3

Performance in collaborative problem solving

This chapter explains how PISA measures students' collaborative problem-solving skills. It defines the five proficiency levels on the collaborative problem-solving scale and describes what students who attain those levels can do. The chapter also examines the relationship between student performance in collaborative problem solving and performance in the three core PISA subjects – science, reading and mathematics – and the links between collaborative problem solving and individual problem solving. It concludes with a discussion of the extent to which students' experiences with ICT are related to their performance in this computer-based assessment.

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.

How well do 15-year-old students work in groups to solve problems and achieve pre-set goals? The PISA 2015 computer-based assessment of collaborative problem solving uses scenarios with which 15-year-olds are likely to be familiar in order to measure their ability to collaborate with others. Test problems included items requiring only simple or moderate problem-solving ability. As such, the assessment focused as much as possible on students' collaboration skills, as opposed to their problem-solving skills, which were evaluated in PISA 2012. Some 52 countries and economies participated in the collaborative problem-solving assessment (32 OECD countries and 20 partner countries and economies).

What the data tell us

- Students in Singapore score higher in collaborative problem solving than students in all other participating countries and economies, followed by students in Japan.
- On average across OECD countries, 28% of students are able to solve only straightforward collaborative problems, if any at all. By contrast, fewer than one in six students in Estonia, Hong Kong (China), Japan, Korea, Macao (China) and Singapore is a low achiever in collaborative problem solving.
- Across OECD countries, 8% of students are top performers in collaborative problem solving, meaning that they can maintain an awareness of group dynamics, ensure team members act in accordance with their agreed-upon roles, and resolve disagreements and conflicts while identifying efficient pathways and monitoring progress towards a solution.
- Collaborative problem-solving performance is positively related to performance in the other assessed domains, but the relationship is weaker than that observed among performance in those other domains.
- Students in Australia, Japan, Korea, New Zealand and the United States perform among the best in collaborative problem solving, on average, compared to students in other countries who show similar performance in science, reading and mathematics.

HOW THE PISA 2015 COLLABORATIVE PROBLEM-SOLVING RESULTS ARE REPORTED

The previous chapter introduces the concept of collaborative problem-solving competence that underlies this assessment. This section discusses how an overall measure of collaborative problem-solving competence was derived from students' answers to questions that measure different types of collaborative problem-solving skills. It then describes how 15-year-olds were classified into five proficiency levels, one of which comprises those students who score below the lowest described level and whose proficiencies could not be identified.

How the assessment was analysed and scaled

Six units were developed and used for the PISA 2015 collaborative problem-solving assessment. Each unit involved a scenario with multiple individual items that students had to work through, all of which led to the resolution of the scenario. In the case of the released unit, *Xandar*, students had to work together to answer as many questions as possible in a simulation of an in-class contest. Units were presented in their entirety to students and were organised into three separate clusters, each of which required 30 minutes to complete. All students who participated in the collaborative problem-solving assessment completed two clusters of science and either one or two additional clusters of collaborative problem solving.

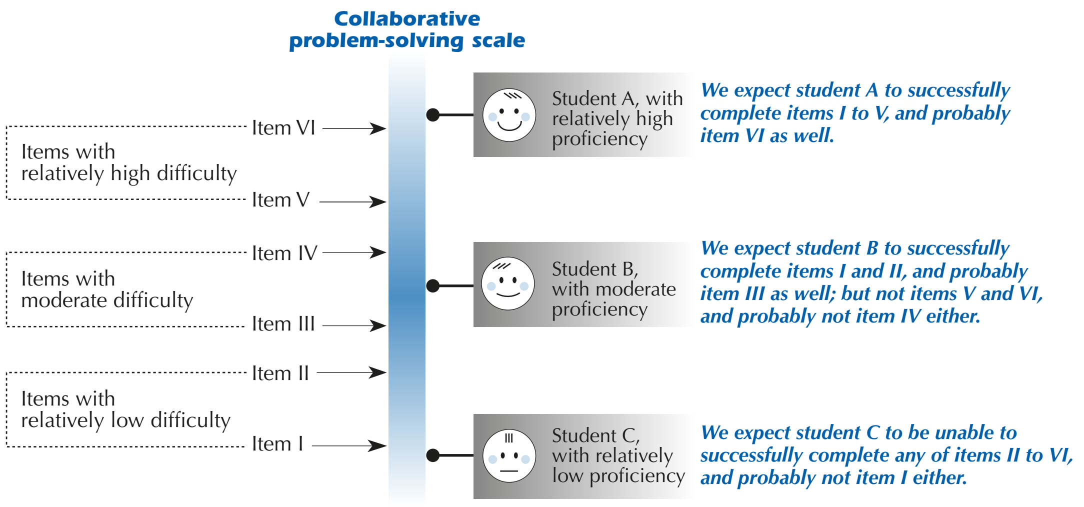
There were no free-response items in the collaborative problem-solving assessment. All items required students to make a multiple-choice selection among various ways to respond to their team members, or to move icons into the appropriate slot or click an option in the visual display area. Since it is an interactive assessment, students were required to respond to each item before moving onto the next item and could not skip or omit items.[1] Collaboration was assessed through student responses in their interactions with one or more computer-based agents. Data from a total of 117 items from these six units were used to analyse and scale performance in collaborative problem solving.

The relative difficulty of each item included in the assessment can be estimated by the proportion of students who answered each question correctly, with smaller proportions of correct answers indicating greater difficulty. Items were then arranged in increasing order of difficulty along a single dimension. The 117 problem-solving items included in the PISA 2015 assessment thus spanned a wide range of difficulty.

Conversely, a student's proficiency relative to the assessment can be estimated from the test questions that he or she answered correctly, taking into account the difficulty of these questions. His or her proficiency in the domain can then be reported on the same scale that measures the questions' difficulty.

Estimates of student proficiency reflect the items students would be expected to successfully complete. Students are likely to be able to complete items that are at or below the difficulty level associated with their own position on the scale.[2] Conversely, they are unlikely to be able to complete questions above the difficulty level associated with their position on the scale. Figure V.3.1 illustrates how this probabilistic model works.

Figure V.3.1 ▪ **Relationship between questions and student performance on a scale**



The further a student's performance is located above a given question on the proficiency scale, the more likely he or she will be able to successfully complete the question. Similarly, the further a student's performance is below a given question, the lower the probability that the student will be able to successfully complete the question.

The location of student proficiency on this scale is set relative to the particular group of questions included in the PISA collaborative problem-solving assessment. However, just as the sample of students who participated in PISA in 2015 was drawn to represent all 15-year-old students in the participating countries and economies, the individual questions used in the assessment were selected to provide a comprehensive representation of the PISA 2015 definition of collaborative problem-solving competence.

A profile of PISA collaborative problem-solving questions

Xandar, one of the six units from the PISA 2015 assessment of collaborative problem solving, was released to the public in order to illustrate the skills examined by the PISA collaborative problem-solving framework and to show how performance was measured. This unit, with several individual items, is presented at the end of Chapter 2 (Figures V.2.2 to V.2.18).

Figure V.3.2 shows where these items are located on the described proficiency scale. Items included in the same unit can span a range of difficulty; the released unit, *Xandar*, contains items in each difficulty level. All units covered a broad section of the PISA problem-solving scale.

A few items included in the test were associated with difficulty levels below Level 1. Among the released items, one asked students to simply click a box saying "Join the Chat" in order to continue with the assessment. The number of items that fall below Level 1 is not sufficient to adequately describe the skills that students who perform below Level 1 possess. However, including such items, which most students in even the lowest-performing countries and economies can complete, is one way to ensure that all countries and economies can learn from the assessment results. PISA 2015 thus not only measures proficiency in collaborative problem solving at different levels, but can also capture some of the basic components of collaborative problem-solving skills.

Figure V.3.2 ▪ **Map of selected collaborative problem-solving questions from the released unit *Xandar***

Level	Lower score limit	Part	Item	Question difficulty (in PISA score points)
4	640	3	2	992
		4	1	730
3	540	2	1	598
		4	2	593
2	440	2	3	537
		1	4	524
			2	502
			3	471
1	340	1	5	434
		2	2	381
		3	1	357
Below Level 1	N/A	1	1	314

Box V.3.1 presents the major differences between easy and difficult items and links them to students' progress in collaborative problem solving.

Box V.3.1. **How students progress in collaborative problem solving**

As students acquire proficiency in collaborative problem solving, they learn to handle increasingly complex demands. What these demands are and what it means for students to become better at collaborative problem solving can be inferred by comparing the easier tasks at the bottom of Figure V.3.2 to the harder tasks shown above them.

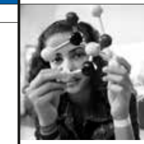
The PISA 2015 collaborative problem-solving assessment was based on a framework (OECD, 2017a) described in Chapter 2 of this report, which defined the domain and how competency in the domain could be evaluated. In order to measure students across a range of competency levels, the items used in the assessment must also span these competency levels.

Philpot et al. (2017) identify a variety of characteristics that affected the difficulty of the items in the PISA 2012 individual problem-solving assessment, including the distance from the goal and the reasoning skills required; the amount of information and how it is represented; the number of constraints and conditions; and the unfamiliarity and complexity of the system. Additional determinants of item difficulty were identified in the framework for the PISA 2015 collaborative problem-solving assessment, related to the three collaborative problem-solving processes (OECD, 2017a):

(1) Establishing and maintaining shared understanding. In the easiest tasks, students work in small teams to solve a well-defined problem that has a clear goal. Much of the information required is already explicitly stated, and the other agents in the problem will prompt the student to provide information or to perform actions. As the item becomes more difficult, students are faced with increasingly ill-defined problems that have vague goals. Navigating this uncertainty in order to understand and then attain the problem goal becomes part of the problem-solving activity. Groups become larger and more information is hidden or not explicitly stated at the beginning, thus requiring students to initiate communication with the other agents to obtain the required knowledge.

(2) Taking appropriate action to solve the problem. The easiest tasks have a clear, well-defined goal and are cast in a familiar, concrete setting. Students start from a point that is one or two steps away from the eventual goal, which can be attained with only minimal input from the other agents. They also have a limited number of possible actions and do not come across any unexpected complications. Other agents' actions are explicitly identified. Tasks that are harder to solve take place in more abstract settings or refer to unfamiliar objects. The goal is less easily identified and students must perform a large number of actions in order to attain this goal. The student's actions become increasingly interdependent on the actions of other group members, which are less and less explicit.

...



(3) Establishing and maintaining team organisation. In tasks at the bottom of the difficulty scale, students interact with co-operative group members who volunteer information about their own actions and motivations. In more difficult problems, students must ask for or else ascertain the actions and motivations of the other group members, who may be less forthright or lack the desire to work collaboratively towards the goal. Students must also monitor the group dynamic, keep agents on track, and manage conflict between them.

Initially, students may be able only to solve problems cast in familiar settings with few possible actions and that are not dependent on other agents, as in Part 1, Item 1 and Part 3, Item 1 of *Xandar*, where they need only to click on a button to start the rest of the unit. As students develop their collaborative problem-solving proficiency, the complexity of the problems that they can solve grows. In an item of moderate difficulty, such as in Part 1, Items 2, 3 and 4 of *Xandar*, students must advance the problem in a collaborative manner by engaging the other agents and responding to their comments and inputs. Finally, the most difficult items, such as Part 3, Item 2 and Part 4, Item 1 of *Xandar*, require students to synthesise information not explicitly mentioned – for example, the status of the students' progress in the contest as shown in the scorecard – and to then adjust the group's problem-solving strategy in order to get back on track towards attaining the goal (see Chapter 2 for a more detailed description of items).

