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Educational Equity in the Russian Federation: Paper 3: Collaborative Problem Solving Skills

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https://bitbucket.org/zagamog/pisa_paper

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This paper examines the equity in achievement of collaborative problem solving skills (CLPS). CLPS equity in Russia is better than OECD, but mainly because of the relative lack of high performers. Policies to improve levels of CLPS performance will likely not face an equity trade-off. These policies need to revise ICT related pedagogy, emphasize extracurricular activities and continue reducing disparities in infrastructure within federal subjects.

KEYWORDS
Educational Equity, PISA/OECD, Russian Federation, Skills

1 | FORWARD LOOKING CONTEXT: COLLABORATIVE PROBLEM SOLVING SKILLS (CLPS)

This investigation of educational equity in Russia is forward looking. In this paper we focus on Collaborative Problem Solving Skills (CLPS) that are part of the set of 21st century skills. In the Russian Federation as in other countries, policy makers seek to ensure equitable provision of CLPS and other 21st century skills. Other terms for 21st century skills are socio-emotional skills and non-cognitive skills. The report of the International Commission on Education for the Twenty-First Century (1996) also known as the Delors Commission report, elaborated an approach to education which goes beyond the provision of knowledge and individual skills to learners. Many countries have sought to implement policy reforms in line with the recommendations of the Commission. The impact of the Delors report was assessed recently by Tawil and Cougoureux (2013). Increasingly, the equitable provision of quality learning is seen as a key

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to national competitiveness and social goals of prosperity for all, see Kyriakides and Creemers (2018). This paper investigates educational equity in the Russian Federation using data from the PISA CLPS data, which was released in December 2017.

Collaborative Problem Solving Skills are conceptualized by OECD/PISA as a conjoint dimension of collaboration skills and problem-solving skills. In this paper we use the commonly understood term *skills* though some education researchers refer to *competencies* rather than skills. Though the terms are often used interchangeably, competency is a somewhat more elaborate concept as compared to a skill. A skill is something an individual may or may not possess - it denotes the capability of an individual to undertake a certain action, whether physical or mental. A competency involves the decision to deploy the skill and the follow-through to implement that decision, typically in a social context. Possessing a competency thus involves moral or ethical dimensions as well as other considerations regarding motivation and effort. The modern conceptualization of education goes beyond the mere provision of skills with an instrumental purpose such as performing a job. In the Delors perspective, education is meant to equip the whole human being with lifelong learning of multiple competencies. For the sake of simplicity, in this paper we refer to skills. However, it is useful to understand the term *competency* as it is used in the official OECD/PISA definition of Collaborative Problem Solving (CLP):

> *Collaborative problem-solving competency is 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.*
>
> *(Oecd 2017, p.134)*

TABLE 1 Matrix of Collaborative Problem Solving Skills for PISA 2015

	(1) Establishing and maintaining shared understanding	**(2) Taking appropriate action to solve the problem**	**(3) Establishing and maintaining team organization**
(A) Exploring and understanding	Discovering perspectives and abilities of team members	Discovering the type of collaborative interaction to solve the problem, along with goals	Understanding roles to solve the problem
(B) Representing and formulating	Building a shared representation and negotiating the meaning of the problem (common ground)	Identifying and describing tasks to be completed	Describe roles and team organization (communication protocol/rules of engagement)
(C) Planning and executing	Communicating with team members about the actions to be/being performed	Enacting plans	Following rules of engagement, (e.g. prompting other team members to perform their tasks)
(D) Monitoring and reflecting	Monitoring and repairing the shared understanding	Monitoring results of actions and evaluating success in solving the problem	Monitoring, providing feedback and adapting the team organization and roles

Source: Reproduced from (Oecd, 2017, p.137)

The framework for the measurement of CLPS in PISA 2015 is depicted in Table 1. The table indicates twelve measured skills that are the combination between one of three proficiency indicated in columns, and four problem-solving processes, depicted in rows. Each of the twelve elements is mapped to a step in the sequence of computerized assessment of CLPS. The computerized assessment is especially important for the forward looking assessment of equity carried out in this paper. Students who come from privileged backgrounds or higher ends of the socio-economic scale, are likely to have enjoyed better access to digital artifacts from an early age. It is likely that upper income parents may themselves be more educated with digital competencies. Tackling inequity in educational quality may be challenging in traditional, print-based contexts as well as digital ones. However, given the trend towards deepening of digitization in multiple social and economic aspects, issues of inequity just assume greater salience and urgency.

