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Overview: Collaborative problem solving

Today's workplaces demand people who can solve problems in concert with others. The increase in jobs requiring a high level of social skills has been accompanied by an increase in the wages for such jobs, suggesting that there is higher demand from employers for such skills instead of simply a surplus of workers who hold such skills. For example, wages have risen by over 20% for jobs that require high social skills but low mathematics skills, suggesting that social skills are increasingly of value to employers.

The importance of collaboration extends beyond the workplace. Many human activities involve groups of people, from a variety of physical and artistic endeavours to living in harmony with one's neighbours. Almost everyone relies on interactions with other individuals to do what he or she cannot do alone. Collaboration skills are essential to facilitating such interactions.

Collaborative problem solving has several advantages over individual problem solving: labour can be divided among team members; a variety of knowledge, perspectives and experiences can be applied to solve the problem; and team members can stimulate each other, leading to enhanced creativity and a higher quality of the solution. But collaboration also poses potential challenges to team members. Labour might not be divided equitably or efficiently, with team members perhaps working on tasks they are unsuited for or dislike. Conflict may also arise among team members, hindering the development of creative solutions. Collaboration is thus a skill in itself.

Yet in most countries and economies, collaboration is not explicitly taught in schools; rather, it is acquired through the teaching of other subjects. For example, students are often asked to perform group work in traditional academic subjects, and are also given chances to interact with one another in a variety of other contexts in other activities and classes, such as physical education class, music class, or extracurricular sports teams.

There have been few attempts to assess how well students collaborate with one another. Hence, PISA 2015 decided to assess 15-year-old students' ability to collaborate in order to solve problems. By doing so, PISA aims to address the lack of internationally comparable data in this field, allowing countries and economies to see, for the first time, where their students stand in relation to students in other education systems. Some 52 countries and economies participated in the collaborative problem-solving assessment (32 OECD countries and 20 partner countries and economies). The data were adjudicated in and results are presented for 51 of these countries and economies.

PISA 2015 defines collaborative problem-solving competency as the capacity of an individual to effectively engage in a process whereby two or more agents attempt to solve a problem by sharing the understanding and effort required to come to a solution and pooling their knowledge, skills and efforts to reach that solution. In the PISA assessment, one agent is the student whose performance is being evaluated; all other agents are computerised simulations. This allows the assessment to control the behaviour of the other agents in order to isolate the collaborative problem-solving ability of the student being evaluated. Had the student been in a group with other students, his or her performance would have depended on the ability of the other students and the pre-existing relationships between them.

All questions in the assessment were either multiple choice or involved moving icons into the appropriate slot; there were no free-response questions. Since it was an interactive assessment, students were required to respond to each question before moving onto the next and could not skip or omit questions. Collaboration was assessed through students' responses in their interactions with computer-based agents.

PISA summarises 15-year-olds' performance in collaborative problem solving on a single performance scale. 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 was compared.

Singapore outperforms all other participating countries in collaborative problem solving.

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 OECD average score. 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.

A gap of 129 score points separates 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. 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 (Figure V.3.3 and Table V.3.2).

Across OECD countries, 8% of students are top performers in collaborative problem solving, but 6% of students do not even attain Level 1 proficiency.

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, with Level 1 as the lowest level and Level 4 as the highest) 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.

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.

Across OECD countries, 8% of students perform at this level. 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. By contrast, in two OECD countries and in seven partner countries, fewer than one in 100 students performs at Level 4; and in Tunisia, fewer than one in 1 000 students performs at this level (Figure V.3.6 and Table V.3.1).

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 the 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.

Across OECD countries, 36% of students are proficient at Level 3 or higher. Level 3 was the most common proficiency level in 10 of the 51 countries/economies with adjudicated data from the collaborative problem-solving assessment (Figure V.3.6 and Table V.3.1).

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.

Across OECD countries, 72% of students perform at Level 2 or higher. 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).

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, these students can help find a solution to a simple problem.

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).

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 (Figure V.3.6 and Table V.3.1).

Performance in collaborative problem solving is strongly related to performance in the core PISA subjects of 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, Hong Kong (China), Japan, Korea and Singapore – are found at the top of each set of rankings. Indeed, scores in the four domains are highly correlated. 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 – and thus the correlations are slightly weaker – than the pairwise correlations between scores in the core PISA subjects, which range from 0.80 to 0.88 (Figure V.3.7). 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).

Top/low performers in the core PISA subjects also tend to be top/low performers in collaborative problem solving.

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 Level 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.

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. It may be that the development of collaborative problem-solving skills in these countries is more strongly linked to the development of science, reading and mathematics literacy; in other words, the development of cognitive and social skills in these countries takes place simultaneously.

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. 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 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.

Most of the variation in student performance is observed within schools.

