 29% if the science score is about 600 points (boys of average socio-economic status are taken as the reference here; all results are presented after accounting for gender and socio-economic status). But for students with a value of one on the index of enjoyment of science, the likelihood increases from 31% to 40%. In other words, among students who enjoy learning science and participating in science-related activities, aptitude or performance have a stronger impact on the likelihood that they expect a career in science. And among high-performing students, interest in science and intrinsic motivation are more strongly associated with whether or not they expect a career in science. (Results for individual countries and economies are presented in Tables I.3.13a and I.3.13b).

In most countries, PISA data show that expectations of future careers in science are positively related to performance in science and, even after accounting for performance, to enjoyment of science activities. They also show that the relationship with performance is not independent of the level of enjoyment (and that the relationship with enjoyment is not independent of the level of performance). This interplay between performance and enjoyment is identified in the statistical analysis by a significant, positive relationship with the interaction term (performance×enjoyment).

Figure I.3.17 ▪ **Students expecting a career in science, by performance and enjoyment of learning**

Estimate, after accounting for gender and socio-economic status, OECD average



Note: The lines represent the predicted share of students expecting a career in a science-related occupation, based on a logistic model with the index of enjoyment of science, performance in science, their product, gender and the PISA index of economic, social and cultural status introduced as predictors. The shaded area around the curves indicates the upper and lower bounds of the 95% confidence interval for these estimates.

Source: OECD, PISA 2015 Database, Table I.3.13b.

StatLink http://dx.doi.org/10.1787/888933432435

The interplay of aptitude and attitudes has important implications for any effort to increase the share of students who want to pursue the study of science beyond compulsory education. It is probably difficult to work in a science-related job without being good at science, and students seem to be aware of this. However, being capable in science does not necessarily mean that a student will enjoy science, science-related activities or pursue a science career. Therefore, in addition to cognitive ability, the beliefs in one's own competence, one's interests and the value that one attaches to relevant subjects are key factors in students' decisions about their careers (Wang and Degol, 2016).

These results also suggest that higher cognitive ability and positive attitudes towards science do not compensate for each other: low scores in one domain cannot be offset by higher scores in the other. To the extent that these associations reflect underlying causal mechanisms, they imply that it is not sufficient to enhance academic proficiency or to develop positive attitudes; if teachers focus on one to the exclusion of the other, then the influence of each is undermined (Nagengast et al., 2011).

While Figure I.3.17 identifies two factors that predict, with some accuracy, whether a student expects a career in science, it does not cover all of the elements that influence that expectation. For instance, in 17 countries and economies, girls remain significantly less likely than boys to expect a science-related career even among students who perform similarly and enjoy science to the same extent. This includes, among OECD countries, Austria, the Czech Republic, Estonia, Hungary, Luxembourg, Mexico, Slovenia and Turkey (as highlighted by negative coefficients for the "girl" indicator in Table I.3.13b). And this is true in many more countries for careers outside of the health sector. This gender difference could be related to other elements of the subjective value of science that were not included in the model, such as attainment value, i.e. how important science is to the student and how well-aligned science is with the student's own identity (Wigfield, Tonks and Klauda, 2009), which in turn is shaped by the social and cultural context in which the student lives, or to differences in self-efficacy, which are discussed at the end of this chapter. As shown in a study of 10-11 year-old girls in England (United Kingdom), despite being highly proficient in science and enjoying the subject, girls may perceive certain science occupations as not appropriate for women and thus devalue related activities as not important for them (Archer et al., 2013).

Similarly, even among students of similar proficiency in science and who reported the same level of enjoyment of science, socio-economic status has an influence on career expectations. Students from more advantaged families (as indicated by higher values on the PISA index of economic, social and cultural status) are more likely to expect to work in science-related

occupations, compared to students from more disadvantaged backgrounds. On average across OECD countries, and even after accounting for differences in science performance and reported level of enjoyment of science, a one-unit increase on the PISA index of economic, social and cultural status is associated with a higher likelihood (+1.7 percentage points) of expecting a career in science. A significant socio-economic difference, even after accounting for students' performance, enjoyment of science and gender, is found in 41 countries and economies (Table I.3.13b). Similar findings inspired several initiatives aimed at raising the profile of science-related careers among high-performing students, particularly from under-represented backgrounds (see e.g. OECD, 2008; Department for Business, Innovation and Skills, 2016).

BIVARIATE ASSOCIATIONS OF ENGAGEMENT WITH SCIENCE AND MOTIVATION FOR LEARNING SCIENCE WITH PERFORMANCE

This section presents simple associations between science engagement and performance, and between motivation for learning science and performance. Such associations do not necessarily reflect a causal relationship. In fact, cause and effect may go both ways; the causal links may also be indirect, mediated by other important factors; or the links may be spurious, reflecting associations with a third, confounding factor that influences both the degree of proficiency in science and the reported frequency of students' engagement in science-related activities or motivation for learning science. More robust causal links could be identified if it were possible to compare the changes in performance over time with concurrent changes in attitudes towards science. However, due to the repeated cross-sectional nature of data in PISA, comparisons across different years are only possible at the country/economy level, i.e. on a small number of observations and with limited scope for accounting for other concurrent changes.