WHAT STUDENTS CAN DO IN COLLABORATIVE PROBLEM SOLVING

PISA summarises student performance in collaborative problem solving on a single scale that provides an overall assessment of 15-year-old students' collaborative problem-solving competence. Results for this overall performance measure are presented below, covering both the average level of performance in problem solving in each country/economy and the distribution of collaborative problem-solving proficiency. The remainder of the report will analyse factors that relate to the observed performance.

Average level of proficiency in collaborative problem solving

This section uses students' average scores to summarise the performance of countries and economies in collaborative problem solving, both relative to each other and to the OECD mean. Since collaborative problem solving was a new domain in PISA 2015, the OECD average performance was set at 500 score points and the standard deviation across OECD countries at 100 score points. This established the benchmark against which each country's collaborative problem-solving performance in PISA 2015 was compared.[3,4]

Figure V.3.3 shows each country's/economy's mean score and allows readers to see for which pairs of countries/economies the differences in the means shown are not statistically significant. The data on which Figure V.3.3 is based are presented in Annex B. In each row, the countries/economies listed in the column on the right are those whose mean scores are not sufficiently different to be distinguished with confidence from the mean score of the country/economy in the middle column. When interpreting mean performance, only those differences among countries and economies that are statistically significant should be considered (Box V.3.2). For all other cases, Country A scores higher than Country B if Country A is above Country B in the list in the middle column; Country A scores lower than Country B if Country A is below Country B in the middle column. For example, while the Netherlands clearly ranks above Austria, the performance of Sweden cannot be distinguished with confidence from that of either Austria or the Netherlands.

Box V.3.2. **What is a statistically significant difference?**

A difference is called statistically significant if it is highly unlikely that such a difference could be observed in the estimates based on samples, if it were the case that no true difference existed between the populations.

The results of the PISA assessments for countries and economies are estimates because they are obtained from samples of students, rather than a census of all students, and because they are obtained using a limited set of assessment tasks, not the universe of all possible assessment tasks. When the sampling of students and assessment tasks is done with scientific rigour, it is possible to determine the magnitude of the uncertainty associated with the estimate. This uncertainty needs to be taken into account when making comparisons so that differences that could reasonably arise simply due to the sampling of students and tasks are not interpreted as differences that actually hold for the populations.

Figure V.3.3 ▪ Comparing countries' and economies' collaborative problem-solving performance

- Statistically significantly **above** the OECD average
- Not statistically significantly different from the OECD average
- Statistically significantly **below** the OECD average

Mean score	Comparison country/economy	Countries and economies whose mean score is NOT statistically significantly different from the comparison country's/economy's score
561	Singapore	
552	Japan	
541	Hong Kong (China)	Korea, Canada, Estonia, Finland
538	Korea	Hong Kong (China), Canada, Estonia, Finland, Macao (China), New Zealand
535	Canada	Hong Kong (China), Korea, Estonia, Finland, Macao (China), New Zealand, Australia
535	Estonia	Hong Kong (China), Korea, Canada, Finland, Macao (China), New Zealand, Australia
534	Finland	Hong Kong (China), Korea, Canada, Estonia, Macao (China), New Zealand, Australia
534	Macao (China)	Korea, Canada, Estonia, Finland, New Zealand, Australia
533	New Zealand	Korea, Canada, Estonia, Finland, Macao (China), Australia, Chinese Taipei
531	Australia	Canada, Estonia, Finland, Macao (China), New Zealand, Chinese Taipei, Germany
527	Chinese Taipei	New Zealand, Australia, Germany, United States, Denmark
525	Germany	Australia, Chinese Taipei, United States, Denmark, United Kingdom, Netherlands
520	United States	Chinese Taipei, Germany, Denmark, United Kingdom, Netherlands
520	Denmark	Chinese Taipei, Germany, United States, United Kingdom, Netherlands
519	United Kingdom	Germany, United States, Denmark, Netherlands
518	Netherlands	Germany, United States, Denmark, United Kingdom, Sweden
510	Sweden	Netherlands, Austria, Norway
509	Austria	Sweden
502	Norway	Sweden, Slovenia, Belgium, Iceland, Czech Republic, Portugal, Spain, B-S-J-G (China)
502	Slovenia	Norway, Belgium, Iceland, Czech Republic, Portugal, B-S-J-G (China)
501	Belgium	Norway, Slovenia, Iceland, Czech Republic, Portugal, Spain, B-S-J-G (China)
499	Iceland	Norway, Slovenia, Belgium, Czech Republic, Portugal, Spain, B-S-J-G (China), France
499	Czech Republic	Norway, Slovenia, Belgium, Iceland, Portugal, Spain, B-S-J-G (China), France
498	Portugal	Norway, Slovenia, Belgium, Iceland, Czech Republic, Spain, B-S-J-G (China), France
496	Spain	Norway, Belgium, Iceland, Czech Republic, Portugal, B-S-J-G (China), France
496	B-S-J-G (China)	Norway, Slovenia, Belgium, Iceland, Czech Republic, Portugal, Spain, France, Luxembourg
494	France	Iceland, Czech Republic, Portugal, Spain, B-S-J-G (China), Luxembourg
491	Luxembourg	B-S-J-G (China), France
485	Latvia	
478	Italy	Russia, Croatia, Hungary, Israel
473	Russia	Italy, Croatia, Hungary, Israel, Lithuania
473	Croatia	Italy, Russia, Hungary, Israel, Lithuania
472	Hungary	Italy, Russia, Croatia, Israel, Lithuania
469	Israel	Italy, Russia, Croatia, Hungary, Lithuania, Slovak Republic
467	Lithuania	Russia, Croatia, Hungary, Israel, Slovak Republic
463	Slovak Republic	Israel, Lithuania, Greece, Chile
459	Greece	Slovak Republic, Chile
457	Chile	Slovak Republic, Greece
444	Cyprus[1]	Bulgaria, Uruguay, Costa Rica
444	Bulgaria	Cyprus,[1] Uruguay, Costa Rica, Thailand, United Arab Emirates
443	Uruguay	Cyprus,[1] Bulgaria, Costa Rica, Thailand
441	Costa Rica	Cyprus,[1] Bulgaria, Uruguay, Thailand, United Arab Emirates
436	Thailand	Bulgaria, Uruguay, Costa Rica, United Arab Emirates, Mexico, Colombia
435	United Arab Emirates	Bulgaria, Costa Rica, Thailand, Mexico, Colombia
433	Mexico	Thailand, United Arab Emirates, Colombia
429	Colombia	Thailand, United Arab Emirates, Mexico, Turkey
422	Turkey	Colombia, Peru, Montenegro
418	Peru	Turkey, Montenegro, Brazil
416	Montenegro	Turkey, Peru, Brazil
412	Brazil	Peru, Montenegro
382	Tunisia	

1. Note by Turkey: The information in this document with reference to "Cyprus" relates to the southern part of the Island. There is no single authority representing both Turkish and Greek Cypriot people on the Island. Turkey recognises the Turkish Republic of Northern Cyprus (TRNC). Until a lasting and equitable solution is found within the context of the United Nations, Turkey shall preserve its position concerning the "Cyprus issue".

Note by all the European Union Member States of the OECD and the European Union: The Republic of Cyprus is recognised by all members of the United Nations with the exception of Turkey. The information in this document relates to the area under the effective control of the Government of the Republic of Cyprus.

Countries and economies are ranked in descending order of mean collaborative problem-solving performance.

Source: OECD, PISA 2015 Database, Table V.3.2.

StatLink http://dx.doi.org/10.1787/888933615743

Figure V.3.4 [Part 1/2] ■ **Collaborative problem-solving performance among participating countries/economies**

	Collaborative problem-solving scale					
			Range of ranks			
			OECD countries		All countries/economies	
	Mean score	95% confidence interval	Upper rank	Lower rank	Upper rank	Lower rank
Singapore	561	559 - 564			1	1
British Columbia (Canada)	561	550 - 573				
Japan	552	546 - 557	1	1	2	2
Massachusetts (United States)	549	537 - 561				
Alberta (Canada)	543	531 - 554				
Hong Kong (China)	541	535 - 547			3	5
Korea	538	533 - 543	2	5	3	7
Canada	535	531 - 540	2	6	4	10
Estonia	535	530 - 540	2	6	4	10
Finland	534	529 - 539	2	7	4	10
Macao (China)	534	531 - 536			5	10
Quebec (Canada)[1]	534	525 - 543				
Nova Scotia (Canada)	533	524 - 542				
New Zealand	533	528 - 538	3	7	5	11
Ontario (Canada)	532	523 - 541				
Australia	531	528 - 535	4	7	7	11
Prince Edward Island (Canada)	529	517 - 541				
Chinese Taipei	527	522 - 531			10	13
North Carolina (United States)	525	514 - 535				
Germany	525	519 - 530	7	10	10	14
Newfoundland and Labrador (Canada)	521	513 - 530				
England (United Kingdom)	521	515 - 527				
United States	520	513 - 527	8	12	11	16
Denmark	520	515 - 525	8	12	12	16
United Kingdom	519	514 - 524	8	12	12	16
Flemish community (Belgium)	519	513 - 524				
Madrid (Spain)	519	512 - 526				
Manitoba (Canada)	519	508 - 529				
Netherlands	518	513 - 522	9	12	13	16
New Brunswick (Canada)	517	507 - 528				
Castile and Leon (Spain)	517	509 - 525				
Northern Ireland (United Kingdom)	514	507 - 521				
Scotland (United Kingdom)	513	508 - 518				
Bolzano (Italy)	512	498 - 527				
Sweden	510	503 - 516	12	15	16	19
Austria	509	504 - 514	13	15	17	19
Saskatchewan (Canada)	508	501 - 515				
Navarre (Spain)	505	492 - 518				
Catalonia (Spain)	505	496 - 514				
Norway	502	497 - 507	14	19	18	24
Slovenia	502	499 - 505	15	19	19	23
Belgium	501	496 - 506	15	20	19	25
Trento (Italy)	500	494 - 505				
Iceland	499	495 - 504	15	21	19	26
Aragon (Spain)	499	487 - 511				
Czech Republic	499	494 - 503	16	22	19	26
Portugal	498	493 - 503	16	22	20	27
Lombardia (Italy)	498	487 - 509				
Castile-La Mancha (Spain)	497	489 - 505				
Spain	496	492 - 501	17	22	22	27
Wales (United Kingdom)	496	489 - 503				
B-S-J-G (China)	496	488 - 504			20	28

* See note 1 under Figure V.3.3.
1. Results for the province of Quebec in this table should be treated with caution due to a possible non-response bias.
Notes: OECD countries are shown in bold black. Partner countries and economies are shown in bold blue.
Regions are shown in black italics (OECD countries) or blue italics (partner countries).
Countries and economies are ranked in descending order of mean collaborative problem-solving performance.
Source: OECD, PISA 2015 Database, Table V.3.2.
StatLink http://dx.doi.org/10.1787/888933615762

Figure V.3.4 [Part 2/2] ▪ Collaborative problem-solving performance among participating countries/economies