There is considerable variation in collaborative problem-solving performance within each country/economy, most of which is observed within schools. On average across OECD countries, the variation in student performance that is observed within schools amounts to 75% of the OECD average variation in student performance. The remaining variation (24%) is due to differences in student performance between schools (Table V.4.1a).

The variation in collaborative problem-solving performance between schools can be partly attributed to differences in the composition of schools and in the school policies and practices that may develop or foster student performance in collaborative problem solving.

Collaborative problem-solving performance is closely correlated to performance in the three core PISA subjects. Many school and neighbourhood factors foster the development of collaboration and problem-solving skills, just as they create the conditions for any type of learning. Differences in student performance in science, reading and mathematics accounted for 62% of the variation in student performance in collaborative problem solving, on average across OECD countries. In other words, on average, 38% of the differences in how students perform in the collaborative problem-solving assessment is unique to collaborative problem solving (Table V.4.1b).

At the same time, a larger fraction of the within-school differences in collaborative problem-solving performance (46% on average across OECD countries) cannot be accounted for by differences in performance in the core PISA subjects (Table V.4.1b). This suggests that differences in the experiences, personalities and opportunities among students attending the same school are the most likely explanations for the remaining differences in performance in collaborative problem solving, after performance in science, reading and mathematics has been accounted for.

Girls significantly outperform boys in every country and economy that participated in the collaborative problem-solving assessment.

Girls outperform boys in collaborative problem solving by 29 score points (515 points compared with 486 points, on average across OECD countries). Indeed, in every country/economy that participated in the collaborative problem-solving assessment, girls significantly outperform boys. The differences are greatest in Australia, Finland, Latvia, New Zealand and Sweden, where girls score over 40 points higher than boys, on average. Girls outperform boys by less than 10 points in Colombia, Costa Rica and Peru, but these differences are still statistically significant (Figure V.4.3).

On average across OECD countries, girls are 1.6 times more likely than boys to be top performers (Level 4) in collaborative problem solving, while boys are 1.6 times more likely than girls to be low achievers (below Level 2). The difference is even starker when examining students who score below Level 1: boys are 2.2 times more likely to score at this level than girls. In no country or economy are boys more likely than girls to be top performers, and in every country or economy are boys more likely than girls to be low performers (Table V.4.2).

After accounting for performance in the three core PISA subjects, girls still outperform boys in collaborative problem solving by 25 score points, on average across OECD countries, and this performance gap is significant and in favour of girls in every country and economy that participated in the assessment (Table V.4.3b).

These findings contrast with the gender differences observed in individual problem solving as discussed in *PISA 2012 Results: Creative Problem Solving* (OECD, 2014). In that assessment, boys scored 7 points higher than girls in individual problem solving, on average across OECD countries, and were 1.5 times more likely than girls to be top performers. Although different groups of students were measured in 2012 and 2015 and the assessments are not directly comparable to one another, the results suggest that it is the collaborative component of the PISA 2015 collaborative problem-solving assessment that favours girls.

The relationship between socio-economic status and performance is weaker in collaborative problem solving than in the three core PISA subjects.

Unsurprisingly, socio-economic status – as measured in PISA by the PISA index of economic, social and cultural status (ESCS) – relates positively to performance in problem solving, as it does to performance in all domains assessed in PISA. But the relationship between socio-economic status and performance differs across domains.

In general, the percentage of the variation in performance explained by socio-economic disparities at both the student and school levels is similar for science (the average across the OECD countries that participated in the collaborative problem-solving assessment is 23%), reading (22%) and mathematics (23%). But this relationship is weaker in collaborative problem solving than in the three other domains (Figure V.4.7). Still, even in collaborative problem solving, about 15% of the variation in performance can be explained by differences in socio-economic status. A higher position on the PISA index of economic, social and cultural status might be associated with greater academic enrichment opportunities, leading to disparities in performance in the cognitive domains. But opportunities to collaborate and co-operate arise in all social and economic contexts, which could reduce the extent to which socio-economic status is related to performance in collaborative problem solving.

The relationship between collaborative problem-solving performance and socio-economic status is positive in almost every country/economy that participated in the assessment; but the score-point improvement associated with a one-point increase in the PISA index of economic, social and cultural status is smaller in collaborative problem solving than in science, reading and mathematics. A one-point increase in students' socio-economic status is associated with a 13-point improvement in collaborative problem-solving performance, compared to between 17 and 19 points in the three core PISA subjects. A one-point increase in schools' socio-economic profile is associated with a 59-point improvement in collaborative problem-solving performance compared to an improvement of between 66 and 73 points in the three core PISA subjects (Table V.4.13e and Figure V.4.8).

Immigrant students tend to score lower in collaborative problem solving than students without an immigrant background.