Within-country associations with performance

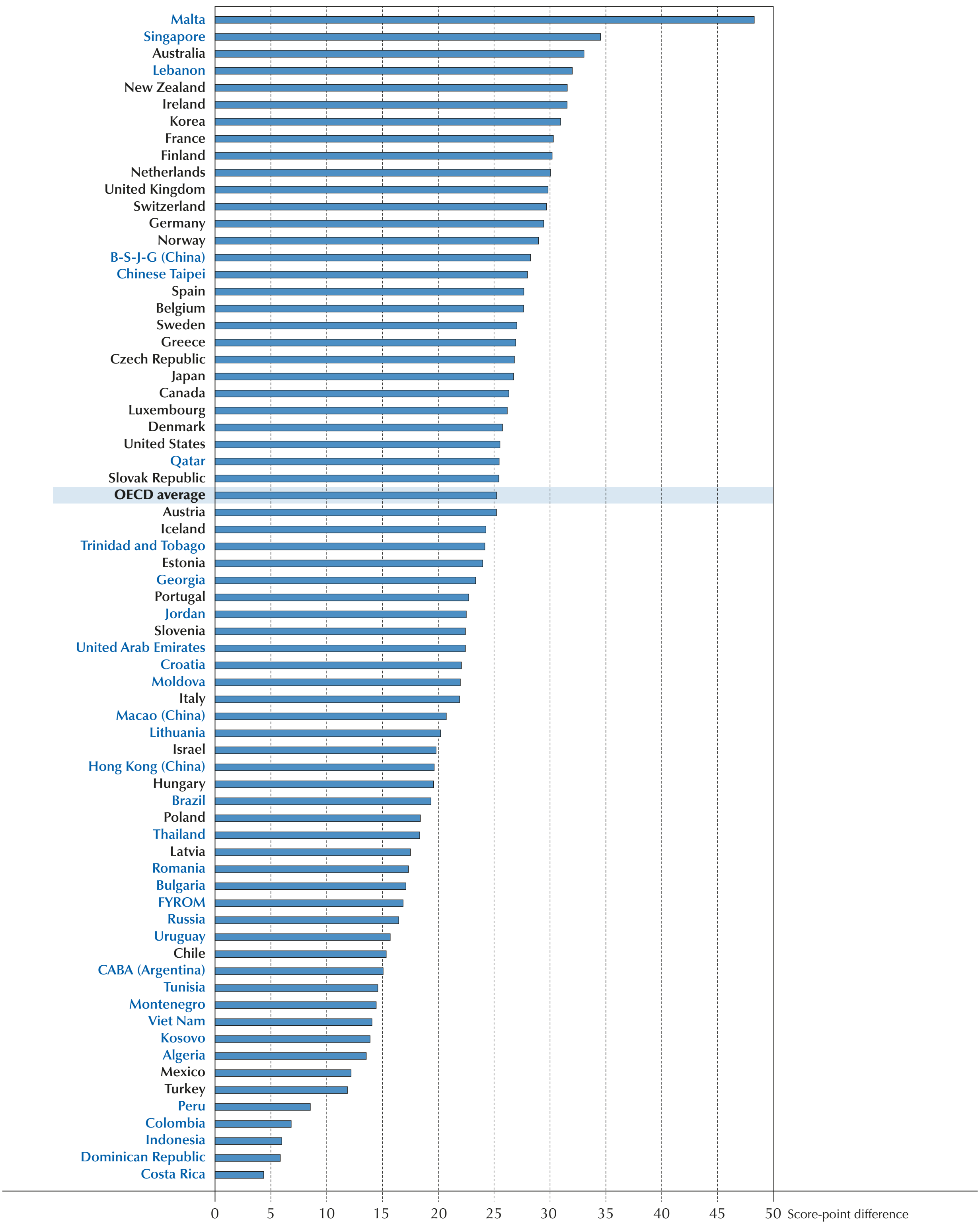
Participation in science-related activities is not strongly related to performance, on average, but the relationship varies greatly depending on the country. In many countries, students who reported participating more frequently in science activities (as indicated by higher values on the index of science activities) tend to score higher, on average. In particular, in Australia, France, Ireland, Japan, Korea and Chinese Taipei, the difference in performance between the 25% of students who reported the most frequent participation in science activities and the 25% of students who reported the least frequent participation is over 40 score points, on average. But in other countries, the opposite pattern is found. In Bulgaria, Colombia, the Dominican Republic, Israel, Peru, Qatar, Tunisia and the United Arab Emirates, for example, students who reported the most frequent participation in science-related activities were often among the lowest performers in science (Table I.3.5b).

Enjoyment of science is, in all countries, positively related to performance in science. As Figure I.3.18 indicates, students who reported less interest in and enjoyment of learning science, and who reported not having fun when learning about science topics, generally scored lower in science than those who reported that they enjoy science and are happy working on science topics. On average across OECD countries, a change of one unit on the index of enjoyment of science corresponds to a 25 score-point difference in science performance. In every country/economy, the 25% of students who reported the most enjoyment scored higher than the 25% of students who reported the least enjoyment – 75 points higher, on average across OECD countries (Table I.3.1b). But the strength of this association varies greatly across countries. In Australia, Malta, New Zealand and Sweden, more than 95 score points separate the most intrinsically motivated students from the least intrinsically motivated, while in Colombia, Costa Rica, the Dominican Republic, Indonesia and Peru, less than 20 score points, on average, separate these two groups of students. Across OECD countries, 9% of the variation in students' science performance can be explained by differences in students' enjoyment of science. In Ireland and Malta, more than 15% of the variation is so explained, and in all but five countries/economies, the association is positive and significant.