	Collaborative problem-solving scale					
			Range of ranks			
			OECD countries		All countries/economies	
	Mean score	95% confidence interval	Upper rank	Lower rank	Upper rank	Lower rank
Asturias (Spain)	496	475 - 517				
La Rioja (Spain)	495	477 - 513				
Galicia (Spain)	494	483 - 505				
France	494	489 - 499	19	23	24	28
German-speaking community (Belgium)	493	480 - 505				
Comunidad Valenciana (Spain)	492	485 - 500				
Luxembourg	491	488 - 494	22	23	27	28
Balearic Islands (Spain)	488	477 - 499				
Murcia (Spain)	486	476 - 496				
Latvia	485	480 - 489	24	24	29	29
Cantabria (Spain)	485	469 - 501				
Canary Islands (Spain)	484	474 - 494				
Basque Country (Spain)	484	474 - 493				
Andalusia (Spain)	483	474 - 491				
French community (Belgium)	479	471 - 487				
Italy	478	473 - 483	25	26	30	32
Dubai (UAE)	477	473 - 481				
Extremadura (Spain)	474	465 - 483				
Bogotá (Colombia)	474	464 - 483				
Russia	473	467 - 480			30	34
Croatia	473	468 - 478			30	34
Hungary	472	468 - 477	26	27	31	35
Israel	469	462 - 476	26	28	31	36
Lithuania	467	463 - 472			33	36
Região Autónoma dos Açores (Portugal)	467	461 - 473				
Slovak Republic	463	458 - 467	27	29	35	37
Greece	459	452 - 466	28	30	36	38
Chile	457	452 - 462	29	30	37	38
Medellín (Colombia)	453	444 - 462				
Manizales (Colombia)	451	444 - 459				
Cyprus*	444	441 - 448			39	42
Bulgaria	444	437 - 452			39	43
Campania (Italy)	443	432 - 453				
Uruguay	443	438 - 447			39	42
Costa Rica	441	436 - 446			39	43
Cali (Colombia)	440	432 - 449				
Thailand	436	429 - 442			42	46
United Arab Emirates	435	430 - 440			42	45
Mexico	433	428 - 438	31	31	43	46
Colombia	429	425 - 434			45	47
Sharjah (UAE)	429	411 - 448				
Turkey	422	416 - 429	32	32	46	48
Abu Dhabi (UAE)	422	413 - 430				
Peru	418	413 - 423			47	49
Montenegro	416	413 - 418			48	50
Brazil	412	407 - 416			49	50
Ajman (UAE)	412	401 - 423				
Fujairah (UAE)	402	388 - 416				
Ras Al Khaimah (UAE)	400	382 - 417				
Umm Al Quwain (UAE)	394	382 - 406				
Tunisia	382	378 - 385			51	51

* See note 1 under Figure V.3.3.
1. Results for the province of Quebec in this table should be treated with caution due to a possible non-response bias.
Notes: OECD countries are shown in bold black. Partner countries and economies are shown in bold blue.
Regions are shown in black italics (OECD countries) or blue italics (partner countries).
Countries and economies are ranked in descending order of mean collaborative problem-solving performance.
Source: OECD, PISA 2015 Database, Table V.3.2.
StatLink http://dx.doi.org/10.1787/888933615762

Figure V.3.3 lists each participating country and economy in descending order of its mean collaborative problem-solving score (left column). The values range from a high of 561 points for partner country Singapore to a low of 382 points for partner country Tunisia. Countries and economies are also divided into three broad groups: those whose mean scores are statistically around the OECD mean (highlighted in dark blue), those whose mean scores are above the OECD mean (highlighted in pale blue), and those whose mean scores are below the OECD mean (highlighted in medium blue).

Because the figures are derived from samples, it is not possible to determine a country's precise rank among the participating countries and economies. However, it is possible to determine, with confidence, a range of ranks in which the country's performance lies (Figure V.3.4).

Singapore is the highest-performing country in collaborative problem solving, with a mean score of 561 points. The second highest-performing country is Japan, with a mean score of 552 points. Both of these countries score over half of a standard deviation, on average, above the average level of students in other OECD countries. Singapore scores significantly higher than every other country/economy, and Japan scores significantly higher than every other country/economy except Singapore.

Thirteen other OECD countries – Korea (538 points), Canada (535 points), Estonia (535 points), Finland (534 points), New Zealand (533 points), Australia (531 points), Germany (525 points), the United States (520 points), Denmark (520 points), the United Kingdom (519 points), the Netherlands (518 points), Sweden (510 points) and Austria (509 points) – and three East Asian partner countries and economies – Hong Kong (China) (541 points), Macao (China) (534 points) and Chinese Taipei (527 points) – score above the OECD average on the PISA collaborative problem-solving scale.

Eight countries – Beijing-Shanghai-Jiangsu-Guangdong (China) (hereafter "B-S-J-G [China]"), Belgium, the Czech Republic, Iceland, Norway, Portugal, Slovenia and Spain – score around the OECD mean of 500 points.

There is a gap of 129 score points between the highest-scoring OECD country, Japan (552 score points), and the lowest-scoring OECD country, Turkey (422 score points), a difference of well over one standard deviation. Less than 10% of students in Japan perform below the mean score in Turkey while only roughly 5% of students in Turkey perform at or above the mean score in Japan (Table V.3.2).

Likewise, 180 score points separate the mean scores of the highest- and lowest-performing countries and economies in the collaborative problem-solving assessment – Singapore (561 score points) and Tunisia (382 score points). This gap corresponds to almost two standard deviations or two proficiency levels. Fewer than one in 20 students in Estonia, Hong Kong (China), Japan, Korea and Singapore performs at or below the mean of the lowest-performing country (Table V.3.2).

How collaborative problem-solving proficiency levels are defined in PISA 2015

PISA 2015 provides one overall collaborative problem-solving proficiency scale, drawing on all the questions in the collaborative problem-solving assessment. The collaborative problem-solving scale was constructed to have a mean score of 500 among OECD countries, with about two-thirds of students across OECD countries scoring between 400 and 600.[5] To help interpret what students' scores mean in substantive terms, the scale is divided into five proficiency levels. Four of these (Levels 1 to 4) are described based on the skills needed to successfully complete the items that are located within them; the last (below Level 1) is defined based on the absence of these skills.

Level 1 is the lowest described level and corresponds to an elementary level of collaborative problem-solving skills; Level 4 corresponds to the highest level of collaborative problem-solving skills. As explained above, students with a score within the range of Level 1 are expected to complete most Level 1 items successfully but are unlikely to be able to successfully complete items at higher levels. By contrast, students with scores in the Level 4 range are likely to be able to successfully complete any item included in the PISA assessment of collaborative problem solving.

Students at the different levels of proficiency in collaborative problem solving

Figure V.3.5 expounds on what students at four of the levels of proficiency in collaborative problem solving can typically do. These summary descriptions are based on the detailed analysis of task demands within each level; Chapter 2 provides such an analysis for the released unit, *Xandar*. The distribution of student performance across proficiency levels in each country/economy is shown in Figure V.3.6.

Figure V.3.5 ■ **Summary descriptions of the four levels of proficiency in collaborative problem solving**

Level	Score range	What students can typically do
4	Equal to or higher than 640 score points	At Level 4, students can successfully carry out complicated problem-solving tasks with high collaboration complexity. They can solve complex problems with multiple constraints, keeping relevant background information in mind. These students maintain an awareness of group dynamics and take actions to ensure that team members act in accordance with their agreed-upon roles. At the same time, they can monitor progress towards a solution and identify obstacles to overcome or gaps to be bridged. Level 4 students take initiative and perform actions or make requests to overcome obstacles and to resolve disagreements and conflicts. They can balance the collaboration and problem-solving aspects of a presented task, identify efficient pathways to a solution, and take actions to solve the given problem.
3	540 to less than 640 score points	At Level 3, students can complete tasks with either complex problem-solving requirements or complex collaboration demands. These students can perform multi-step tasks that require integrating multiple pieces of information, often in complex and dynamic problems. They orchestrate roles within the team and identify information needed by particular team members to solve the problem. Level 3 students can recognise the information needed to solve a problem, request it from the appropriate team member, and identify when the provided information is incorrect. When conflicts arise, they can help team members negotiate a solution.
2	440 to less than 540 score points	At Level 2, students can contribute to a collaborative effort to solve a problem of medium difficulty. They can help solve a problem by communicating with team members about the actions to be performed. They can volunteer information not specifically requested by another team member. Level 2 students understand that not all team members have the same information and can consider differing perspectives in their interactions. They can help the team establish a shared understanding of the steps required to solve a problem. These students can request additional information required to solve a problem and solicit agreement or confirmation from team members about the approach to be taken. Students near the top of Level 2 can take the initiative to suggest a logical next step, or propose a new approach, to solve a problem.
1	340 to less than 440 score points	At Level 1, students can complete tasks with low problem complexity and limited collaboration complexity. They can provide requested information and take actions to enact plans when prompted. Level 1 students can confirm actions or proposals made by others. They tend to focus on their individual role within the group. With support from team members, and when working on a simple problem, these students can help find a solution to the given problem.

Proficiency at Level 4

Students proficient at Level 4 on the collaborative problem-solving scale can successfully carry out complicated problem-solving tasks with high collaboration complexity. They maintain an awareness of group dynamics and ensure that team members act in accordance with their agreed-upon roles, while simultaneously monitoring progress towards a solution of the given problem. They take initiative and perform actions or make requests to overcome obstacles and to resolve disagreements and conflicts. Students who perform at Level 4 are also referred to as "top performers" in the rest of this report.[6]

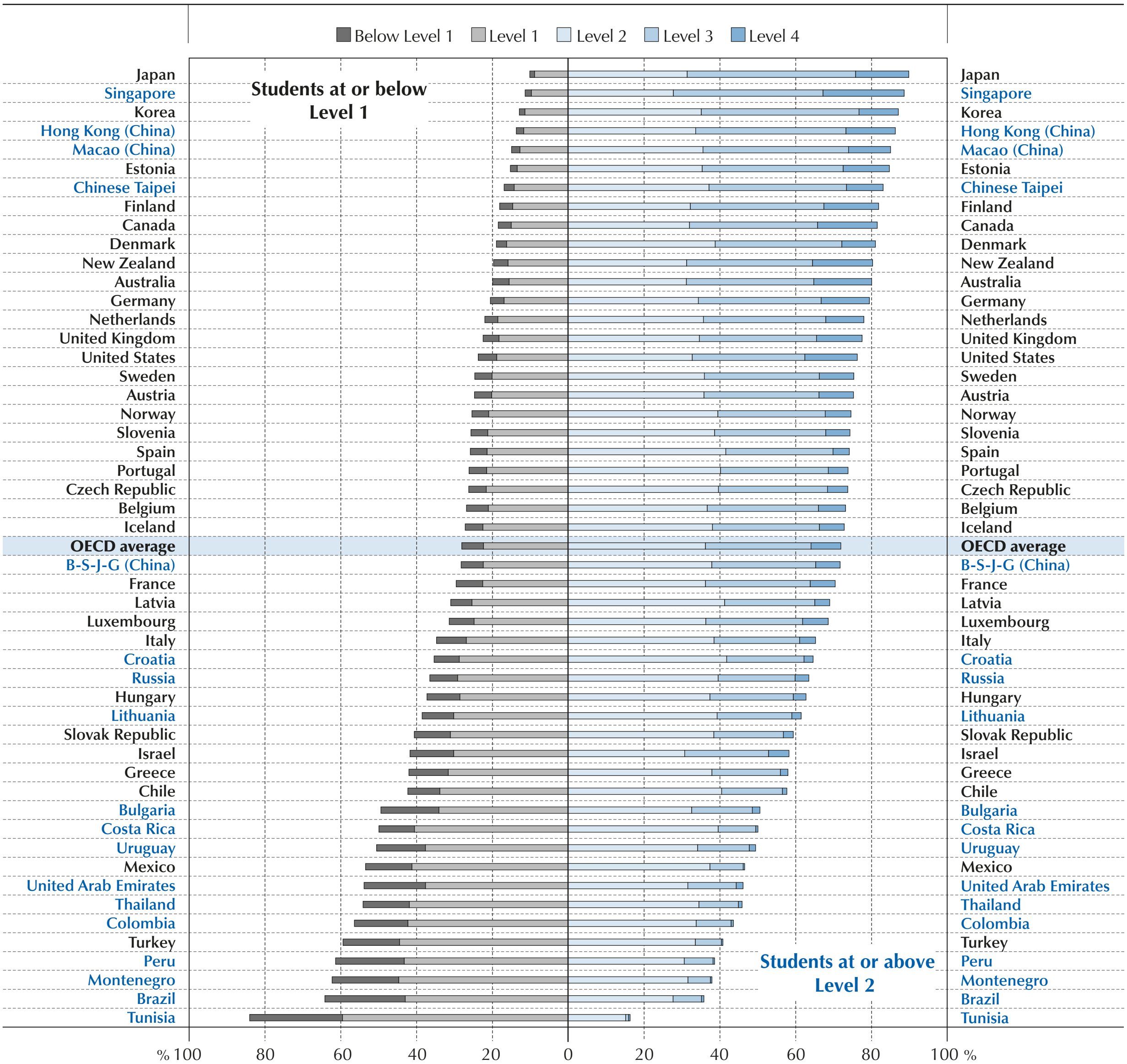
Part 3, Item 2 of *Xandar* is an example of a Level 4 item. It requires students first to recognise that one of the other team members has answered a question that he or she was supposed to answer. Students must then remind their team members that they should act in accordance with the roles hitherto agreed upon, instead of complimenting the student who correctly answered the wrong question. While the latter response develops a collaborative dynamic among team members, the credited response does so while also advancing towards a solution to the problem.