In many countries and economies, children of immigrants are more at risk of low performance in academic subjects than the children of parents who were born in the country or economy. A gap in collaborative problem-solving performance between immigrant and non-immigrant students is also observed: on average across OECD countries, the children of immigrants score 36 points lower than non-immigrant students. However, in Macao (China), Singapore and the United Arab Emirates, immigrant students score better than non-immigrant students in collaborative problem solving (Table V.4.14a). The largest gaps in performance among countries where at least 6.25% of students are immigrants are observed in Denmark, where immigrant students score more than 60 points lower than students without an immigrant background, and in Austria, Belgium, France and Sweden, where immigrant students score between 50 and 60 points lower.

Performance differences related to immigrant background are no longer observed after accounting for performance in the three core PISA subjects.

A majority of 15-year-olds in almost all PISA-participating countries and economies reported positive attitudes towards co-operating with others.

The PISA 2015 student questionnaire asked students whether they strongly agree, agree, disagree, or strongly disagree with eight statements related to their attitudes towards collaboration:

- I prefer working as part of a team to working alone.
- I am a good listener.
- I enjoy seeing my classmates be successful.
- I take into account what others are interested in.
- I find that teams make better decisions than individuals.
- I enjoy considering different perspectives.
- I find that teamwork raises my own efficiency.
- I enjoy co-operating with peers.

In almost all OECD and partner countries and economies, the majority of students reported that they either agree or strongly agree with these statements. In fact, there are only two exceptions: only 48% of students in Turkey and 44% of students in Montenegro reported that they agree or strongly agree with the statement "I prefer working as part of a team to working alone".

Responses to these eight statements are combined into two indices of co-operation that reflect the valuing of relationships and teamwork (Figure V.5.3). Each index is standardised to have a mean of 0 and a standard deviation of 1 across OECD countries.

Students in Portugal have the highest index of valuing relationships (0.37) among all OECD and partner countries and economies, followed by Costa Rica, the United Arab Emirates and Singapore, all three of which have average indices of valuing relationships greater than 0.30 (Figure V.5.4). Students in these countries are especially likely to agree that they are good listeners, that they enjoy seeing their classmates be successful, that they take into account what others are interested in and that they enjoy considering different perspectives.

Students in Portugal also have the highest index of valuing teamwork (0.32) among OECD countries; however, the average student in the Dominican Republic has an index of valuing teamwork of 0.51 – over half a standard deviation above

the average student in OECD countries. These students are those who most prefer working as part of a team to working alone, who find that teams make better decisions than individuals, who find that teamwork raises their own efficiency and who enjoy co-operating with peers.

On average across OECD countries, the correlation between the indices of valuing relationships and teamwork is 0.41 (Table V.5.12). Countries with a high mean value on one index also tend to have a high mean value of the other index.

Girls and boys differ in what they value when it comes to collaborating with others.

Girls were significantly more likely than boys to agree or strongly agree with the four statements that comprise the index of valuing relationships. For example, on average across OECD countries, girls were 5.3 percentage points more likely than boys to report that they agree or strongly agree that "[they] are a good listener" (Figure V.5.5). Moreover, this difference is significant and in favour of girls in 54 of 56 countries; in the two other countries, the difference is not significant. Gender differences are most pronounced in Italy and Latvia, where there is a 10 percentage-point gap (Table V.5.4a).

By contrast, boys were significantly more likely than girls to report that they agree or strongly agree with the four statements that comprise the index of valuing teamwork (Figure V.5.5). The difference is most pronounced for the statement "I prefer working as part of a team to working alone", with which boys were 5.1 percentage points more likely than girls to agree or strongly agree. This difference is significant and in favour of boys in 38 of 56 countries; it is significant and in favour of girls in only one country: Beijing-Shanghai-Jiangsu-Guangdong (China) (hereafter "B-S-J-G [China]") (a 4.1 percentage-point gap). The gender gap is widest in Canada, Iceland and Sweden, where it exceeds 10 percentage points (Table V.5.4b).

Socio-economic status is associated with differences in students' attitudes towards collaboration.

There are significant differences related to socio-economic status in the propensity to agree or strongly agree with each statement. Advantaged students were 6.1 percentage points more likely than disadvantaged students to report that they agree or strongly agree with the statement "I take into account what others are interested in"; 5.7 percentage points more likely to agree or strongly agree with the statement "I enjoy considering different perspectives"; 4.8 percentage points more likely to agree or strongly agree with the statement "I am a good listener"; and 1.4 percentage points more likely to agree with the statement "I enjoy seeing my classmates be successful" (Figure V.5.6). These four statements comprise the index of valuing relationships.