Instrumental motivation to learn science also tends to be positively related to performance. As Figure I.3.19 indicates, students who reported less instrumental motivation to learn science generally scored somewhat below those who reported that what they learn in science at school is important for them because they need this knowledge for what they want to do later on. But the association between instrumental motivation and performance is weaker than the association between intrinsic motivation and performance. On average across OECD countries, a one-unit increase on the index of instrumental motivation corresponds to only a nine-point improvement in performance. The relationship is flat, or slightly negative, in a few countries/economies. In 31 countries and economies, the relationship between students' instrumental motivation and science performance is significantly more positive among the highest-achieving students (those scoring at the 90th percentile) than among the lowest-achieving students (those scoring at the 10th percentile). This implies that there is greater variation in science performance among students with high instrumental motivation than among students with low instrumental motivation (Table I.3.3d).

Figure I.3.18 ▪ **Students' enjoyment of science and science performance**

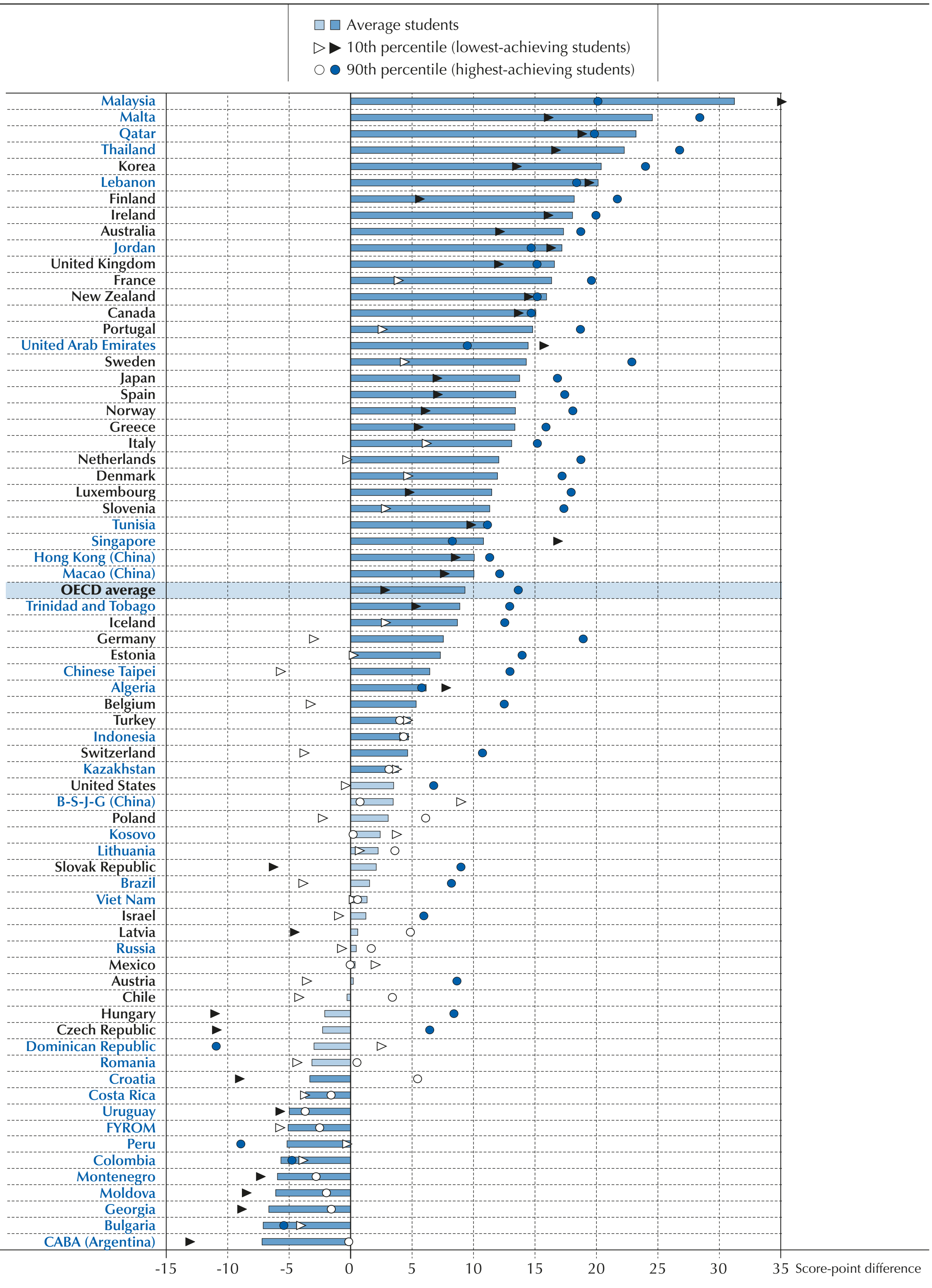
Score-point difference associated with one-unit increase in the index of enjoyment of science



Note: All score-point differences are statistically significant (see Annex A3).
Countries and economies are ranked in descending order of the score-point difference associated with the index of enjoyment of science.
Source: OECD, PISA 2015 Database, Table I.3.1d.
StatLink http://dx.doi.org/10.1787/888933432440

Figure I.3.19 ▪ **Students' instrumental motivation to learn science and science performance**

Score-point difference associated with one-unit increase in the index of instrumental motivation



Note: Statistically significant differences are marked in a darker tone (see Annex A3).

Countries and economies are ranked in descending order of the score-point difference of average students associated with the index of instrumental motivation.

Source: OECD, PISA 2015 Database, Table I.3.3d.

StatLink http://dx.doi.org/10.1787/888933432452

Associations with performance at the country/economy level

Average levels of participation in science activities, of enjoyment of science and of instrumental motivation reported in PISA are all negatively related to mean performance in PISA (Table I.3.7), a finding often referred to as the attitude-achievement paradox (Bybee and McCrae, 2011; Lu and Bolt, 2015). This paradox illustrates the difficulty of comparing self-reported scales across countries and cultural contexts (see Box I.2.4 in Chapter 2).