Across OECD countries, 8% of students perform at this level, although student proficiency varies among countries. More than one in five students in Singapore (21%) and between 15% and 16% of students in Australia, Canada and New Zealand perform at this level. These four countries are also among the top-performing countries and economies in collaborative problem solving (Figure V.3.4). Indeed, every country whose mean performance in collaborative problem solving is above the OECD average also has a larger-than-average proportion of students who perform at Level 4.[7]

In contrast, in two OECD countries and in seven partner countries, fewer than 1 in 100 students performs at Level 4; and in Tunisia, fewer than 1 in 1 000 students performs at this level (Figure V.3.6 and Table V.3.1).

Figure V.3.6 ■ **Proficiency in collaborative problem solving**

Percentage of students at the different levels of collaborative problem-solving proficiency



Countries and economies are ranked in descending order of the percentage of students at Level 2, 3 or 4 in collaborative problem solving.
Source: OECD, PISA 2015 Database, Table V.3.1.
StatLink http://dx.doi.org/10.1787/888933615781

Proficiency at Level 3

Students proficient at Level 3 on the collaborative problem-solving scale can complete tasks with either complex problem-solving requirements or complex collaboration demands. They can recognise information needed to solve a problem, request it from the appropriate team member, and identify when the provided information is incorrect. These students can perform multi-step tasks that require integrating multiple pieces of information.

Part 4, Item 2 of *Xandar* is an example of a Level 3 task. Students must recognise that Zach, one of the team members, needs help and then come up with a suggestion as to how to help him while simultaneously attending to their own tasks.

As students proficient at Level 4 can also complete Level 3 items, the following discussion uses “proficient at Level 3 or higher” synonymously with “can sucessfully complete a Level 3 item”. The same terminology will be used below to refer to the cumulative proportions at lower levels.

Across OECD countries, 36% of students are proficient at Level 3 or higher. In Hong Kong (China), Japan, Korea and Singapore, more than one in two students are capable of completing Level 3 items, and just under one in two students (over 45%) in Australia, Canada, Estonia, Finland, Germany, Macao (China), New Zealand and Chinese Taipei performs at Level 3 or higher. In every country that performs significantly above the OECD mean, the proportion of students proficient at Level 3 or higher is also above the OECD mean (Figure V.3.6 and Table V.3.1).

Level 3 was the most common proficiency level in 10 of the 51 countries/economies with adjudicated data from the collaborative problem-solving assessment.[8] By contrast, in two OECD countries and five partner countries, fewer than one in ten students performs at Level 3 or higher. In Tunisia, fewer than one in 100 students can successfully complete a Level 3 item (Figure V.3.6 and Table V.3.1).

Proficiency at Level 2

Students proficient at Level 2 on the collaborative problem-solving scale can contribute to a collaborative effort to solve a problem of medium difficulty. They can communicate with team members about the actions to be performed and they can volunteer information not specifically requested by another team member.

Part 2, Item 3 of *Xandar* is one example of a Level 2 task. Alice and Zach, the other two team members, have already chosen their subject areas. The student must process this information and signal that they have done so by stating that they will choose the remaining subject area.

Across OECD countries, 72% of students perform at Level 2 or higher. In Hong Kong (China), Japan, Korea, Macao (China) and Singapore, over 85% of 15-year-olds are proficient at Level 2 or higher; in a further seven countries/economies – Australia, Canada, Denmark, Estonia, Finland, New Zealand and Chinese Taipei – over 80% of 15-year-olds achieve this level of competence. This is the most common proficiency level in 28 of the 51 countries and economies with comparable data. However, in two OECD countries and eight partner countries, a majority of students cannot complete Level 2 items successfully (Figure V.3.6 and Table V.3.1).

Proficiency at Level 1

Students proficient at Level 1 can complete tasks with low problem difficulty and limited collaboration complexity. They tend to focus on their individual role within the group, but with support from team members. When working on a simple problem, these students can help find a solution to the problem.

Part 3, Item 1 of *Xandar* is an example of a Level 1 problem. Students are told or reminded (depending on how they finished Part 2) that their subject area is geography, and that the other team members have been assigned the other two subjects. Focusing on their own role in the group, they must then click the correct button – the "Geography" button – to get started.

Across OECD countries, 94% of students reach this level of collaborative problem-solving proficiency. However, in Tunisia, almost one in four students (25%) fails to reach this level of proficiency. More than one in five students in Brazil (21%) and more than one in six students in Montenegro and Peru (both 18%) are likewise not proficient at Level 1. Level 1 is the most common proficiency level in 13 of the 51 countries/economies with available data (Figure V.3.6 and Table V.3.1).

Proficiency below Level 1

The PISA 2015 collaborative problem-solving assessment was not designed to assess either elementary collaboration skills or elementary problem-solving skills. Hence, there were insufficient items to fully describe performance that fell below Level 1 on the collaborative problem-solving scale.

Across OECD countries, 6% of students score below Level 1 on the proficiency scale. Between one in 50 students and one in 100 students in Estonia, Hong Kong (China), Japan, Korea and Singapore score below Level 1 (Figure V.3.6 and Table V.3.1).

HOW COLLABORATIVE PROBLEM-SOLVING PERFORMANCE RELATES TO PERFORMANCE IN SCIENCE, READING AND MATHEMATICS

A comparison of the mean scores in collaborative problem solving, science, reading and mathematics shows that the same countries/economies – Canada, Korea, Hong Kong (China), Japan and Singapore – are found at or near the top of each set of rankings. Thus, one may wonder to what extent the collaborative problem-solving assessment measures collaboration skills as opposed to general cognitive skills.

Scores in the four domains are indeed highly correlated, as shown in Figure V.3.7. On average across OECD countries, student performance in collaborative problem solving shows a correlation of 0.77 with performance in science, 0.74 with performance in reading, and 0.70 with performance in mathematics. These numbers are lower than the pairwise correlations between scores in the core PISA subjects, which range from 0.80 to 0.88. Collaborative problem-solving outcomes, while still closely related to outcomes in science, reading and mathematics, appear to be slightly less strongly related to these core subject outcomes than these core subject outcomes are related to each other.

Figure V.3.7 ▪ **Correlations among performance in collaborative problem solving and in core PISA subjects**

OECD average

Correlation between:			
Mathematics	**Reading**	**Science**	...and...
0.70	0.74	0.77	**Collaborative problem solving**
	0.80	0.88	**Mathematics**
		0.87	**Reading**

Source: OECD, PISA 2015 Database, Table V.3.4.

The link between student scores in collaborative problem solving, science, reading and mathematics is strongest in Bulgaria, the United Arab Emirates and the United States and weakest in Costa Rica, the Russian Federation (hereafter "Russia") and Tunisia. In these latter three countries, however, correlations between performance in collaborative problem solving and performance in each of the three core PISA subjects still exceed 0.55 (Table V.3.4).

Another way to see the relationship is by looking at the extent to which top or low performance in the three core PISA domains predicts performance in collaborative problem solving. In science, reading and mathematics, top performers are defined as those students who perform at Levels 5 or 6, while low performers are those students who perform below the baseline proficiency level, Level 2. In collaborative problem solving, top performers are defined as those students who perform at Level 4, while low performers are those students who perform below Level 2.[9]

Some 44% of top performers in science, 39% of top performers in reading, and 34% of top performers in mathematics are also top performers in collaborative problem solving, on average across OECD countries (Table V.3.3a). Some 55% of students who are top performers in all three core PISA subjects (all-round top performers) are also top performers in collaborative problem solving (Figure V.3.8). This proportion is particularly large in Australia, Canada, New Zealand, Singapore, the United Kingdom and the United States where over 69% of students who are all-round top performers are also top performers in collaborative problem solving.

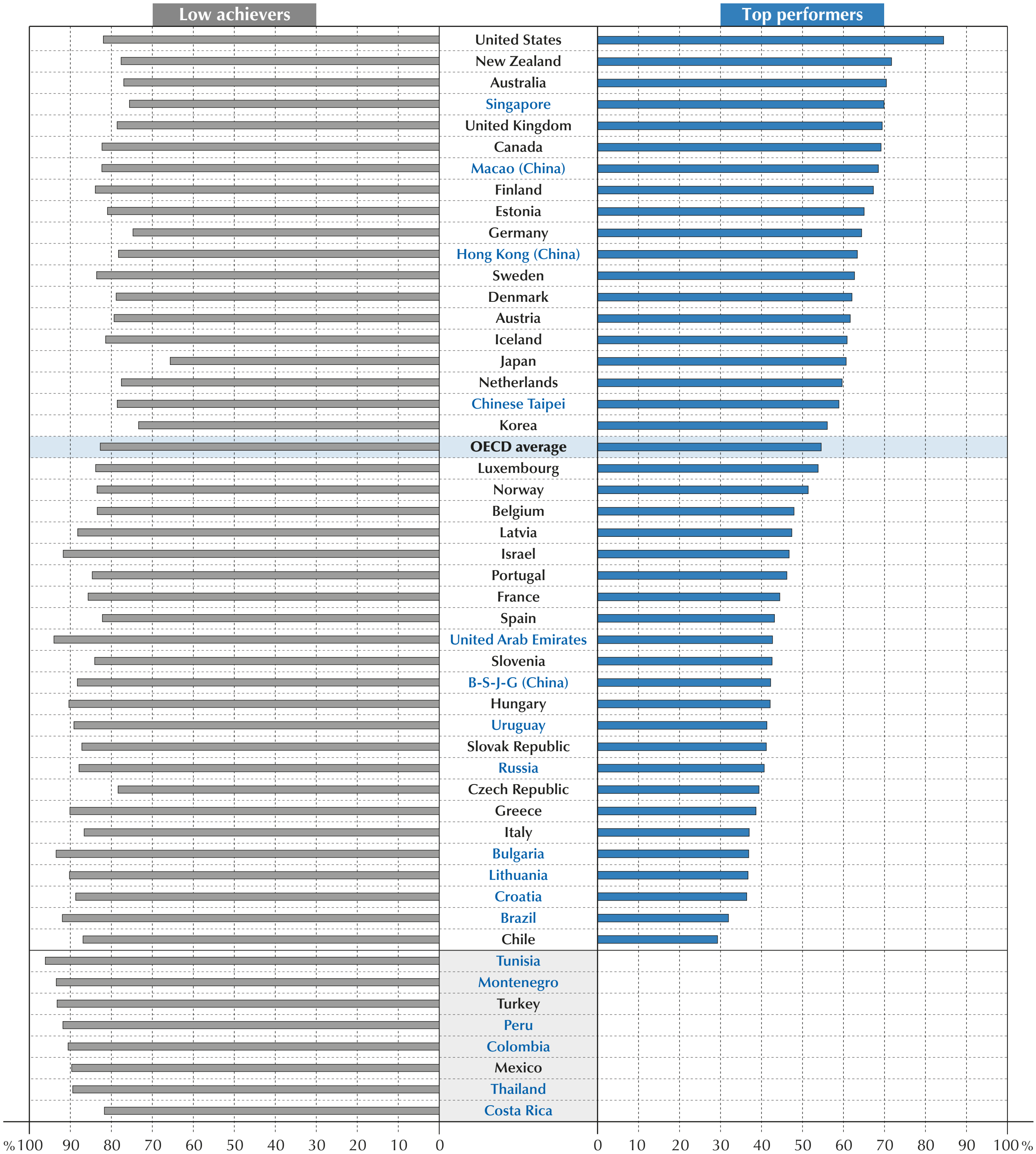
By contrast, in Brazil and Chile, fewer than one in three all-round top performers score at the highest level in collaborative problem solving. This may imply that collaborative problem-solving skills in these countries are developed independently of skills and literacy in the three core PISA subjects. However, the share of top performers in these countries is very small: 0.6% in Brazil and 1.2% in Chile.