By contrast, disadvantaged students were 7.5 percentage points more likely than advantaged students to agree or strongly agree with the statement "I find that teamwork raises my own efficiency"; 5.5 percentage points more likely to agree or strongly agree with the statement "I prefer working as part of a team to working alone"; 5.2 percentage points more likely to agree or strongly agree with the statement "I find that teams make better decisions than individuals"; and 1.0 percentage points more likely to agree or strongly agree with the statement "I enjoy co-operating with peers". These four statements comprise the index of valuing teamwork.

The data indicate that advantaged students were more likely to report that they agree or strongly agree that they engage in co-operative activities that do not directly involve personal gain, while disadvantaged students were more likely to report that they agree or strongly agree that teamwork brings benefits. A similar dichotomy is observed between girls and boys.

The relationships between students' attitudes towards collaboration and their performance in collaborative problem solving are remarkably consistent across countries.

Are students who have more positive attitudes towards collaboration also better able to solve problems collaboratively? Within-country differences in student performance related to self-reported attitudes towards collaboration are remarkably consistent across countries and economies (Figure V.5.8 and Tables V.5.2a to V.5.2h). On average across OECD countries, students who reported that they agree or strongly agree with the statements that comprise the index of valuing relationships score better than those who reported that they disagree or strongly disagree with those statements. The performance gap varies from 38 points for the statement "I take into account what others are interested in" to 26 points for "I enjoy seeing my classmates be successful."

By contrast, students who reported that they agree or strongly agree with the statements comprising the index of valuing teamwork score below students who reported that they disagree or strongly disagree with those statements, on average across OECD countries. For example, the performance gap related to the statement "I find that teamwork raises my own efficiency" is 22 points, while the gap related to the statement "I prefer working as part of a team to working alone" is 17 points.

But other patterns are observed after accounting for performance in the three core PISA subjects (science, reading and mathematics). There is a positive association between agreeing or strongly agreeing with any of the items related to attitudes towards collaboration – both the items that comprise the index of valuing relationships and those that comprise the index of valuing teamwork – and relative performance in collaborative problem solving (Figure V.5.8).[1] These positive associations persist after accounting for gender, and students' and schools' socio-economic profile. On average across OECD countries, students who agree or strongly agree with the statements in the index of valuing relationships perform between five and eight points higher in collaborative problem solving after accounting for performance in the three core PSIA subjects, gender, and students' and schools' socio-economic profile, while they perform between two and five points higher if they agree or strongly agree with the statements in the index of valuing teamwork.

Hence, it appears that positive attitudes towards collaboration – whether for altruistic reasons or for the benefit of one's own success in a collaborative project – are associated with the distinctively collaborative aspects of solving problems collaboratively. Students who perform at lower levels of proficiency are more likely to recognise the effectiveness of collaboration. However, a positive disposition towards collaboration, even if it is for the benefits to oneself that collaboration can bring, is still associated with better performance in collaborative problem solving when comparing students with similar performance in science, reading and mathematics.

Participation in physical activities has a limited relationship with students' ability to collaborate with others.

Many studies have tried to discover a link between participation in sports and academic performance, with inconclusive results. PISA 2015 asked students to report the number of days during which they engaged in moderate physical activity (such as walking, climbing stairs or riding a bike to school) for at least 60 minutes per day, or vigorous physical activity (such as running, cycling, aerobics, soccer and skating) for at least 20 minutes per day during the week before the PISA assessment. PISA also asked students how often, on average, they attend physical education classes each week during the school year.

Students who engage in moderate physical activity two or more days per week score higher in the collaborative problem-solving assessment than students who engage in such activity fewer than two days per week (Figure V.6.1 and Table V.6.1a). Students who attend one or two days of physical education class per week score highest in collaborative problem solving (Figure V.6.2, Tables V.6.1c and V.6.2c). These students score around 20 points higher than students who do not attend any physical education class, on average across OECD countries. However, students who participate in four days of physical education class per week score at least 31 points lower in collaborative problem solving than those who take part in one or two classes per week, and 10 points lower than those who do not take part in any physical education class.

After accounting for performance in science, reading and mathematics, there are few significant differences in performance on the collaborative problem-solving assessment related to the number of days in an average week during which a student engages in moderate physical activity (Table V.6.3a). However, additional days of vigorous physical activity beyond two days per week are associated with successively lower relative performance scores in collaborative problem solving (after accounting for performance in the three core PISA subjects) (Table V.6.3b).

Most differences in relative performance associated with the number of days that a student attends physical education class per week are not significant across OECD countries. The greatest differences are found among students who attend four or five days of physical education class per week, who score over five points lower in collaborative problem solving than students who attend fewer days of physical education class per week, but who have similar scores in science, reading and mathematics (Table V.6.3c). In other words, students' collaboration-specific skills are observed to decrease above a certain threshold of vigorous physical activity or attendance in physical education classes.