Comparing changes across time at the country/economy level avoids the problem of accounting for varying cultural standards for self-reporting because direct comparisons of student responses are limited to students from the same country, albeit at different points in time. Changes between 2006 and 2015 in student participation in science activities, in students' enjoyment of science and in students' instrumental motivation to learn science are all unrelated, or only weakly related, to concurrent changes in students' science scores (correlations lower than 0.3 in absolute value; see Table I.3.8). This may indicate that student performance in science can improve even in the absence of greater motivation to learn science, and, conversely, that students can develop greater motivation to learn science even if there is no improvement in their science scores.

SCIENCE SELF-EFFICACY

The term "self-efficacy" is used to describe students' belief that, through their actions, they can produce desired effects, such as solving a difficult problem or achieving a personal goal. This, in turn, is a powerful incentive to act or to persevere in the face of difficulties (Bandura, 1977).

Science self-efficacy refers to future-oriented judgements about one's competency in accomplishing particular goals in a specific context, where meeting these goals requires scientific abilities, such as explaining phenomena scientifically, evaluating and designing scientific enquiry, or interpreting data and evidence scientifically (Mason et al., 2012). Better performance in science leads to higher levels of self-efficacy, through positive feedback received from teachers, peers and parents, and the positive emotions associated with it. At the same time, students who have low self-efficacy are at high risk of underperforming in science, despite their abilities (Bandura, 1997). If students do not believe in their ability to accomplish particular tasks, they may not exert the effort needed to complete the task, and a lack of self-efficacy becomes a self-fulfilling prophecy. Self-efficacy in science has been related to students' performance, but also to their career orientation and their choice of courses (Nugent et al., 2015).

While younger children have often been found to hold more positive beliefs about their general ability than older children, domain-specific self-efficacy tends to increase with age. This can reflect the fact that as children become better at understanding and interpreting the feedback received from parents, peers or teachers, they become more accurate and realistic in their self-assessments (Wigfield and Eccles, 2000).

PISA 2015 asked students to report on how easy they thought it would be for them to: recognise the science question that underlies a newspaper report on a health issue; explain why earthquakes occur more frequently in some areas than in others; describe the role of antibiotics in the treatment of disease; identify the science question associated with the disposal of garbage; predict how changes to an environment will affect the survival of certain species; interpret the scientific information provided on the labelling of food items; discuss how new evidence can lead them to change their understanding about the possibility of life on Mars; and identify the better of two explanations for the formation of acid rain. For each of these, students could report that they "could do this easily", "could do this with a bit of effort", "would struggle to do this on [their] own", or "couldn't do this". Students' responses were used to create the index of science self-efficacy. The values of this index were equated with the values of the corresponding index for PISA 2006 to allow for comparisons across PISA cycles. A one-unit increase on the index corresponds to the difference between a student who reported that he or she would struggle to do any of the eight science-related tasks on his or her own (average index of science self-efficacy: -1.05), and a student who reported that he/she could do, with a bit of effort, at least six of the tasks, but would struggle with the remaining two (average index: -0.05).

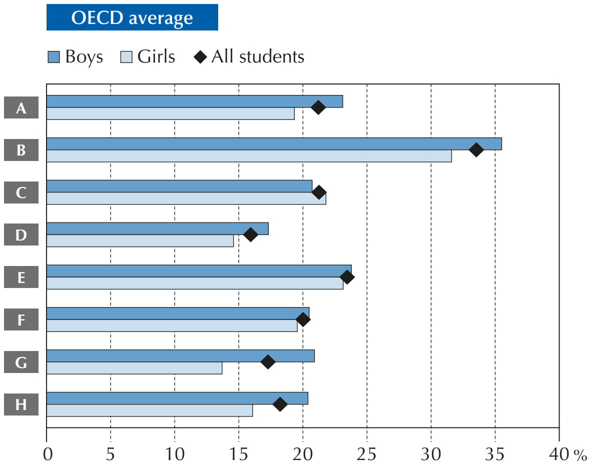
Figure I.3.20 and Table I.3.4c show that girls are more likely than boys to have low self-efficacy. In 41 countries and economies, the mean index of science self-efficacy among boys is significantly higher than that among girls. Gender differences in science self-efficacy are particularly large in Denmark, France, Germany, Iceland and Sweden, where they exceed 0.3 unit on the self-efficacy scale. In eight countries/economies, girls reported higher science self-efficacy than boys, on average; and in 23 countries/economies, the difference between boys and girls in science self-efficacy is not significant.

A detailed analysis of each task reveals that the gender gap in self-confidence depends on the type of problem or situation boys and girls encounter. Boys were more likely to report that they can "easily" discuss how new evidence can lead them to change their understanding about the possibility of life on Mars, recognise the science question that underlies a newspaper report on a health issue, or identify the better of two explanations for the formation of acid rain.