1.1 | Computerized Assessment using Artificial Intelligence (AI) Agents

The use of a computerized assessment for CLPS is more of a technical necessity rather than a policy-driven choice, though policy concerns about digital skills do coincide in this case. It is best to use an example to understand this necessity - consider the case of the first cell A1 from Table 1 "Discovering perspectives and abilities of team members." The ability of a standardized test to measure your ability to discover perspectives and abilities of team members depends greatly on what those perspectives and abilities are, and how willing and able the team members are to allow you to discover them. With different sets of human team members for each tested student, it would be practically impossible to extract the true skill level from the displayed skill level in interaction with others. Computerization takes care of this problem by having each test taker interact with simulated agents whose behavior is pre-programmed and controlled. The PISA 2015 used a visual graphic and text based interaction, but is easy to see how future simulations can become more lifelike. Screen representations of 3-D images of other children are technologically accessible through a web browser - see for example www.mursion.com. Probably sooner than we think, costs of virtual reality and augmented reality will come down drastically. For now, is useful to take a quick look at how text based interaction is used to measure CLPS in PISA 2015.

Annex 1 reproduces screenshots from a sample unit released by OECD/PISA. Assessment takes place through a sequence of tasks organized to form a unit of assessment - the released sample unit is titled 'The Aquarium'. The test taker interacts with one other person, a computerized agent named Abby. The screenshots show how the test taker is introduced to the interface and then provided with the problem statement (see Figure A4) and the time limit to undertake a specific task. Assessment depends on the options chosen by the test taker in response to the context and the prompts from Abby, as can be seen in the successive screenshots. The interface provides the test taker with a set of controls and allows him or her to look at the choices made by Abby. Feedback through an easily accessible interface informs about the progress on the task so the test taker can iterate towards an optimal solution while communicating and taking decisions jointly as a 'team'. Once the entire sequence of tasks that comprises the Aquarium unit is completed, the test taker moves to the next assignment. In the example shown in Figure A8, this is the 'Class Logo' unit, where there are now two agents with whom the test taker interacts[1]

As with other PISA proficiency scores, scores are standardized to an OECD mean of 500 and a standard deviation of 100. Singapore is the highest scoring country with a mean score of 561. Germany is around the middle of the high performing set of countries above the OECD mean. The mean score for the Russian Federation, with the same sample of 15 year old children as for other PISA proficiency measures, was 473, about one-fourth of a standard

[1] This is a quick overview regarding the CLPS assessment by way of introduction to the analysis presented in this paper. Oecd (2017) provides details about the associated literature and fascinating details about the validity, reliability and accuracy of CLPS measurement.

deviation below the OECD mean. Another country with similar performance to the Russian Federation, is Israel, with a mean score of 469. These three countries are used as reference points for comparison in this paper. PISA CLPS scores, like PISA Math, Science and Reading scores for 2015, are presented in sets of ten 'plausible values' for each individual. The PISA CLPS scale is divided into five levels, with descriptions of the meaning of each of these levels in the OECD/PISA documentation. Level 1 is the base level of skill, but a level "Below Level 1" was introduced on account of the presence of test takers who could not reach Level 1. Students at Level 1 can solve simple problems with the help of team members. At the other end of the spectrum, students at Level 4 can solve complex coordination problems and display behaviors such as taking initiative and resolving conflicts.

2 | DISTRIBUTION OF CLPS ACROSS ECONOMIC, SOCIAL AND CULTURAL STATUS (ESCS)

OECD/PISA defines an index of Economic, Social and Cultural Status (ESCS) based on information collected from students regarding parental education, parental occupation, and home possessions including books at home. The variable is calibrated for an OECD mean of zero and standard deviation of 1. We divide the sample into five quintiles according to ESCS for the relevant unit - country or OECD as a whole, with Q1 being the poorest quintile and Q5 being the wealthiest quintile. Table 2 shows the overall distribution of CLPS and its distribution by ESCS quintile. The comparison between results for the Russian Federation and for all of OECD reveals some key facts.