How students spend their time before and after school can be related to their performance in collaborative problem solving.

PISA 2015 asked students whether they participated in a variety of activities both before and after school on the most recent school day prior to sitting the PISA assessment. Several of these activities might have a social – or perhaps antisocial – component to them: using the Internet/chat/social networks; playing video games; meeting friends or talking to friends on the phone; and working in the household or taking care of family members.

Students who play video games score, on average, 32 points lower than students who do not play video games; and students who talk to their friends on the phone or meet their friends score 23 points below students who do not.

In no country or economy do students who played video games, or who met their friends or talked to them on the phone on the last school day prior to the PISA assessment score significantly better than those who did not engage in those activities (Figure V.6.5, Tables V.6.7b and V.6.7c).

This gap remains significant after accounting for performance in science, reading and mathematics. The relative score of students who play video games outside of school is 15 points below that of students who do not play video games, on average across OECD countries; after also accounting for gender and students' and schools' socio-economic profile, the gap is still significant but only 4 score points wide (Figure V.6.5, Table V.6.7b).

By contrast, accessing the Internet, chat or a social network was associated with a seven score-point improvement in collaborative problem-solving performance, on average across OECD countries (Figure V.6.5). This relationship in favour of students who accessed these forms of communication was observed in 23 out of 51 countries/economies. This performance gap exceeds 35 score points in Brazil, Colombia and Norway (Table V.6.7a).

After accounting for performance in science, reading and mathematics, gender, and students' and schools' socio-economic profile, a significant gap of six score points in collaborative problem-solving performance is still observed across OECD countries in favour of students who had accessed the Internet, chat, or social networks outside of school (Figure V.6.5). Thisgap is significant and in favour of students who had accessed such media in 13 of 51 participating countries and economies, and is over 15 points wide in the Czech Republic and Germany. By contrast, the performance gap is significant and in favour of students who had not accessed such media only in the United States, where it is 10 score points wide (Table V.6.7a).

Students interacted with computer agents in a virtual interface in this assessment, a process that is more akin to using electronic forms of communication than talking to friends on the telephone or seeing them outside of school. Students who use the Internet, chat or social media outside of school might therefore have an advantage in the assessment.

Student truancy appears more related to students' attitudes towards being and working with others, in general, than to their collaboration-specific skills.

On average across OECD countries, students who had skipped a whole day of school in the two weeks prior to the PISA test score 39 points below those who had not skipped a whole day of school in collaborative problem solving (Table V.6.9a). The difference is particularly stark in B-S-J-G (China), Japan, Korea, Slovenia and Chinese Taipei, where it exceeds 65 score points. In no country/economy do students who had skipped a whole day of school during that period perform better on the collaborative problem-solving assessment than students who had not.

The significant relationships related to truancy and lateness vanish after accounting for student performance in science, reading and mathematics, gender, and students' and schools' socio-economic profile: there is no longer any difference in collaborative problem-solving performance between students who had and those who had not skipped a whole day of school, skipped some classes or arrived late for school. It therefore appears that there is no association between student truancy and lateness, and the distinctively collaborative aspects of collaborative problem solving. This may lend support to the hypothesis that students choose to play truant from school because of factors related to their academic performance and how they view school itself, as opposed to their ability to collaborate with classmates.

Students who play truant or arrive late for school are also less likely to have positive attitudes towards collaboration. On average across OECD countries, students who had skipped at least one day of school or had skipped some classes in the two weeks prior to sitting the PISA assessment have significantly lower values on both the index of valuing relationships and the index of valuing teamwork. Students who had arrived late for school have a lower index of valuing relationships, but there is no difference observed in the index of valuing teamwork. After accounting for gender, and students' and schools' socio-economic profile, students who play truant or arrive late for school have lower indices of both valuing relationships and valuing teamwork (Figure V.6.7).

The largest gaps in attitudes towards collaboration are seen when considering the statements that are included in the index of valuing relationships, which are closely related to valuing others' opinions and success. It thus appears that there is a particularly strong relationship between the decision to play truant and the extent to which a student values friendships and interpersonal relationships.

Students who had not played truant or who had not arrived late for school had lower indices of valuing relationships and teamwork when they attended schools where more of their classmates were truant or late for school, after accounting for gender, and students' and schools' socio-economic profile (Tables V.6.11a-c).

Attendance at pre-primary school is associated with more positive attitudes towards collaboration later on.

Some 95% of 15-year-old students, on average across OECD countries, had attended some form of pre-primary school. Results from the PISA 2015 collaborative problem-solving assessment and student questionnaire show that students who had attended pre-primary school score 29 points higher than students who had not attended pre-primary school. A significant difference is observed in 21 of the 47 countries for which data are available (Table V.6.12a). In no country or economy is the gap significant in favour of students who had not attended pre-primary school.