Figure I.3.20 ■ Students' self-efficacy in science, by gender

Percentage of students who reported that "[they] could easily do" the following tasks

- **A** Recognise the science question that underlies a newspaper report on a health issue
- **B** Explain why earthquakes occur more frequently in some areas than in others
- **C** Describe the role of antibiotics in the treatment of disease
- **D** Identify the science question associated with the disposal of garbage
- **E** Predict how changes to an environment will affect the survival of certain species
- **F** Interpret the scientific information provided on the labelling of food items
- **G** Discuss how new evidence can lead you to change your understanding about the possibility of life on Mars
- **H** Identify the better of two explanations for the formation of acid rain



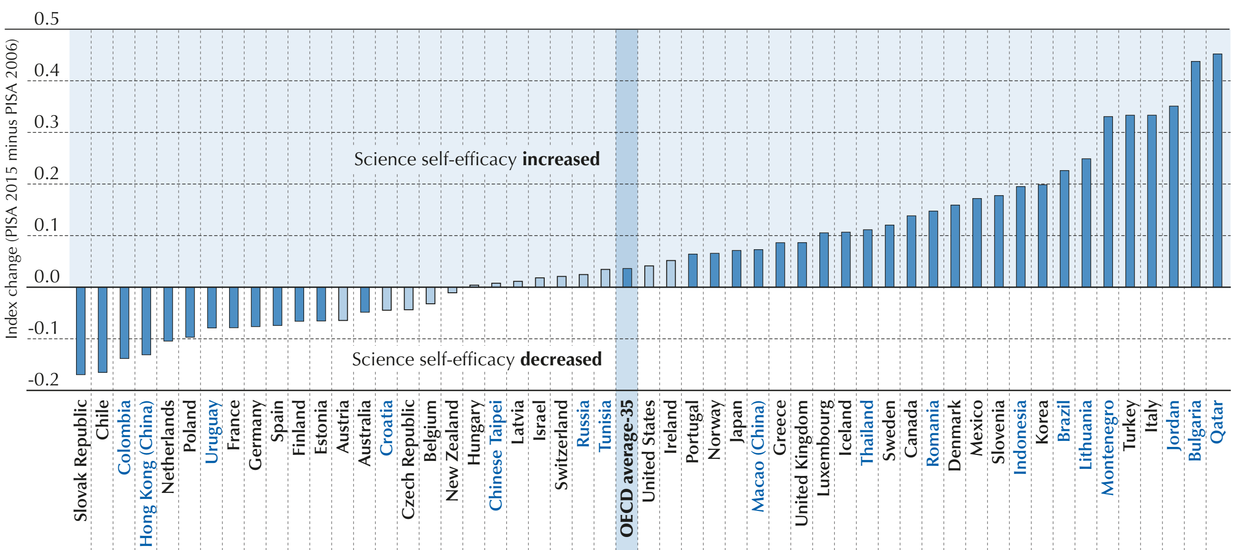
		A	B	C	D	E	F	G	H
OECD	Australia	21	41	22	12	32	17	17	13
	Austria	18	37	21	14	21	15	15	18
	Belgium	21	33	23	12	23	21	18	17
	Canada	28	36	25	22	36	25	22	22
	Chile	17	32	15	13	19	18	15	16
	Czech Republic	28	38	28	13	21	21	19	14
	Denmark	25	47	17	17	27	26	21	15
	Estonia	19	32	18	16	16	20	14	15
	Finland	15	43	18	14	15	20	18	11
	France	18	30	26	11	20	20	20	12
	Germany	21	37	24	13	23	17	13	19
	Greece	27	34	26	18	24	18	17	23
	Hungary	22	22	20	19	17	18	15	19
	Iceland	28	37	24	19	30	27	23	21
	Ireland	17	49	21	21	25	20	14	30
	Israel	32	25	21	21	25	34	22	19
	Italy	25	33	19	18	26	26	19	20
	Japan	8	19	6	10	12	7	7	5
	Korea	13	21	15	18	18	10	12	11
	Latvia	19	29	16	16	20	18	16	17
	Luxembourg	21	38	26	15	25	19	17	16
	Mexico	26	24	20	25	27	18	18	21
	Netherlands	17	41	24	11	19	15	16	18
	New Zealand	17	37	17	12	27	15	14	15
	Norway	14	29	23	15	24	17	19	20
	Poland	21	30	25	16	21	30	17	21
	Portugal	25	34	20	16	31	27	20	24
	Slovak Republic	23	24	21	14	18	21	17	18
	Slovenia	22	30	18	18	17	18	15	24
	Spain	17	39	22	12	23	21	20	20
	Sweden	16	33	17	15	26	17	17	20
	Switzerland	18	33	20	12	20	14	15	14
	Turkey	29	30	26	26	27	25	22	29
	United Kingdom	25	43	35	14	34	19	20	24
	United States	28	35	26	19	34	25	22	17
Partners	Albania	26	32	21	17	30	26	17	29
	Algeria	29	33	23	32	25	25	17	18
	Brazil	33	31	23	23	27	23	19	21
	B-S-J-G (China)	16	20	12	18	15	23	10	20
	Bulgaria	32	29	27	27	28	27	23	23
	CABA (Argentina)	31	36	17	17	31	25	18	19
	Colombia	23	20	17	22	24	17	14	17
	Costa Rica	18	25	17	24	24	16	14	16
	Croatia	20	28	32	19	22	16	17	24
	Dominican Republic	38	36	29	38	36	32	27	30
	FYROM	32	26	25	17	29	23	22	22
	Georgia	26	36	28	35	34	25	21	22
	Hong Kong (China)	12	21	12	12	15	18	10	18
	Indonesia	12	12	10	19	11	10	7	7
	Jordan	37	35	40	42	35	36	29	38
	Kosovo	25	23	23	16	22	23	16	20
	Lebanon	38	24	27	25	31	31	22	27
	Lithuania	23	34	27	19	23	20	21	19
	Macao (China)	14	28	14	14	18	18	9	22
	Malta	23	26	17	16	33	27	18	25
	Moldova	19	30	22	28	26	22	15	19
	Montenegro	33	32	29	27	29	27	24	27
	Peru	23	29	19	28	29	22	18	20
	Qatar	32	28	30	28	33	25	22	30
	Romania	18	20	18	15	19	18	16	16
	Russia	25	27	22	24	19	24	16	17
	Singapore	17	33	15	13	28	16	13	31
	Chinese Taipei	17	29	16	21	22	18	14	22
	Thailand	17	17	13	20	16	16	13	15
	Trinidad and Tobago	24	31	22	27	37	24	18	23
	Tunisia	31	23	19	21	21	23	18	17
	United Arab Emirates	32	31	32	29	32	27	24	32
	Uruguay	30	36	20	18	23	22	19	18
	Viet Nam	16	17	21	24	26	13	5	14