TABLE 2 Distribution of Collaborative Problem Solving Skills

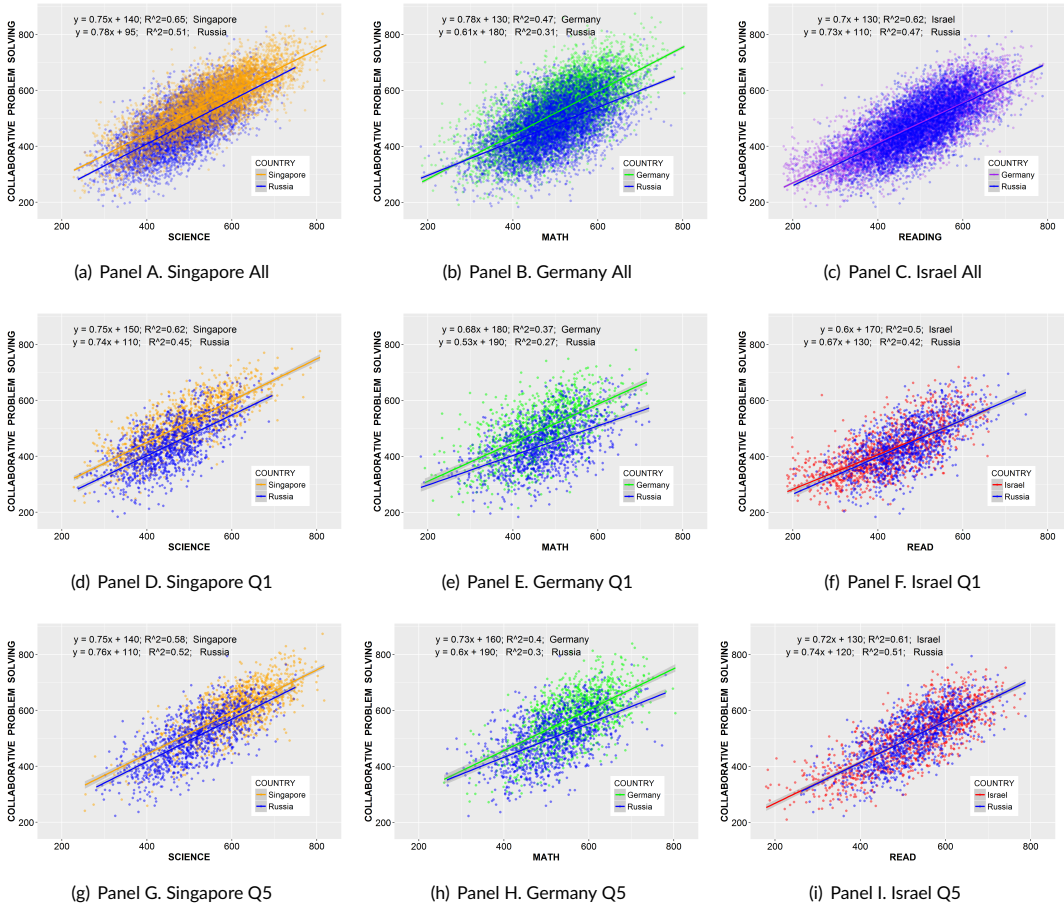
	Below Level 1		Level 1		Level 2		Level 3		Level 4		Mean	
	%	(S.E.)	%	(S.E.)	%	(S.E.)	%	(S.E.)	%	(S.E.)	Mean	(S.D.)
Russian Federation	7.3	(0.7)	29.2	(1.3)	39.6	(1.2)	20.3	(1.2)	3.6	(0.5)	473	(92)
OECD	5.7	(0.1)	22.4	(0.2)	36.2	(0.2)	27.8	(0.2)	7.9	(0.1)	500	(100)
Russia Q1 Poorest	12.4	(1.6)	40.8	(2.0)	34.8	(2.4)	10.9	(1.4)	1.1	(0.4)	437	(86)
OECD Q1 Poorest	11.6	(0.5)	36.1	(0.7)	35.2	(0.5)	14.6	(0.5)	2.6	(0.2)	450	(93)
Russia Q5 Richest	3.3	(1.1)	22.0	(1.7)	38.8	(2.2)	29.2	(2.2)	6.6	(1.3)	504	(93)
OECD Q5 Richest	2.2	(0.4)	11.1	(0.5)	29.3	(0.9)	37.1	(0.8)	20.3	(0.9)	555	(101)

Source: Calculations from OECD/PISA data

Table 2 shows that less than 4% of Russian 15 year olds achieve level 4 of CLPS proficiency, compared to nearly 8% of OECD 15 year olds. 36.5% of Russian students are in the category of Level 1 or below, compared to 28.1% for OECD. This disparity deepens when we look at ESCS quintiles. Thus, more than 53% of Russian students are at Level 1 or below, compared with about 48% for OECD, also a high number and indicative of equity problems in OECD countries. The most striking difference in Table 2 is in the performance of the richest or fifth ESCS quintile. Approximately one-fourth of Q5 students in the Russian Federation are at the lowest levels of performance (Level 1 or below), compared to about 13% for OECD. And while more than 20% of OECD Q5 students attain the highest level 4 of CLPS skills, only 6.6% of Russian Federation Q5 students do so.

The overall conclusion from Table 2 is a common equity problem between OECD and the Russian Federation, with a strong association between the student ESCS level and the CLPS score. Low performance in the highest quintile for

the Russian Federation leads to a less serious equity problem compared to OECD. Few of even the top ESCS quintile children in the Russian Federation attain the top performance level 4 of CLPS. To the extent that the ESCS levels in absolute terms are lower in the Russian Federation, this fact indicates disparities in ESCS rather than disparities in educational performance. But it does indicate a gap which policy makers in the Russian Federation would be keen to overcome, especially as Russian performance on traditional achievement measures in PISA matches OECD levels.