On average across OECD countries, there is no significant relationship between attendance at pre-primary school and the distinctive aspects of collaborative problem solving, indicating that the performance gap described above reflects the relationship between collaborative problem-solving performance and performance in science, reading and mathematics. Attendance at pre-primary school has no discernible effect on the unique aspects of collaborative problem solving (or what one would attribute to collaboration skills as opposed to general academic proficiency) ten years later. In fact, after accounting for performance in the three core PISA subjects, a significant advantage in collaborative problem-solving performance among students who had attended pre-primary school is observed only in Norway (11 score points) and Russia (12 score points), while a significant disadvantage among students who had attended pre-primary school is found in the United States (11 score points) (Figure V.6.8).

On average across OECD countries and after accounting for gender, and students' and schools' socio-economic profile, students who had attended pre-primary school have significantly higher values on the indices of enjoying and valuing co-operation and were more likely to agree or strongly agree with all of the items that comprise these two indices. Students who had attended pre-primary school were between two and five percentage points more likely than those who had not attended to agree or strongly agree with each of the statements that are related to attitudes towards collaboration, after accounting for gender, and students' and schools' socio-economic profile. For instance, they were 4.7 percentage points more likely to agree that they "prefer working as part of a team to working alone", a gap that widens to over 15 percentage points in the Czech Republic and France. They were also 4.0 percentage points more likely to agree that they "take into account what others are interested in", a gap that grows to over 10 percentage points in the Czech Republic, Germany and Luxembourg (Table V.6.13).

Thus, attendance at pre-primary school is positively correlated with positive attitudes towards collaboration, and while attendance at pre-primary school is also positively correlated with performance in collaborative problem solving, this relationship disappears once performance in science, reading and mathematics is accounted for. These results provide some support to the idea that pre-primary schools develop socialisation skills and positive attitudes towards co-operating with others that can have a lasting impact.

Students who are regularly asked to discuss their work in class tend to have more positive attitudes towards collaboration.

The PISA 2015 student questionnaire asked students about how often certain activities occur during science class. Four of these activities were identified as being communication-intensive: explaining one's ideas in science class; spending time in the laboratory doing practical experiments; arguing about science questions; and taking part in class debates about investigations.

Significant relationships between these activities and attitudes towards collaboration are observed both on average across OECD countries and in many other countries and economies. On average across OECD countries, the indices of valuing relationships and teamwork are higher among students who reported that they participate in these activities in most or all lessons than among those who reported that they participate in these activities in only some lessons or never/hardly ever.

Students who are given opportunities to explain their ideas in most or all lessons were two to six percentage points more likely to agree or strongly agree with each of the statements regarding attitudes towards collaboration. This difference is observed in most countries and economies. For example, after accounting for gender, and students' and schools' socio-economic profile, in 46 of the 56 countries and economies that administered the student questionnaire on computer, students who reported that they explain their ideas in most or all science lessons were more likely to agree that they are "a good listener"; in 37 out of 56 countries and economies, these students also agreed that they "enjoy considering different perspectives" (Tables V.6.15a-d).

Figure V.1.1 ■ Snapshot of performance in collaborative problem solving and attitudes towards collaboration

Countries/economies with a mean performance/relative performance **above** the OECD average
Countries/economies with a mean performance/relative performance not significantly different from the OECD average
Countries/economies with a mean performance/relative performance **below** the OECD average