Similar relationships are observed among low performers, although there is greater observed overlap. On average across OECD countries, 74% of low performers in science, 74% of low performers in reading, and 67% of low performers in mathematics are also low performers in collaborative problem solving. Some 83% of low performers in all three core subjects (all-round low performers) are also low performers in collaborative problem solving. Hence, it may be that a certain level of functional literacy in the three core domains is a pre-requisite for performance in collaborative problem solving (Figure V.3.8).

In Bulgaria, Montenegro, Tunisia, Turkey and the United Arab Emirates, over 93% of students who are all-round low performers are also low performers in collaborative problem solving. By contrast, in Germany, Japan and Korea, less than 75% of all-round low performers are low performers in collaborative problem solving. This is likely due to the particularly low scores of low performers in the former group of countries: the average student who is an all-round low performer in Tunisia scores lower in these domains than the average student who is an all-round low performer in Japan. Another interpretation is that collaborative problem-solving skills might be more "fundamental", that is, developed in all students, regardless of ability, in the latter three countries, while they might be more dependent on basic literacy skills in the former five countries.

Figure V.3.8 ▪ **Top performers and low achievers in four PISA subjects**

Percentage of top performers/low achievers in collaborative problem solving among all-round top performers/low achievers in the three core PISA subjects



Notes: Top performers in collaborative problem solving are students who score at Level 4. All-round top performers score at Level 5 or 6 in science, reading and mathematics.

Low achievers in collaborative problem solving score below Level 2. All-round low achievers score below Level 2 in science, reading and mathematics.

Due to sample size limitations, the proportion of top performers for the eight countries at the bottom of the figure could not be accurately determined.

Countries and economies are ranked in descending order of the proportion of top performers in collaborative problem solving among all-round top performers in the three core PISA subjects.

Source: OECD, PISA 2015 Database, Tables V.3.3a and V.3.3b.

StatLink http://dx.doi.org/10.1787/888933615800

Mean performance across countries is more closely correlated than individual student performance. Across OECD countries, the correlations between mean country collaborative problem-solving scores and mean country scores in the three core domains are between 0.87 and 0.96, while the correlations between mean country scores within the three core domains are between 0.95 and 0.98. Education systems that are strong in one domain thus appear also to be strong in other domains, although individual students may have strengths and weaknesses in particular areas.

Relative performance in collaborative problem solving

As discussed above, performance in collaborative problem solving is closely linked to performance in the three core PISA domains of science, reading and mathematics. In order to isolate the distinctive aspects of collaborative problem-solving ability, scores in collaborative problem solving were regressed over scores in the three core domains. Each student's relative performance – his or her performance in collaborative problem solving after accounting for proficiency in science, reading and mathematics – was then calculated.[10] This calculation pooled data from all PISA-participating countries and economies and thus allowed for the ranking of countries and economies by their average relative performance.[11]

Although the average relative performance across all students pooled over all countries/economies is, by definition, equal to zero, the average relative performance in OECD countries is slightly positive at three score points, indicating that students in OECD countries have, on average, higher collaborative problem-solving skills than students in participating partner countries/economies who perform similarly in the three core domains.

Figure V.3.9 shows each participating country and economy in order of its mean relative collaborative problem-solving performance. The values range from a high of 23 points for OECD country Japan to a low of -22 points for partner country Russia. Countries and economies are also divided into three broad groups: those whose mean relative scores are statistically around the OECD mean (pale blue bars), those whose mean relative scores are above the OECD mean (medium blue bars), and those whose mean relative scores are below the OECD mean (dark grey bars). The range and variation of relative scores are noticeably smaller than that of raw performance scores. One way to interpret such scores is to say that, on average, students in Japan perform 0.23 standard deviations better than expected given their scores in science, reading and mathematics. Another interpretation is that based on their collaborative problem-solving performance, students in Japan score below expected in science, reading and mathematics.

Australia, Japan, Korea, New Zealand and the United States are among the highest-performing countries in terms of relative performance in collaborative problem solving. Students in these countries score between 20 and 23 points higher in collaborative problem solving, on average, than would be expected given their science, reading and mathematics scores (Figure V.3.9).

Ten other OECD countries – Iceland (15 points), Denmark (14 points), Germany (14 points), Austria (13 points), the United Kingdom (12 points), Canada (10 points), Sweden (9 points), Estonia (8 points), the Netherlands (8 points) and Finland (7 points) – and three partner countries/economies – Singapore (16 points), Hong Kong (China) (15 points) and Macao (China) (11 points) – score above the OECD average in relative performance in collaborative problem solving (Figure V.3.9).

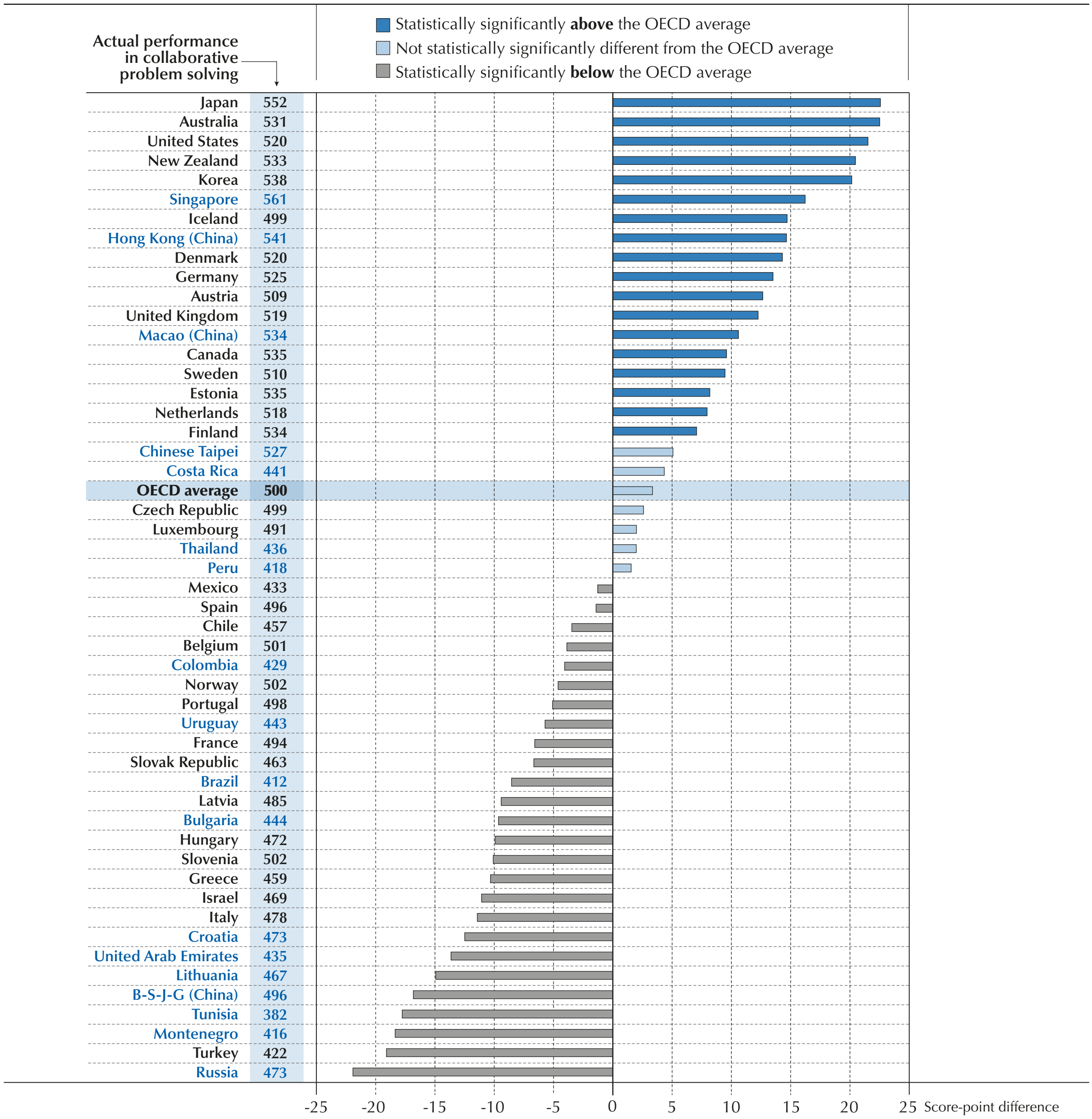
Six countries – Costa Rica, the Czech Republic, Luxembourg, Peru, Chinese Taipei and Thailand – score around the OECD average of three points in relative performance in collaborative problem solving.

There is a gap of 42 score points between the relative performance of the highest-scoring OECD country, Japan (23 score points) and the lowest-scoring OECD country, Turkey (-19 score points), a difference of 42% of a standard deviation in raw performance. Some 66% of students in Japan perform better in collaborative problem solving than would be expected given their science, reading and mathematics scores, while only 35% of students in Turkey do so (Table V.3.9a). Similar results are observed in the poorest-performing country, the partner country Russia, where only 36% of students perform better in collaborative problem solving than would be expected given their performance in the three core PISA domains.

There are notable differences between country comparisons of raw and relative scores in collaborative problem solving. For instance, while Chinese Taipei ranks above the OECD average in raw performance scores, it does not differ significantly from the OECD average in relative performance. Students in Belgium, B-S-J-G (China), Norway, Portugal, Slovenia and Spain, while at the OECD average in raw collaborative problem-solving scores, score below the average once accounting for their science, reading and mathematics performance. These differences may be explained by students in these countries being weaker in the uniquely collaborative aspects of the assessment than students in countries that perform similarly in science, reading and mathematics. Explained another way, students in these countries perform particularly strongly in science, reading and mathematics without a correspondingly higher performance in collaborative problem solving.