(a) Panel A. Singapore All (b) Panel B. Germany All (c) Panel C. Israel All

(d) Panel D. Singapore Q1 (e) Panel E. Germany Q1 (f) Panel F. Israel Q1

(g) Panel G. Singapore Q5 (h) Panel H. Germany Q5 (i) Panel I. Israel Q5

FIGURE 1 Distribution of CLPS, Science, Math and Reading Proficiency

Figure 1 provides a graphical overview of CLPS proficiency related to proficiency in Science, Math and Reading. As a scatter plot for the entire OECD sample would be too dense, the data for the Russian Federation is compared to Singapore, Germany and Israel. The scatter plots in Figure 1 represent data from individual students. Blue dots represent Russian students, with yellow, green and red chosen for the comparator countries. All graphs show a strong positive correlation between CLPS and the other subjects.

The leftmost panel of Figure 1 shows that children from Singapore outperform Russian children on both Science and CLPS. In the Q1 poorest group the performance gap is apparent for CLPS (vertical axis), but not as much for

Science (horizontal axis). In the Q5 richest group, Singapore students appear to do better on both Science and CLPS. In the middle panel showing comparison with German PISA test takers, the performance difference is seen mainly for CLPS but not for Mathematics - there is no obvious smear of the green dots towards the north-eastern corner of the graph. For the poorest Q1 group there appears to be a performance gap on CLPS but not for Math scores. The rightmost panel shows a comparison with Israel for CLPS and Reading. The overall comparison does not show any pattern, which would be expected given the parity in mean scores between the two countries. There appears to be some benefit for Israeli children from the poorest Q1 quintile. The pattern hinted by the scatter plots in Figure 1 is confirmed by a look at the numbers in Annex Tables A1 through A3 comparing Russia with OECD for Science, Math and Reading.

The annex tables show that contrary to the case of CLPS, Russian Federation does better than OECD in the equity comparison for Science, Math and Reading, is better than that for OECD. Further, the positive relative performance on equity for the Russian Federation comes from better performance of the lower ESCS quintiles. This can be seen clearly in the case of Reading results presented in Table A2. Whereas less than 25% of Russian Q1 children are at Level 1a or below in Reading, the comparable figure for OECD is nearly 38%. The difference is even more pronounced in the case of Mathematics. Russian Q1 students at below level 1 are only 8.9%, compared to 21.4% for OECD. On the positive end of the proficiency scale, 19.1% of Russian Q1 students were top performers, compared to only 9.2% for OECD. Indeed, the mean score for Russian Q1 students is more than half a standard deviation ahead of their OECD counterparts. Typically, half a standard deviation on the PISA scale is regarded to be equivalent of one year of instruction.

The stylized fact motivating this paper appears to be fairly unambiguous: Russia shows better equity as compared to the OECD with regards to the traditional subjects of Science, Mathematics and Reading, as measured in the latest available round of OECD/PISA results. However, for the forward looking collaborative problem solving skills, Russian performance lags behind OECD in levels. Russian equity is slightly better, but only because of the relatively low number of high performers in the Russian Federation. A previously published paper, Kapuza et al. (2017), reporting a World Bank supported research program, has examined the issue of better equity with regard to the traditional subjects.[2]. In this paper, we turn our attention to the equity issues regarding collaborative problem solving skills.

3 | ANALYSIS OF VARIANCE OF CLPS

A basic distributional concern in education concerns the source of variation in performance. From a policy perspective, it is vital to know how much performance is clustered or segmented by region. In a large, federal country like the Russian Federation, it is useful to know how much low performance tends to be focused or clustered in economically backward regions. With significant policy choices available within federal subjects, it is useful to understand how performance varies by federal subject. Schools are of course another critical locus of attention - this is the reason that OECD/PISA always publishes findings regarding the analysis of variance by school - how much of a country's performance variation takes place across schools, and how much variation is within a school. For this kind of analysis, the best data is census level performance data from all schools. In this paper we use PISA data for Russia that was implemented with a stratified sample that covered 42 regions in Russia, that together represent 75% of the population of the Russian Federation (Figure 2). The sample size in each region was not big enough to be representative of the

[2] Another paper in the same World Bank supported series of education equity themed research for the Russian Federation explores the performance of resilient schools - with high proportion of children from lower socio-economic quintiles but which show high performance.

region, so the inference only extends to the schools that were covered in the sample. With a total Russian Federation sample of 6036 students, spread across 42 federal subjects, the average sample for each region was about 140 students, from about 4 to 10 schools in each region. So, definitive estimates for regions cannot be made with the data, but the sample is large enough for informed qualitative inference.

The Russian Federation is distributed into twelve economic regions - these are not legal entities but are contiguous federal subjects grouped together by similar level of economic development and geographical conditions.