	Collaborative problem solving						
	All students	Relative performance[1]	Boys	Girls	Gender difference (boys – girls)	Index of valuing relationships	Index of valuing teamwork
	Mean score	Score dif.	Mean score	Mean score	Score dif.	Mean index	Mean index
OECD average-32	**500**	**3**	**486**	**515**	**-29**	**0.01**	**0.00**
Singapore	561	16	552	572	**-20**	0.32	0.27
Japan	552	23	539	565	**-26**	-0.22	-0.03
Hong Kong (China)	541	15	523	559	**-36**	-0.04	0.05
Korea	538	20	522	556	**-33**	-0.02	0.14
Canada	535	10	516	555	**-39**	0.11	0.00
Estonia	535	8	522	549	**-27**	0.03	-0.10
Finland	534	7	511	559	**-48**	-0.08	-0.22
Macao (China)	534	11	515	553	**-38**	-0.15	0.01
New Zealand	533	20	513	553	**-41**	0.01	0.07
Australia	531	23	511	552	**-41**	0.09	0.01
Chinese Taipei	527	5	513	541	**-28**	0.22	0.37
Germany	525	14	510	540	**-30**	0.15	0.14
United States	520	22	507	533	**-26**	0.13	0.06
Denmark	520	14	509	530	**-21**	0.01	-0.12
United Kingdom	519	12	503	536	**-34**	-0.04	-0.04
Netherlands	518	8	504	531	**-27**	-0.18	-0.26
Sweden	510	9	489	531	**-42**	0.05	-0.19
Austria	509	13	498	521	**-24**	0.24	0.19
Norway	502	-5	487	518	**-30**	0.11	-0.23
Slovenia	502	-10	484	521	**-36**	-0.04	0.02
Belgium	501	-4	489	514	**-25**	-0.06	-0.11
Iceland	499	15	485	512	**-27**	-0.09	-0.20
Czech Republic	499	3	486	512	**-26**	-0.20	0.00
Portugal	498	-5	489	507	**-19**	0.37	0.32
Spain	496	-1	485	508	**-22**	0.19	0.15
B-S-J-G (China)	496	-17	486	508	**-22**	0.01	0.39
France	494	-7	480	508	**-29**	-0.07	0.11
Luxembourg	491	2	478	504	**-25**	0.03	0.00
Latvia	485	-9	465	505	**-40**	-0.30	-0.14
Italy	478	-11	466	489	**-23**	-0.14	0.02
Russia	473	-22	460	486	**-25**	-0.25	-0.18
Croatia	473	-12	459	486	**-27**	0.01	0.21
Hungary	472	-10	459	485	**-26**	-0.03	-0.02
Israel	469	-11	459	481	**-22**	0.24	-0.03
Lithuania	467	-15	453	482	**-29**	0.16	0.33
Slovak Republic	463	-7	448	478	**-30**	-0.34	-0.12
Greece	459	-10	444	475	**-31**	0.03	0.18
Chile	457	-3	450	464	**-14**	0.08	0.21
Cyprus[2]	444	-6	424	464	**-40**	0.07	0.10
Bulgaria	444	-10	429	461	**-31**	-0.03	-0.07
Uruguay	443	-6	434	451	**-17**	0.11	0.20
Costa Rica	441	4	437	445	**-7**	0.35	0.34
Thailand	436	2	416	451	**-35**	0.10	0.37
United Arab Emirates	435	-14	416	454	**-38**	0.32	0.45
Mexico	433	-1	426	440	**-14**	0.16	0.23
Colombia	429	-4	425	433	**-8**	0.05	0.23
Turkey	422	-19	411	434	**-23**	0.00	-0.04
Peru	418	2	414	421	**-7**	-0.08	0.09
Montenegro	416	-18	403	429	**-26**	-0.05	-0.09
Brazil	412	-9	402	421	**-18**	-0.04	0.20
Tunisia	382	-18	375	387	**-12**	0.12	0.43
Ireland	m	m	m	m	m	0.03	0.04
Poland	m	m	m	m	m	-0.21	-0.06
Switzerland	m	m	m	m	m	0.19	0.22
Dominican Republic	m	m	m	m	m	0.27	0.51
Qatar	m	m	m	m	m	0.12	0.23

1. Relative scores are the residuals obtained from a pooled linear regression, across all participating countries/economies, of the performance in collaborative problem solving over performance in science, reading and mathematics.

2. 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.

Note: At the country/economy level, differences that are statistically significant are marked in bold (see Annex A3).

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

Source: OECD, PISA 2015 Database, Tables V.3.2, V.3.9a, V.4.3a and V.5.1.

StatLink http://dx.doi.org/10.1787/888933615724

Students who reported more positive relationships with other students score higher in collaborative problem solving.

The relationships that students establish with their schoolmates should be particularly relevant for the type of interpersonal skills evaluated in the collaborative problem-solving assessment. PISA asked students about their sense of belonging at school and about their experiences with bullying, and asked principals about the phenomena that hinder student learning. Students feel mostly positive about their relationships with their schoolmates. On average across OECD countries, about four in five students agreed that they seemed to be liked by other students and make friends easily at school; a slightly larger proportion disagreed that they feel lonely at school (Figure V.7.2). An even greater majority reported that they are never, or almost never, threatened or hit or pushed by other students.

Overall, students who reported more positive student-student interactions score higher in collaborative problem solving (Table V.7.3). On average across OECD countries, students who agreed that other students seem to like them score 9 points higher in collaborative problem solving, after accounting for students' and schools' socio-economic profile. Students also score considerably higher in collaborative problem solving when they reported that they are never, or almost never, threatened (18 points) or hit or pushed (14 points) by other students. In fact, in almost every school system, students who are not threatened by other students score higher in collaborative problem solving.

More positive student-student interactions at the school-level are always associated with better student performance, even those negatively related to collaborative problem solving performance at the student level. For instance, on average across OECD countries, for every 10 percentage-point increase in the number of schoolmates who reported that they are never, or almost never, hit or pushed by other students, student performance in collaborative problem solving increases by 11 score points.