Figure V.3.9 ■ **Countries' and economies' relative performance in collaborative problem solving**

Score-point difference between actual and expected performance in collaborative problem solving



Note: A student's relative performance in collaborative problem solving is defined as the residual obtained upon an ordinary least-squares regression of the student's performance in collaborative problem solving over his or her performance in science, reading and mathematics. The regression is performed at an international level, pooling data from all countries and economies that participated in the collaborative problem-solving assessment.

Countries and economies are ranked in descending order of the relative performance in collaborative problem solving.

Source: OECD, PISA 2015 Database, Tables V.3.2 and V.3.9a.

StatLink http://dx.doi.org/10.1787/888933615819

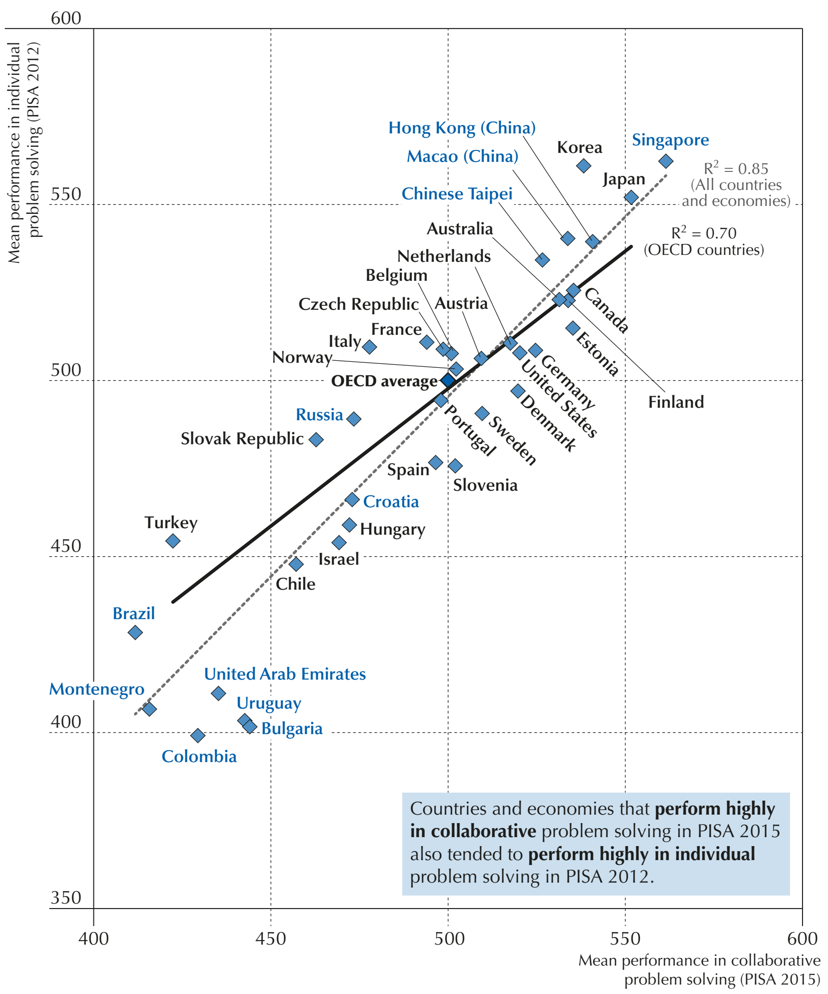
By contrast, some countries/economies perform better when considering their relative performance. In Iceland, students ranked at the OECD average in raw performance, but were above the OECD average when considering relative performance. Moreover, in Costa Rica, Luxembourg, Peru and Thailand, students performed below the OECD average in their raw collaborative problem-solving scores but at the OECD average once accounting for scores in the other three domains. In these countries, students have stronger skills in the uniquely collaborative aspects of the assessment than would have been expected given their science, reading and mathematics performance. Conversely, they perform worse in science, reading and mathematics than their collaborative problem-solving scores would have suggested.

THE LINKS BETWEEN COLLABORATIVE PROBLEM SOLVING AND INDIVIDUAL PROBLEM SOLVING

PISA 2015 measured collaborative problem solving, which, as described in Chapter 2, is modelled on three competencies related to collaboration and four processes related to problem solving. As a result, a student's performance in collaborative problem solving is not purely a measure of his or her collaboration skills but also reflects his or her ability to use collaboration to resolve a problem or work towards a goal.

Individual problem solving was measured in the innovative domain in PISA 2012. Figure V.3.10 plots the raw performance scores of countries/economies that participated in both the individual problem-solving assessment in 2012 and the collaborative problem-solving assessment in 2015. There is a strong positive correlation (as measured by an r^2 of 0.85 among all countries and economies, and 0.70 among OECD countries) between the mean scores in the two assessments. Countries that performed well in individual problem solving in PISA 2012 also tend to perform well in collaborative problem solving in 2015. This might be expected, due to the cognitive skills and the problem-solving processes common to both assessments.

Figure V.3.10 ■ **Performance in individual problem solving (PISA 2012) and in collaborative problem solving (PISA 2015)**



Note: Only those countries and economies with available data or valid results for the PISA 2012 assessment of individual problem solving and the PISA 2015 assessment of collaborative problem solving are shown.

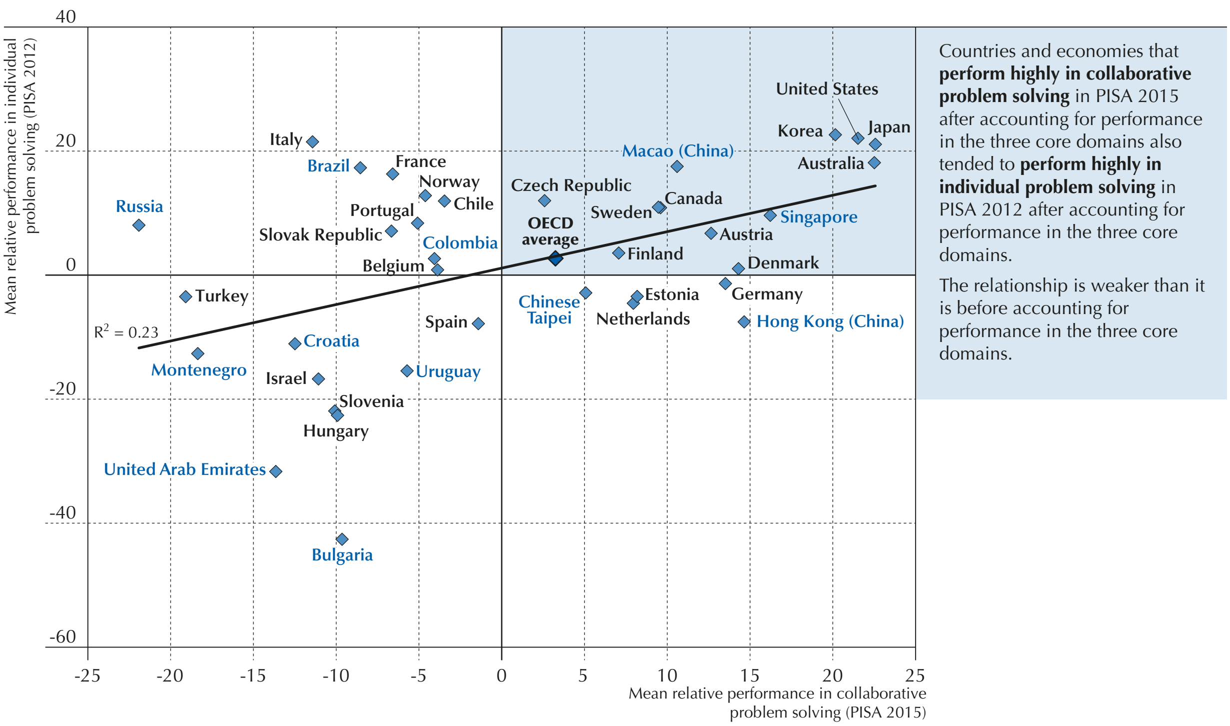
Source: OECD, PISA 2015 Database, Table V.3.2, and PISA 2012 Database, Table V.3.2, from *PISA 2012 Results: Creative Problem Solving (Volume V)*.

StatLink http://dx.doi.org/10.1787/888933615838

As described above and in *PISA 2012 Results: Creative Problem Solving (Volume V)* (OECD, 2014), students' general level of ability, as reflected in their performance in science, reading and mathematics, is also highly correlated with their performance in both individual and collaborative problem solving. Relative scores for problem solving, calculated (as for collaborative problem solving) from the residuals on a regression of performance in creative problem solving against performance in the three core PISA subjects, were calculated using data from PISA 2012. Countries'/economies' mean relative scores in individual problem solving and collaborative problem solving are plotted against each other in Figure V.3.11.

Relative scores in collaborative problem solving are weakly and positively correlated with relative scores in individual problem solving (Figure V.3.11), with an r^2 of 0.23. This drop in the correlation coefficient after accounting for performance in science, reading and mathematics indicates that much of the relationship between scores in the two types of problem solving was due to their common relationship with the cognitive elements also displayed in the science, reading and mathematics assessments.

Figure V.3.11 ▪ **Relative performance in individual problem solving (PISA 2012) and in collaborative problem solving (PISA 2015)**



Note: Only those countries and economies with available data or valid results for the PISA 2012 assessment of creative problem solving and the PISA 2015 assessment of collaborative problem solving are shown.
Source: OECD, PISA 2012 and PISA 2015 Databases, Tables V.3.9a and V.3.9b.
StatLink http://dx.doi.org/10.1787/888933615857

The remaining correlation between the relative scores includes the problem-solving elements that are common to both assessments. Its weaker magnitude also indicates, however, that relative scores in collaborative problem solving measure something distinct from relative scores in individual problem solving. This supports the idea that the three collaborative problem-solving competencies described in Chapter 2 exist and can be measured, and that collaborative problem solving is a skill in its own right, distinct from individual problem solving.

It is important to remember that the general trends mentioned above compare different students: 15-year-olds in 2012 versus 15-year-olds in 2015. The cognitive skills and (individual) problem-solving capabilities of students in 2015 may be different from those of students in 2012. Indeed, PISA measures trends in the three core domains, and many countries/economies show noticeable performance changes in these domains even over a three-year period.

However, on the assumption that three-year trends in most countries are small, these correlations are indicative of a likely relationship between individual (pure) problem solving and collaborative problem solving, the latter of which combines aspects of both pure problem-solving and collaboration skills.

THE INFLUENCE OF COMPUTER DELIVERY ON PERFORMANCE IN COLLABORATIVE PROBLEM SOLVING

The PISA 2015 collaborative problem-solving assessment is interactive and hence could only be delivered in a computer-based format. It was assumed that almost all 15-year-old students in 2015 were familiar with computers and other information and communications technology (ICT), especially in countries that chose to conduct the assessment on computer. However, the extent to which students use and are comfortable with computers and ICT equipment might have affected their performance in the collaborative problem-solving assessment compared to their performance on a similar test conducted in a different medium.

In an optional questionnaire on ICT familiarity administered in 43 out of the 52 countries/economies that assessed students' performance in collaborative problem solving, students were asked to report on the extent to which they use ICT at school and their self-perceived comfort with ICT. Their responses are summarised in Box V.3.3.

Box V.3.3. **Indices related to students' use of and familiarity with ICT**

The ICT questionnaire in PISA 2015 was administered in 46 of the 57 OECD and partner countries/economies that participated in the computer-based assessment; in addition, the questionnaire was administered in schools in the United Kingdom outside of Scotland.[12] It asks students about the availability of, their use of, and attitudes towards computers and other forms of ICT.