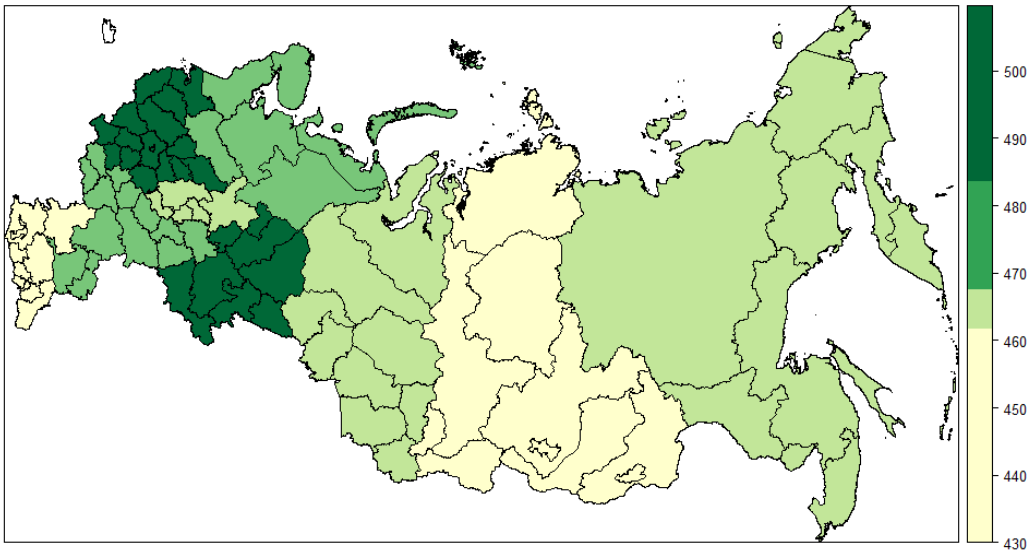


FIGURE 2 PISA CLPS Proficiency by Economic Regions

	All Russia	Central	Central Black Earth	East Siberian	Far Eastern	Northern	North Caucasus	North Western	Volga	Ural	Volga-Vyatka	West Siberian	Kaliningrad
CLPS	473	493	467	453	462	510	430	489	483	484	474	466	467
Science	487	505	494	471	475	513	452	504	490	487	482	497	477
Mathematics	494	507	504	477	485	512	462	511	509	490	493	514	487
Reading	495	512	499	478	482	532	455	508	506	493	499	500	487

TABLE 3 Mean PISA 2015 Scores by Economic Region

Figure 2/Table 3 provide the data regarding the score distribution by economic region. Annex 3 figures provide

the equivalent figures for other PISA 2015 subjects by way of comparison. The table and the maps show that regional differentiation is highest for CLPS, which is part of the motivation for the focus on CLPS in this paper. Northern, North Western and Central regions perform higher than the national average fairly consistently, and Northern region outperforms OECD even for CLPS. However, for subjects other than CLPS the mean scores are higher than OECD in many cases, for example the West Siberian region Mathematics score is the highest ranked among all regions. Performance of North Caucasus region on CLPS is quite low, in national comparison it would be similar to Thailand and Mexico. East Siberia for CLPS also is about one-third standard deviation lower than the OECD mean. Overall, the picture by economic regions appears to be a positive one, the pattern is fairly steady and there is not a sharp contrast between extremely high performing regions and very low performing ones. In connection with broader regional development goals and public policy issues such as inter-regional migration, the relatively mild variation across economic regions makes the policy maker's job to improve equity a little bit easier. We look shortly at the quantitatively measured analysis of variance.