Note: All gender differences are statistically significant (see Annex A3).
Source: OECD, PISA 2015 Database, Tables I.3.4a and I.3.4c.
StatLink http://dx.doi.org/10.1787/888933432466

But in the majority of PISA-participating countries and economies, girls reported at least as frequently as boys did that they feel confident in describing the role of antibiotics in the treatment of disease. In the Netherlands, for instance, in contrast to the pattern observed for all other tasks, more girls than boys reported that they could easily explain the role of antibiotics (27% of girls, but only 20% of boys so reported). For this task, a significant difference, in favour of girls, is found in 26 countries and economies, as well as on average across OECD countries.

Between 2006 and 2015, students' science self-efficacy remained broadly stable, on average across OECD countries. In 2015, students were more likely to report that they could easily describe the role of antibiotics in the treatment of disease (+3 percentage points), but less likely to report that they could easily interpret the scientific information provided on the labels of food items. However, this average stability masks the significant improvement in students' science self-efficacy observed in 26 countries and economies, and the significant deterioration in self-efficacy observed in 12 countries and economies (Figure I.3.21). In Italy, for example, only 10% of students in 2006 reported that they could easily recognise the science question that underlies a newspaper report on a health issue; by 2015, 25% of students so reported. Similarly, only 8% of students in 2006 felt confident explaining the role of antibiotics in the treatment of disease; by 2015, 19% of students felt confident in doing so (Tables I.3.4a, I.3.4e and I.3.4f).

Figure I.3.21 ▪ **Change between 2006 and 2015 in students' self-efficacy in science**