Since students completed the collaborative problem-solving assessment on the computer, their performance may be related to their use and familiarity with computers and ICT. Two ICT indices in particular were thought to be relevant to performance in the assessment:

- The index of the use of ICT at school. Students were asked how often they used digital devices for the following activities while at school: online chatting; using e-mail; browsing the Internet; downloading, uploading or browsing material from the school's website or Intranet; posting work onto the school's website; playing simulations; practicing and drilling, such as for learning foreign languages or mathematics; doing homework; and doing group work and communicating with other students.
- The index of students' self-reported ICT competence. Students were asked to what extent they agreed or disagreed that: they feel comfortable using digital devices that they are less familiar with; they can give advice if friends or relatives want to buy new digital devices or applications; they feel comfortable using digital devices at home; they think they can solve problems they come across with digital devices; and they can help friends or relatives who have a problem with digital devices.

Indices were normalised to an average of 0 and a standard deviation of 1 across OECD countries. As these are self-reported indices, there is cultural bias in how students respond, with students in some countries/economies being more likely to respond positively even if the underlying trait, such as the level of ICT use in school, is the same.

Students in Australia, Denmark, Sweden, and Thailand reported the highest use of ICT at school, with average indices over 0.50 (or over half a standard deviation above the OECD average); students in the East Asian countries of B-S-J-G (China), Japan and Korea reported the lowest use of ICT at school, with average indices below -0.50 (Table V.3.10a).

Self-reported ICT competence is found to be particularly high in Australia, Denmark, France, Ireland, New Zealand, Portugal, Sweden and the United Kingdom (excluding Scotland), where the index was between 0.20 and 0.40. This index was particularly low in the three East Asian countries of B-S-J-G (China), Japan and Korea, where it was between -0.49 and -1.00 (Table V.3.10b).

On average across OECD countries, students who rank between the 25th and 75th percentiles in the index of ICT use at school (i.e. those in the second and third quarters in their country/economy) perform better than students who use ICT at school the most (those in the top quarter) or the least (those in the bottom quarter). Moreover, students who use ICT the most in their school score 29 points lower in collaborative problem solving, on average, than students who use ICT the least. In Bulgaria, Greece, Israel, Latvia, Lithuania and Portugal, this gap is over 50 score points. Only in Australia and Japan, both of which are among the top countries/economies in collaborative problem solving, do students who report that they use ICT the most in school perform better than students who say they use ICT the least (Figure V.3.12, Table V.3.11a).

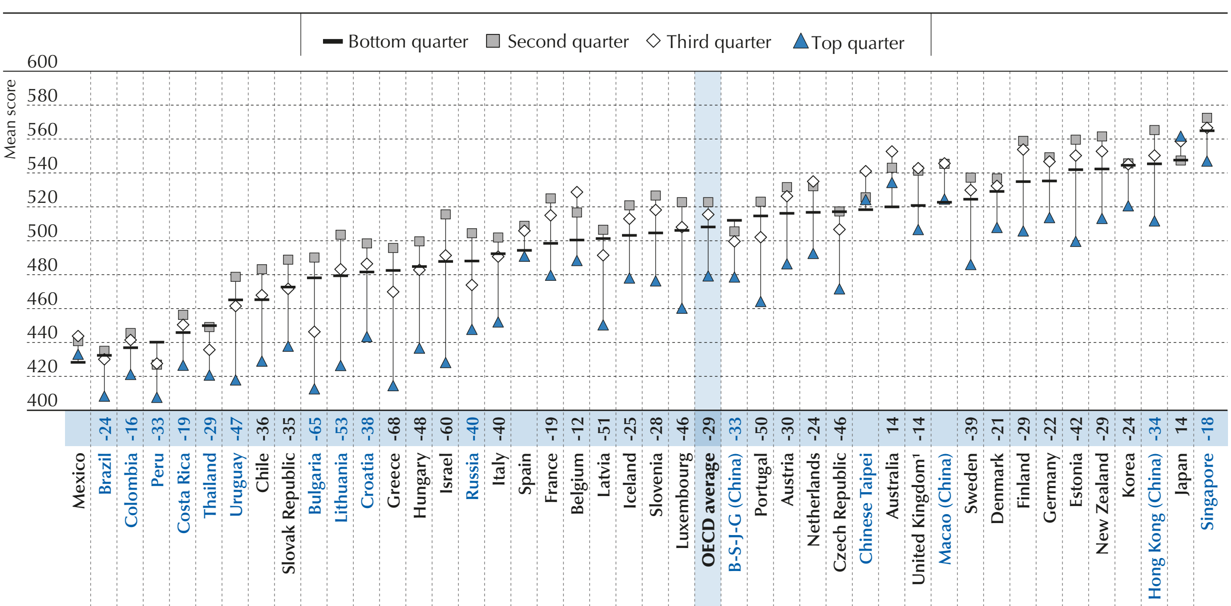
Students who reported that they use ICT the most frequently (those in the top quartile of ICT use at school in their country/economy) are only 60% as likely as other students to be top performers in collaborative problem solving. In Bulgaria, Greece and Lithuania, these students are less than 20% as likely as other students to be top performers in collaborative problem solving (Table V.3.11a).

Greater dependence on ICT may reduce the time students spend interacting and co-operating with each other, and thus may reduce their opportunities to learn how to collaborate, how to interpret the nuances of human communication, or how to compromise and consider others' opinions. Students might spend much of their time in a one-on-one "interaction" with education software, perhaps being distracted by it, thereby disengaging from the group (Heflin, Shewmaker and Nguyen, 2017).

Particularly infrequent use of ICT at school is often found in socio-economically disadvantaged schools. As is discussed in the next chapter, this is associated with lower performance in collaborative problem solving. Because of the cross-sectional and non-experimental nature of the variation in ICT use, the relationship between ICT use and performance in collaborative problem solving is not necessarily one of cause and effect.

By contrast, students' self-reported ICT competence is found to be positively related to performance in collaborative problem solving. Students who rank in their country's top quarter of self-reported ICT competence score 11 points higher in collaborative problem solving than students who rank in their country's bottom quarter, on average across OECD countries. The difference is especially large (more than 40 score points) in Bulgaria, Colombia and Lithuania. Only in Belgium do students who reported being highly competent in ICT score worse in collaborative problem solving (Table V.3.11b).

Figure V.3.12 ■ **Index of ICT use at school and performance in collaborative problem solving**



1. Only the United Kingdom subnational entities of England, Northern Ireland and Wales participated in the ICT questionnaire.

Notes: Statistically significant score-point differences in collaborative problem-solving performance between students in the top and bottom quarters of the index of ICT use at school are shown next to the country/economy name (see Annex A3).

Countries and economies are ranked in ascending order of the performance in collaborative problem solving among students in the bottom quarter of the index of ICT use at school.

Source: OECD, PISA 2015 Database, Table V.3.11a.

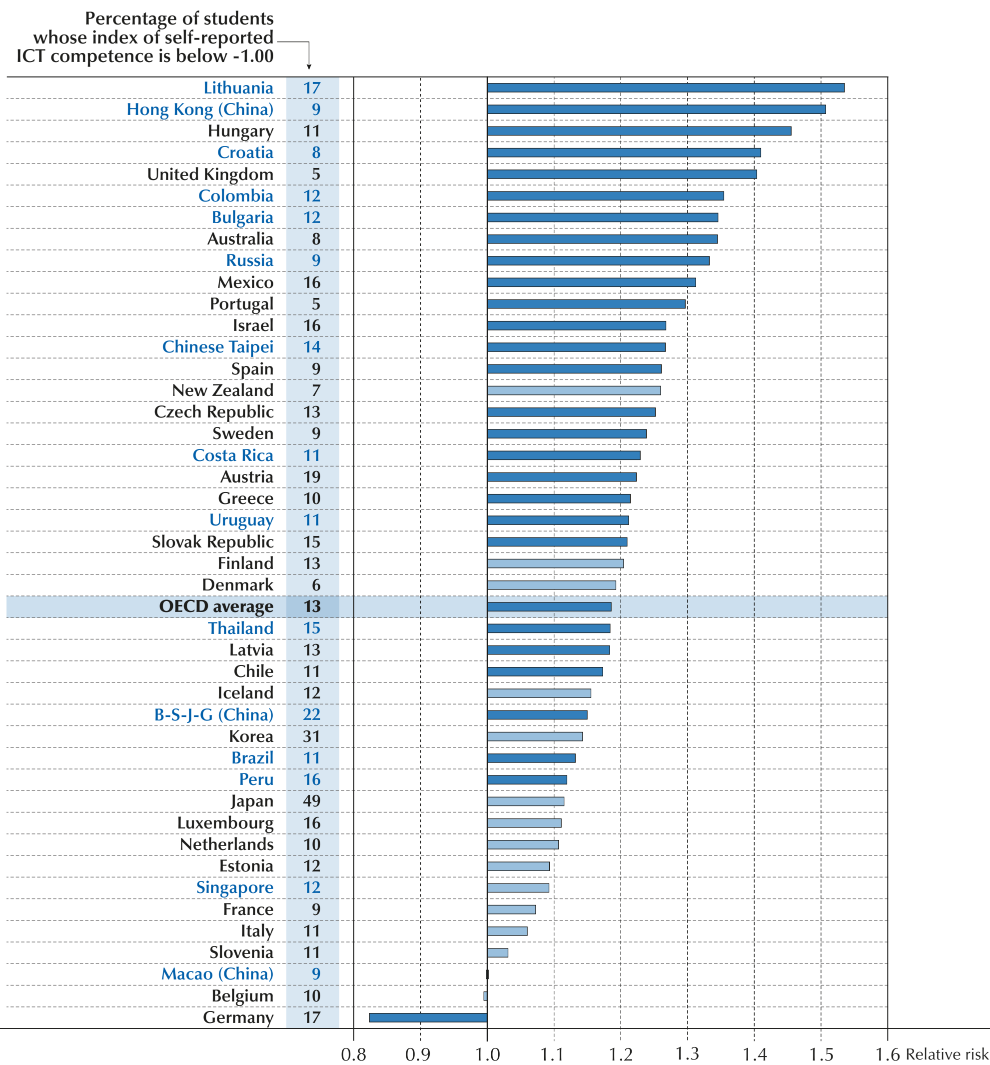
StatLink http://dx.doi.org/10.1787/888933615876

The index of self-reported ICT competence was normalised to have an average of 0 and a standard deviation of 1 across OECD countries. On average across all OECD countries that distributed the ICT questionnaire, 13% of 15-year-old students have an index of self-reported ICT competence that is below -1.00. Fewer than 7% of students in Denmark, Ireland, Portugal and the United Kingdom (excluding Scotland) reported such low ICT competence, while students in B-S-J-G (China), Japan and Korea were the most likely to report low ICT competence, with more than 20% of students in these countries so reporting (Figure V.3.13 and Table V.3.12).[13]

On average, students whose index of self-reported ICT competence was below -1.00 were 19% more likely to be low performers and scored, on average, 18 points below students with a higher index of self-reported ICT competence. Students with low self-reported ICT competence in Croatia, Hong Kong (China), Hungary, Lithuania and the United Kingdom (excluding Scotland) had a notably higher likelihood (over 40%) of being low performers. Only in Germany were students with an index of self-reported ICT competence below -1.00 less likely to be low performers than students with a higher index (Figure V.3.13 and Table V.3.12).

Figure V.3.13 ■ **Low performance in collaborative problem solving and self-reported ICT competence**

Increased likelihood that students whose index of self-reported ICT competence is below -1.00 are low performers compared to those whose index is above -1.00



Note: Statistically significant relative risk is shown in a darker tone (see Annex A3).