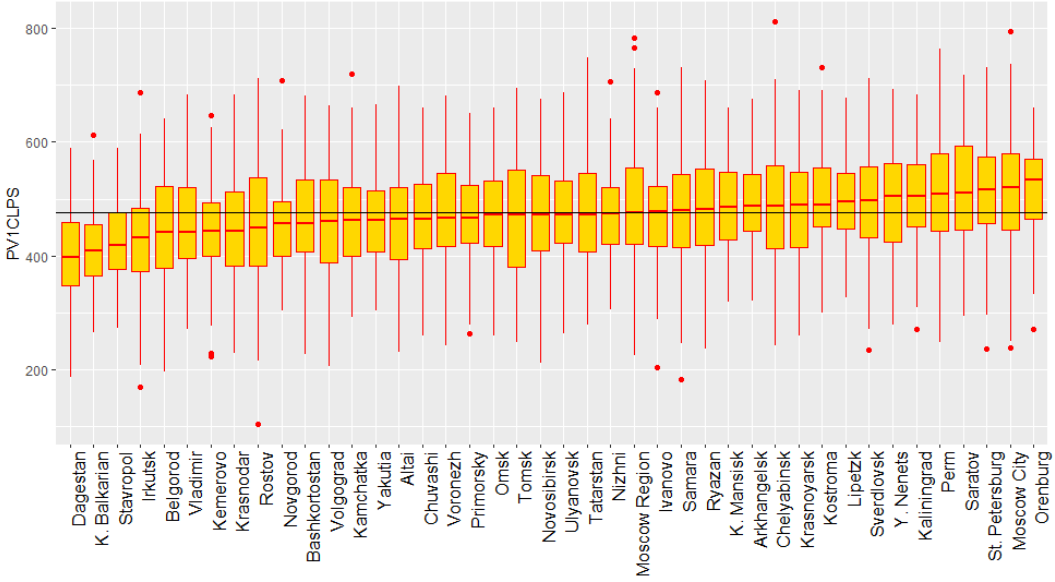


FIGURE 3 PISA CLPS Proficiency by Economic Regions

Figure 3 shows a box plot diagram of CLPS proficiency scores by Federal subject for the 42 federal subjects that are part of the PISA sample. The sample sizes do not allow for inference to be made about specific regions, only qualitative comparisons can be made. Annex 4 presents the equivalent box plots for Science, Math and Reading. Overall, the interpretation of Figure 3 is similar to the one made from Figure 2 for economic regions. There are a few regions where the distribution of scores appears significantly below the national median (shown by the black line at national mean CLPS score of 473), and few regions where the scores are substantially higher. A formal quantitative analysis regarding the pattern of variation is needed to verify the facts hinted by the maps and box plots

We consider the simplest, unconditional, variance components model, depicted in the following equation, where the score of the ith student in the jth school located in the kth federal subject that belongs to the lth economic

region is depicted, where β_0 is the unconditional mean and the other terms are random effects at each level.

$$y_{ijkl} = \beta_0 + \gamma_l + \mu_{kl} + \psi_{jkl} + e_{ijkl}, \tag{1}$$

where:

$\gamma_l \sim \mathcal{N}\left(0, \sigma_e^2\right)$	variance at economic region level
$\mu_{kl} \sim \mathcal{N}\left(0, \sigma_f^2\right)$	variance at federal subject level
$\psi_{jkl} \sim \mathcal{N}\left(0, \sigma_s^2\right)$	variance at school level
$e_{ijkl} \sim \mathcal{N}\left(0, \sigma^2\right)$	variance at individual student level

We estimate the model depicted in Equation 1, for CLPS and the traditional subjects. The purpose of this analysis is to determine the intra-class correlation coefficient (ICC), a point estimate of the variance explained by each level as a percentage of the total variance. The analysis shows that the percentage of variance explained by economic region and federal subject are very small - between 1% to 3%, across all four subjects, with no discernible pattern across the four subjects including CLPS. The percentage variance explained at the school level, after accounting for variation by economic and federal region, for CLPS was 19% and for Science, Mathematics and Reading it varied between 21% and 22%. The CLPS variance explained at the school level (ignoring organization into Economic Region and Federal Subjects) for the Russian Federation as a whole is 21%, slightly lower in magnitude to the 25% average for OECD countries. In previous rounds of PISA the percentage variance explained at school level for the traditionally measured subjects used to be higher, thus indicating a positive trend in the Russian Federation with regard to equity as measured by this variable. High percentage of variation at the school level is an indication of a quality or segmentation difference between schools.

It is useful to dig a bit deeper into the variance pattern by school level. We focus on CLPS, with the note that the pattern is not different for the other subjects. We initially ignore the fact that students belong to schools that are located in Federal Subjects. If we look only at the variation by Federal Subject, the variance explained is about 7%. If we include both Federal Subject and Economic Region, the Federal Subject variance explained drops to 4% and 3% is attributed to the Economic Region. This means that nearly half of the variation in Federal Subjects is because they belong to different Economic Regions. Now if we bring back schools into consideration, the percentage variance explained by Economic Region and Federal Subject together are less than 4%, with schools accounting for 19% of the variance in CLPS scores. We look finally at the variation across Federal Subjects in the percentage variance explained at the school level. Since there are only 4 to 10 schools in the PISA sample for each Federal Subject, inference is limited to the sample of schools drawn and not the entire Federal Subject. Annex Table A4 presents a comparison across the four subjects. In general, there is a consistent pattern, but some of the exceptions might benefit from investigation that requires local data beyond the OECD/PISA data used in this paper.