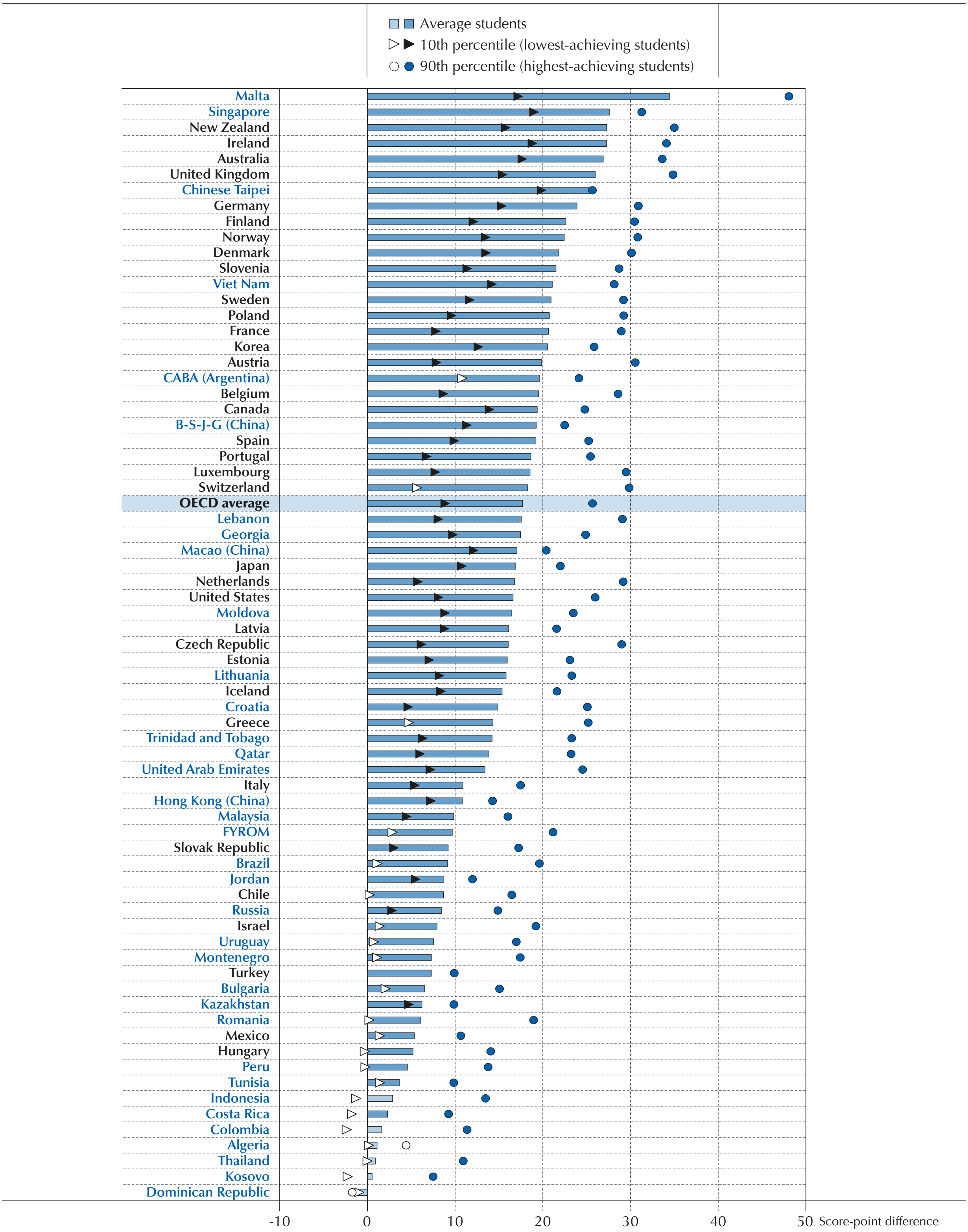


Note: Statistically significant differences are marked in a darker tone (see Annex A3).
Countries and economies are ranked in ascending order of the change in the index of self-efficacy in science between 2006 and 2015.
Source: OECD, PISA 2015 Database, Table I.3.4f.
StatLink http://dx.doi.org/10.1787/888933432476

As Figure I.3.22 shows, students who have low science self-efficacy perform worse in science than students who are confident about their ability to use their science knowledge and skills in everyday contexts. The blue bars in Figure I.3.22 indicate the estimated score-point difference in science performance associated with a difference of one unit on the index of science self-efficacy. On average across OECD countries, science self-efficacy is associated with a difference of 17 score points. The association is positive and significant in almost all PISA-participating countries and economies. The difference in science performance associated with students' self-efficacy is more than 25 score points in Australia, Ireland, Malta, New Zealand, Singapore, Chinese Taipei and the United Kingdom (all of which, except Malta, have mean scores above the OECD average). The association is flat, and not significant, in Algeria, Colombia, the Dominican Republic, Indonesia, Kosovo and Thailand (as well as in Bulgaria, Costa Rica, Hungary and Peru, after accounting for gender and socio-economic status) – all countries with mean scores below the OECD average. On average across OECD countries, however, only 6% of the variation in students' science performance can be explained by differences in how confident students feel about their ability to handle a range of situations in which they need to use their science skills and knowledge (Tables I.3.4b and I.3.4d).

Figure I.3.22 ▪ **Students' self-efficacy in science and science performance**

Score-point difference associated with one-unit increase in the index of self-efficacy



Note: Statistically significant differences are marked in a darker tone (see Annex A3).

Countries and economies are ranked in descending order of the score-point difference of average students associated with the index of self-efficacy.

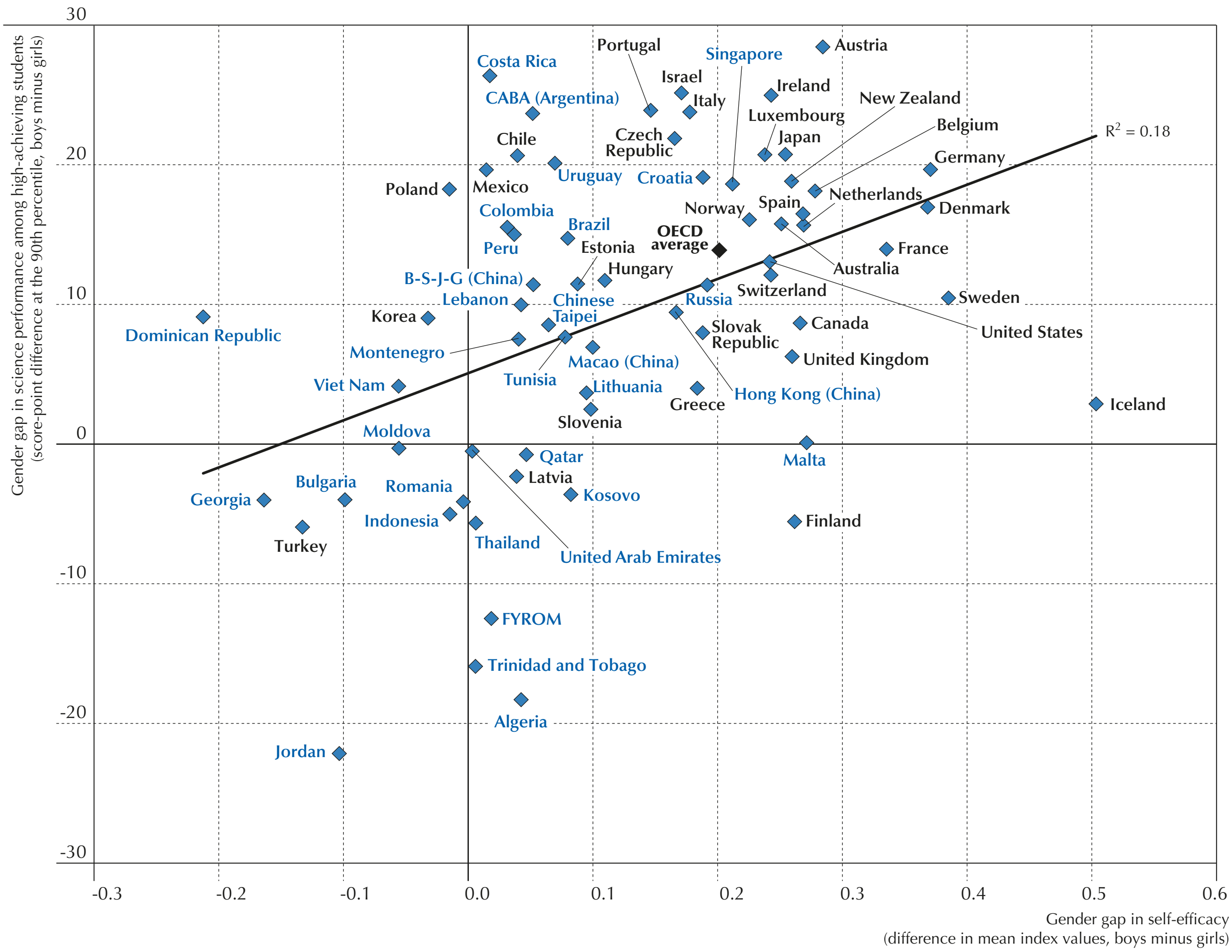
Source: OECD, PISA 2015 Database, Table I.3.4d.