Countries and economies are ranked in descending order of the increased likelihood that students whose index of self-reported ICT competence is below -1.00 are low performers in collaborative problem solving compared to students whose index is above -1.00.

Source: OECD, PISA 2015 Database, Table V.3.12.

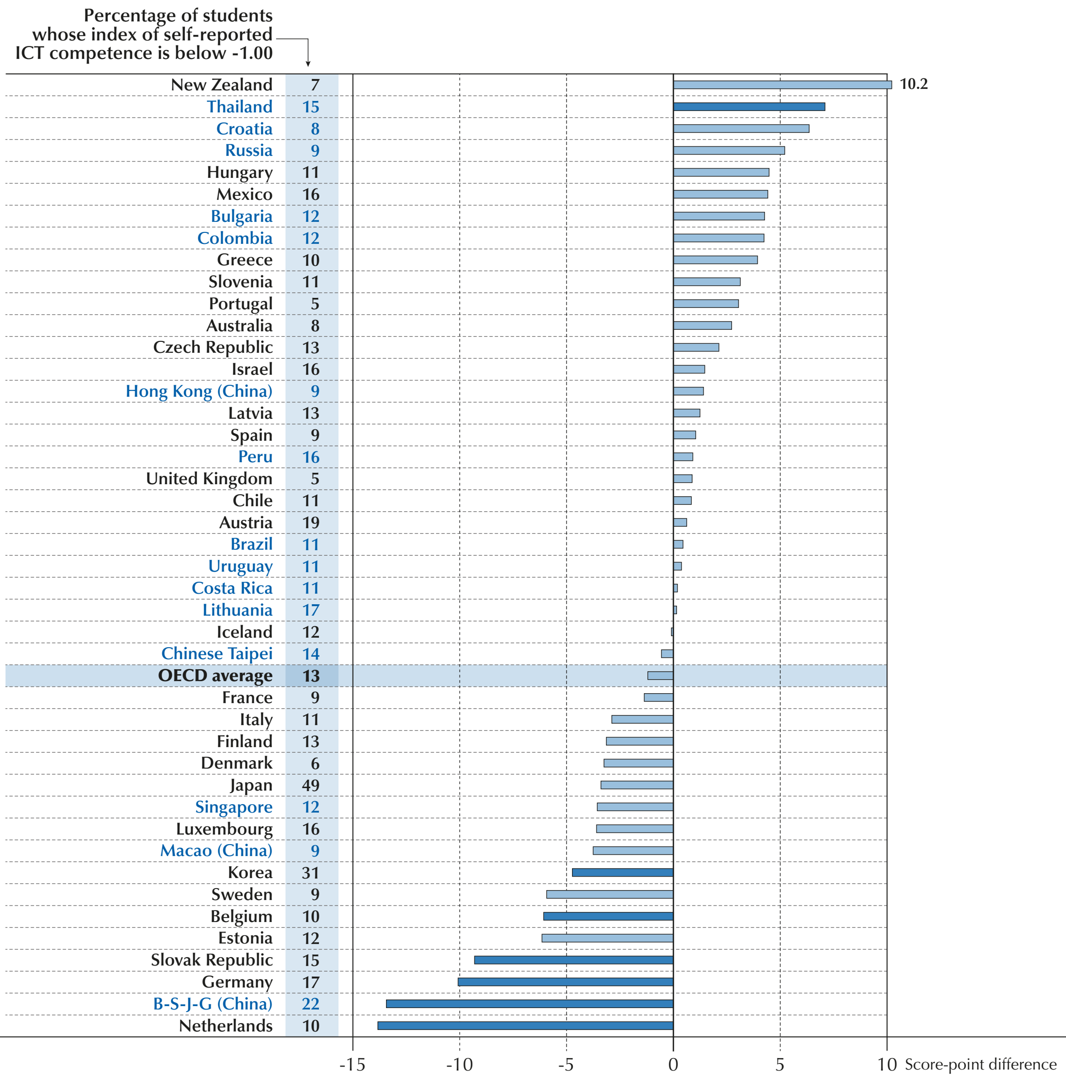
StatLink http://dx.doi.org/10.1787/888933615895

Hence, low self-reported competence in ICT is associated with poor performance in collaborative problem solving. It may be that low ICT competence hinders performance, or that there is a threshold in ICT competence below which certain levels of performance in collaborative problem solving are less likely to be observed. However, the direction of the association cannot be ascertained from this analysis. Moreover, the correlation between ICT competence and performance is low: ICT competence explains only 0.6% of the variation in collaborative problem-solving performance.

If low self-reported ICT competence hinders performance in the computer-based collaborative problem-solving assessment, it should also hinder performance in the science, reading and mathematics assessments as those assessments are also delivered via computer. To analyse whether ICT competence is related to performance in the distinctly collaborative aspects of the collaborative problem-solving assessment, Figure V.3.14 shows the relationship between self-reported ICT competence and relative performance, defined as the residual in a regression of performance in the collaborative problem-solving domain over performance in the science, reading and mathematics domains.

Figure V.3.14 ■ **Students' self-reported ICT competence and relative performance in collaborative problem solving**

Score-point difference between students whose index of self-reported ICT competence is above -1.00 and those whose index is below -1.00



Note: Statistically significant score-point differences are shown in a darker tone (see Annex A3).
Countries and economies are ranked in descending order of the score-point difference in the relative performance in collaborative problem solving between students whose self-reported ICT competence is above -1.00 and those whose index is below -1.00.
Source: OECD, PISA 2015 Database, Table V.3.12.
StatLink http://dx.doi.org/10.1787/888933615914

On average across OECD countries, there is no significant difference in relative performance between students whose index of self-reported ICT competence is above -1.00 and those whose index is below -1.00. A significant difference at the country level was observed only in Thailand, where students with a higher index had higher relative scores; and in Belgium, B-S-J-G (China), Germany, Korea, the Netherlands and the Slovak Republic, where students with a higher index had lower relative scores. In general, therefore, students' ICT competency did not have a strong relationship with their performance in the distinctly collaborative aspects of the assessment; any relationship could be accounted for through the cognitive skills shown in their science, reading and mathematics assessments (Table V.3.12).

Collaboration today increasingly takes place in a virtual environment, using technology that gives people sitting on different continents the ability to interact in real time. The PISA 2015 collaborative problem-solving assessment mirrors how 15-year-old students will have to collaborate in the near future. While education systems should still aim to improve their students' ICT skills, the collaborative aspects of this assessment show little relationship to students' comfort with ICT.

Notes

1. In certain situations, after a pause of 60 or 90 seconds, students who had not selected a response were moved onto the next step in the simulation; such inactivity was recorded as an incorrect response.

2. In particular, a student has a probability of 0.62 of correctly answering an item at the same point on the scale as his or her own ability level. The width of each proficiency level (to be described below in the main text) is set so that, for a test composed entirely of questions spread uniformly across a level, all students whose scores fall within that level would be expected to answer at least half of the questions correctly. In particular, students who are at the lower score limit for a level are expected to respond correctly to 52% of the questions at this level, while students who are at the upper score limit for a level are expected to respond correctly to 70% of the questions at this level.

3. PISA scores are represented on a scale whose units do not have a substantive meaning (unlike physical units, such as metres or grams) but are set in relation to the variation in results observed across all test participants. There is theoretically no maximum or minimum score in PISA; rather, the results are scaled to have approximately normal distributions, with means around 500 and standard deviations around 100. In statistical jargon, a one-point difference on the PISA scale therefore corresponds to an effect size of 1%, and a 10-point difference to an effect size of 10%.

4. Numerous studies have attempted to identify the score-point difference equivalent to a progression of one grade level in school, or the increase in score as a student moves from, for instance, grade 9 to grade 10. This cannot be ascertained from a single PISA cycle, as 15-year-old students enrolled in grade 9 are not equivalent to 15-year-old students enrolled in grade 10 due to selection effects. Instead, two types of studies can provide a better measure of the grade-equivalence of PISA scores: longitudinal follow-up studies, where the same students who sat the PISA test are re-assessed later in their education, and cross-sectional designs, where representative samples of students are compared across adjacent age groups and grades. Unfortunately, neither of these studies was available for the PISA 2015 collaborative problem-solving assessment.

5. Technically, the mean score in collaborative problem solving across OECD countries was set at 500 points and the standard deviation at 100 points, with the data weighted so that each OECD country contributed equally. The average standard deviation of the problem-solving scale across OECD countries, as reported in the Appendix tables, is less than 100 score points because it is computed as the arithmetic average of the within-country standard deviations. This reported measure does not include the performance variation between countries. The standard deviation of 100 used for standardising scores, on the other hand, is a measure of overall variation within and between OECD countries.

6. Top performers in science, reading and mathematics are defined as those students who achieve at Level 5 or 6 in those domains. As only four levels of proficiency were defined in collaborative problem solving, top performers in collaborative problem solving were defined as those students who achieve the top level of performance, Level 4.

7. This statement and similar statements in the following sections do not consider potential error margins in the percentage of students who perform at each level. In other words, the percentage of students who perform at Level 4 in these countries is not necessarily significantly higher than the percentage of students who perform at Level 4 on average in OECD countries.

8. This statement does not consider potential error margins in the percentage of students who perform at each level. In other words, the percentage of students who perform at Level 3 in these 10 countries is not necessarily significantly higher than the percentage of students who perform at Level 2 on average in OECD countries.

9. Top performance and low achievement are defined independently and represent a different set of skills for each subject. Moreover, while Levels 5 and 6 represent top performance in the core subjects, only four proficiency levels were defined for collaborative problem solving, and only Level 4 represents top performance in that subject. Hence, top performance and low achievement are not equivalent across different subjects.

10. A linear ordinary least squares regression of performance in collaborative problem solving over performance in science, reading and mathematics was performed. Thus, a student's predicted performance in collaborative problem solving was ascertained from his or her performance in science, reading and mathematics. The student's relative performance was then defined as his or her actual performance in collaborative problem solving minus his or her predicted performance in collaborative problem solving, or in other words, the residual of the regression. One of the properties of the regression, to ensure that the predictions are not biased, is that the average residual (or relative performance) is equal to 0. Student weights were adjusted so that all countries and economies contributed equally to the regression.

11. By contrast, other analyses conducted in this report and in other PISA reports typically analyse data for each country/economy separately. This would have resulted in an average residual for each country/economy of 0 and made impossible the ranking of countries/economies on the basis of their relative collaborative problem-solving score. However, in the rest of this report (Chapters 4, 5, 6 and 7), where the focus is on differences between individuals within the same country, relative scores are calculated at the country level and then regressed over other potential explanatory variables, such as demographic characteristics or school practices, as it is the change in relative score that is of interest, not the absolute value of the relative score.

12. Five countries that administered PISA 2015 on the computer did not participate in the collaborative problem-solving assessment. Among these five countries, four (the Dominican Republic, Ireland, Poland and Switzerland) administered the ICT questionnaire.

13. Self-reported indices from students in Japan and Korea are amongst the lowest across PISA-participating countries and economies, likely attributable to cultural factors. Please see *PISA 2015 Results: Students' Well-Being* (OECD, 2017b) for further information.

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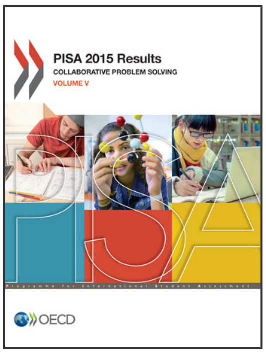

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