4 | FULL MODEL: ANALYSIS OF VARIANCE WITH RANDOM EFFECTS MODEL

We utilize a two-level model, with random effects at the school level. Given our interest in equity, we also want to analyze the school level variation of two key variables - ESCS and HOMEPOS. ESCS is the OECD constructed index of Economic, Social and Cultural Status, constructed with an OECD average of zero and OECD level standard deviation of one. We use the same OECD constructed variable, which for the Russian Federation has a mean of 0.05 and standard deviation of 0.73. ESCS is a composite indicator, which combines information about parental education,

parental occupation and home possessions. HOMEPOS is also considered separately, an index (with zero OECD mean and one standard deviation) of home possessions such as cars, televisions, and number of rooms in the home. The mean of HOMEPOS for the Russian Federation sample is -0.36 and the standard deviation is 0.79. The estimated model is represented in the following equation, where the score of the ith student in the jth school is depicted, and β_0 is the unconditional mean.

$$y_{ij} = \alpha_0 + \beta_{0j} + \beta_{1j} X_{ij} \tag{2}$$

$$\beta_{1j} = \gamma_{00} + u_{01j} + \epsilon_{ij}, \tag{3}$$

$$\begin{bmatrix} \gamma_{00} \\ u_{01} \end{bmatrix} \sim N \begin{bmatrix} \sigma^2_{\gamma_{00}} & \\ \sigma_{\gamma_{00} u_{01}} & \sigma^2_{u_{01}} \end{bmatrix}$$

$$\epsilon_{ij} \sim \mathcal{N}\left(0, \sigma^2\right)$$

We include X in the model mostly with fixed coefficients and two with random coefficients (marked in blue text) shown in Table 4 below. This means that we allow for the slope coefficient on these two variables to be different for each school, rather than fixed for the whole sample as for the other variables. We find that of the 21% variance at the school level described in the simple model, about 12% of the variance is explained by the intercept term after 4% for the ESCS and 6% variance from HOMEPOS. This is important from the policy perspective as it indicates the relative homogeneity of schools when it comes to educational inequity.

TABLE 4 Variables for modeling Production of CLPS Score - Russian Federation

Variable	Variable description
Student characteristic and geographical	
Female	Gender of Student - Female is 1
City	City where school located > 100,000 population
Immigrant	Student or Student's parents born in foreign country
GDP_PC	GDP per capita (in PPP USD of 2009 from UNDP 2011 Report
Student home endowment	
ESCS	Economic, Social and Cultural Status Index - OECD/PISA construct
HOMEPOS	Home Possessions Index - OECD/PISA construct
HEDRES	Home Educational Resources Index - OECD/PISA construct
PARENTSC	Percentage parents who participate in various school activities
NBOOKS	Estimated number of books at home
CULTPOSS	Index of Cultural Possessions at home - OECD/PISA construct
School endowment	
EDUSHORT	Index of school infrastructure problem- OECD/PISA construct
STAFFSHORT	Index of teaching staff problem - OECD/PISA construct
STUBEHA	Index of student behavior as a problem - OECD/PISA construct
TEACHBEHA	Index of teacher behavior as a problem - OECD/PISA construct
ECACT	Index of Extra-curricular activities provided at school - Russia
ICT related variables	
ICTRES	Index of ICT Resources at home - OECD/PISA construct
USESCH	Index of ICT Resource use at school - OECD/PISA construct
ENTUSE	Index of ICT use outside of school - OECD/PISA construct
INTICT	Index of student interest in ICT - OECD/PISA construct

Table 5 describes the comparative profile of the lowest performing group for CLPS scores. The numbers are self-explanatory for the most part, and the results do not appear to be dramatically significant from an educational policy perspective - the low performers are more likely to be boys, live in a small town or a rural area, and belong to a federal subject with lower GDP per capita. They are likely to have poorer home endowments such as cultural possessions and number of books.

What is more interesting from Table 5 is to take a note of patterns that are not observed in Table 5. Immigrant status does not appear to matter in determining group membership of the low performance group. This implies that immigrant children in the Russian Federation may not suffer disadvantages in terms of educational opportunities. For the OECD as a whole, being an immigrant implies a 36 point score deficit in the CLPS score. According to the OECD, the equivalent figure for the Russian Federation is a positive 3-point surplus. OECDreports a further analysis of the correlation between CLPS scores and scores in Science, Mathematics and Reading (Oecd, 2017, pages 101-102). They find that when compared to performance in the three traditionally measured subjects, Russian immigrant children actually obtain a nearly 10-point surplus in the CLPS score.