After accounting for student performance in science, reading and mathematics – that is, among students who perform similarly in these core PISA subjects – students score higher in collaborative problem solving when they, or more of their schoolmates, reported that they are never, or almost never, threatened, hit or pushed by other students (Table V.7.4). Students also score higher when more of their schoolmates agreed that other students seem to like them, disagreed that they felt lonely at school, or reported that other students never, or almost never, make fun of them.

Parents' engagement with school, and students' relationships with their parents and teachers are all associated with performance in collaborative problem solving.

On average across the OECD countries that distributed the parent questionnaire, students score higher in collaborative problem solving, after accounting for the socio-economic profile of students and schools, when their parents socialise more with their children's school friends and their parents, and also when they feel comfortable talking to more school staff (Table V.7.13). In addition, students who reported that their teachers say something insulting to them in front of others at least a few times per year score 23 points lower in collaborative problem solving than students who reported that this never, or almost never, happened to them during the previous 12 months (Table V.7.18).

Most associations between the quality of student-teacher relationships and collaborative problem-solving scores disappear once scores in science, reading and mathematics are accounted for (Table V.7.19). This suggests that the quality of student-teacher relationships is as important for learning how to solve problems collaboratively as for acquiring knowledge and skills in science, reading and mathematics. However, when students, or their schoolmates, believe they have been treated unfairly, their relative performance in collaborative problem solving is significantly lower. For instance, in 25 out of 47 education systems, students who reported that their teachers never, or almost never, discipline them more harshly than other students score higher in collaborative problem solving, after accounting for their performance in the core PISA subjects, than students who reported they are disciplined more harshly at least a few times per year (Figure V.7.8).

On average across OECD countries, students score higher in collaborative problem solving when they, their parents, their schoolmates or their schoolmates' parents reported more positive student-parent relationships, after accounting for the socio-economic profile of students and schools (Table V.7.23). For instance, students score 19 points higher in the collaborative problem-solving assessment when they reported that they had talked to their parents after school on the day prior to the PISA test; and on average across the OECD countries that distributed the parent questionnaire, students score five points higher in collaborative problem solving when their parents strongly agreed that they are interested in their child's school activities or encourage them to be confident (Figure V.7.10 and Table V.7.23).

WHAT THE RESULTS MEAN FOR POLICY

Results from the PISA collaborative problem-solving assessment show that a very small proportion (9%) of the differences in students' performance, after accounting for performance in science, reading and mathematics, is observed between schools. This would seem to indicate that no matter which school parents send their children to, their children have the opportunity to develop strong collaboration skills. However, PISA data cannot discern whether this is because schools are more equitable in providing learning opportunities for collaborative skills, or whether collaboration skills are mainly developed outside schools.

Education systems can foster collaboration skills and attitudes in existing subjects or courses, or through new programmes, as Singapore did with its *Project Work* programme. The OECD is collecting information on how collaboration and co-operation are incorporated into school curricula through its *Education 2030* project.

Physical education, for example, is one subject that naturally provides many opportunities to embed collaboration activities and to develop social skills and attitudes towards collaboration. Collaboration is vital to many activities in physical education class, most obviously team sports.

Results also show that exposure to diversity in the classroom is associated with better collaboration skills. Students without an immigrant background perform better in the collaboration-specific aspects of the assessment when they attend schools with a larger proportion of immigrant students. Education systems could investigate whether, in their own context, diversity and students' contact with those who are different from them and who may hold different points of view can aid in developing collaboration skills.

This report also shows that fostering positive relationships at school can benefit students' collaborative problem-solving skills and their attitudes towards collaboration, especially when these relationships involve students directly. Students who establish more positive relationships with peers, teachers and parents tend to score higher in collaborative problem solving, and so do other students in the school. The good news is that most students, teachers and principals report a positive learning environment in their schools. However, too many students report that they feel isolated at school, are bullied repeatedly or are treated unfairly by teachers. Schools can identify those students who are socially isolated, organise social activities to foster constructive relationships and school attachment, provide teacher training on classroom management, and adopt a whole-school approach to prevent and address school bullying. Parents can also make a difference, as collaboration begins at home.

Note

1. Relative collaborative problem-solving performance is calculated by an ordinary least squares regression of collaborative problem-solving performance over performance in science, reading and mathematics. In Chapter 3, the regression is performed at the international level in order to rank countries and economies. In Chapters 4, 5, 6 and 7, the regression is performed at the individual country or economy level, as the focus is on factors related to differences in performance within each country/economy. This results in an average residual of 0 for each country/economy.

Reference

OECD (2014), *PISA 2012 Results: Creative Problem Solving: Students' Skills in Tackling Real-Life Problems (Volume V)*, PISA, OECD Publishing, Paris, http://dx.doi.org/10.1787/9789264208070-en.