StatLink http://dx.doi.org/10.1787/888933432481

The blue bars in Figure I.3.22 show the association between science self-efficacy and science performance at the mean; the triangles and the circles symbolise the relationship between science self-efficacy and science performance near the top and the bottom of the performance distribution. Across OECD countries, science self-efficacy is positively associated with science performance; but while the association is 17 points at the mean, similar increases in self-efficacy are associated with greater improvements in performance near the top of the performance distribution, among the highest-achieving students, than among the lowest-achieving students. Specifically, a change of one unit on the index is associated with a 25 score-point difference at the 90th percentile of the performance distribution, but with only a 9 score-point difference at the 10th percentile of the performance distribution. The association between self-efficacy and performance among the highest-achieving students is positive and significantly stronger than among the lowest-achieving students in all but two countries and economies (Algeria and the Dominican Republic). In Austria, the Czech Republic, France, Lebanon, Luxembourg, the Netherlands, Poland and Switzerland, for example, a one-unit increase on the self-efficacy index corresponds to a difference of about 30 score points in performance at the 90th percentile, but of less than 10 score points at the 10th percentile. Among the lowest-achieving students, the association is significant and positive in only 51 out of 72 countries and economies (Table I.3.4d).

Students' average science self-efficacy is not associated with a country's mean science performance (correlation: -0.2). In some of the highest-performing countries, such as Japan and Viet Nam, students reported some of the lowest levels of self-efficacy in science; in others, such as Canada, both performance and self-efficacy are above average. Similarly, among low-performing countries, there is great variation in students' science self-efficacy, with no clear pattern emerging.

Figure I.3.23 ■ **Gender gaps in self-efficacy and performance in science**



Source: OECD, PISA 2015 Database, Tables I.2.7 and I.3.4c.

StatLink http://dx.doi.org/10.1787/888933432491

But levels of self-efficacy tend to be positively associated with the percentage of students expecting a career in science-related occupations (r=0.5) or with the average frequency of participation in science-related activities (r=0.5), as discussed earlier (Tables I.2.3, I.3.4b and I.3.7).

These correlations involving mean index values are greatly affected by differences in how self-report scales are used (see Box I.2.4 in Chapter 2). One way to account for the variation in response style in cross-country comparisons is to explore associations of *changes* in index values across time with concurrent performance changes, or of *differences* in index values across boys and girls with gender gaps in performance. Indeed, the country-level variation in response style is, under plausible assumptions, netted out when index values are compared first within countries, across time or gender, and when only the resulting differences are compared across countries.

At the system level, changes in students' self-efficacy are weakly correlated with changes in students' performance in science (r=0.37), but they are related, as discussed previously, to changes in students' participation in science activities (r=0.48) (Table I.3.8). The gender gap in science self-efficacy is also moderately related to the gender gap in science performance, particularly among high-achieving students (r=0.43) (Table I.3.9). Countries and economies where the 10% best-performing boys in science score significantly above the 10% best-performing girls tend to have larger gender gaps in self-efficacy, in favour of boys. Meanwhile, in countries and economies where girls reported greater self-efficacy than boys, the gender gap among high-achieving students is not statistically significant; and in Jordan, the gender gap is to girls' advantage (Figure I.3.23 and Tables I.2.8a and I.3.4c).

These moderate correlations between students' self-efficacy and performance show that differences in self-efficacy can explain some of the variation in science performance observed across countries. In particular, they may explain why there are fewer top-performing girls than boys, despite similar average performance. At the same time, gender-related disparities in self-efficacy clearly do not account for all gender gaps in performance.

Notes

1. In 2006, the question was administered in paper format; in 2015, most countries/economies administered the question in computer format. In 2006, responses were coded according to the International Standard Classification of Occupations (ISCO), 1988 edition; in 2015, responses were coded according to the International Standard Classification of Occupations (ISCO), 2008 edition. These contextual changes in the methods used to measure career expectations must be borne in mind when comparing student responses across these two cycles.

2. Occupations are defined by the first three digits in the International Standard Classification of Occupations (ISCO), 2008 edition.

3. In 2006, students reported their level of agreement with four out of the five items retained for the PISA 2015 questionnaire. They responded on a scale from "strongly agree" to "strongly disagree" to the question "How much do you agree with the statements below?". In 2015, the response scale was inverted (from "strongly disagree" to "strongly agree"), and the question stem was changed ("How much do you disagree or agree with the statements about yourself below?"). These minor changes are expected to have a negligible influence on comparisons between 2006 and 2015, and values for the PISA 2015 index of enjoyment of science are reported on the scale originally developed in PISA 2006.

4. The PISA 2015 index of instrumental motivation to learn science is reported on the scale as the corresponding index for PISA 2006.

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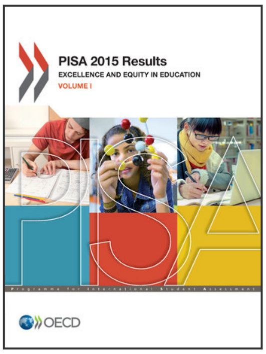
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