TABLE 5 Profiling Russian Federation Low Achievement Group with others

Variable	All		Q1 Lowest		Q2		Q3		Q4		Q5 Highest	
	Mean	(S.E.)	Mean	(S.E.)	Mean	(S.E.)	Mean	(S.E.)	Mean	(S.E.)	Mean	(S.E)
Female	0.51	(0.01)	0.40	(0.02)	0.46	(0.01)	0.52	(0.02)	0.57	(0.02)	0.59	(0.02)
City	0.51	(0.02)	0.33	(0.03)	0.43	(0.02)	0.50	(0.03)	0.57	(0.03)	0.71	(0.03)
Immigrant	0.16	(0.01)	0.15	(0.01)	0.15	(0.01)	0.15	(0.01)	0.17	(0.01)	0.20	(0.02)
GDP_PC	17,806	(658)	15,629	(596)	16,518	(689)	17,725	(687)	18,232	(704)	21,001	(1105)
ESCS	0.05	(0.02)	-0.25	(0.03)	-0.11	(0.03)	0.08	(0.03)	0.18	(0.02)	0.34	(0.02)
HOMEPOS	-0.36	(0.02)	-0.56	(0.04)	-0.45	(0.03)	-0.32	(0.03)	-0.28	(0.03)	-0.18	(0.02)
HEDRES	0.42	(0.01)	0.17	(0.03)	0.40	(0.03)	0.44	(0.03)	0.53	(0.03)	0.53	(0.02)
PARENTSC	48.66	(1.21)	48.95	(1.68)	48.67	(1.1)	49.27	(1.19)	48.43	(1.36)	47.94	(2.03)
NBOOKS	139.85	(3.02)	103.1	(5.42)	115.26	(4.9)	139.09	(7.49)	151.76	(5.66)	188.5	(4.94)
CULTPOSS	0.34	(0.02)	0.04	(0.03)	0.25	(0.03)	0.39	(0.02)	0.43	(0.02)	0.55	(0.03)
EDUSHORT	0.31	(0.10)	0.50	(0.11)	0.41	(0.1)	0.26	(0.1)	0.23	(0.1)	0.13	(0.16)
STAFFSHORT	0.08	(0.10)	0.20	(0.12)	0.10	(0.12)	0.03	(0.11)	0.05	(0.1)	0.01	(0.13)
STUBEHA	0.70	(0.12)	0.87	(0.12)	0.71	(0.13)	0.58	(0.12)	0.67	(0.12)	0.64	(0.18)
TEACHBEHA	0.27	(0.13)	0.22	(0.17)	0.21	(0.14)	0.20	(0.12)	0.34	(0.14)	0.37	(0.17)
ECACT	-0.03	(0.08)	-0.29	(0.15)	-0.13	(0.1)	0.04	(0.08)	0.04	(0.08)	0.20	(0.09)
ICTRES	-0.33	(0.02)	-0.48	(0.04)	-0.42	(0.03)	-0.32	(0.03)	-0.28	(0.03)	-0.16	(0.03)
USESCH	0.12	(0.03)	0.44	(0.06)	0.29	(0.06)	0.13	(0.05)	-0.01	(0.04)	-0.20	(0.05)
ENTUSE	0.29	(0.02)	0.16	(0.05)	0.31	(0.04)	0.37	(0.06)	0.32	(0.03)	0.26	(0.03)
INTICT	-0.24	(0.02)	-0.40	(0.04)	-0.27	(0.03)	-0.16	(0.03)	-0.18	(0.02)	-0.19	(0.02)

Source: Calculations from OECD/PISA data

Another variable that shows a lack of correlation with membership of the lowest group is PARENTSC - parental participation at school. This variable is derived from principal reports of parental participation at school to discuss their children's progress, to take part in local school government or to volunteer. Higher percentage of parents taking part in school activities would be expected to be related to group membership in Table 5, but one does not find this to be the case. A similar observation about the lack of discriminating power can be made regarding the variable TEACHBEHA. This variable purports to describe problems regarding teacher behavior, such as teacher absenteeism, or the teacher being too strict or not prepared for class.

In Table 6 we present the results of the equation described in Equations 2 and 3 with two of the explanatory variables - ESCS and HOMEPOS modeled with random slopes at the school level. PISA scores are presented at individual level with ten alternative imputations (plausible values) and a methodology that allows to utilize the information contained in all the plausible values simultaneously. Methodology for using all plausible values for ordinary least squares (OLS) is well established in the literature. Methodology for random effects regressions using all plausible values is also available, but the use is not yet established. Here we use an arbitrarily chosen first plausible value as the dependent CLPS score variable, with weights to account for the sampling scheme used in PISA. For comparison, we also present the OLS results using the same weights and all plausible values.

TABLE 6 Random Effects Model Production of CLPS Score - Russian Federation

Variable	Variable description	Random Eff.	S.E	OLS Model	S.E.
Intercept	Constant	434.64	(9.67)	423.69	(10.8)
ESCS	Economic, Social and Cultural Status Index	—	-	24.59	(2.99)
HOMEPOS	Home Possessions Index	—	-	−36.40	(6.21)
FEMALE	Gender of Student - Female is 1	17.99	(2.33)	18.64	(4.23)
CITY	City where school located > 100,000 population	29.32	(5.33)	27.52	(5.47)
IMMIGRANT	Student or Student's parents born in foreign country	3.75	(3.12)	6.71	(5.75)
GDP_PCM	GDP per capita (in PPP USD of 2009)	0.88	(0.35)	0.69	(0.3)
HEDRES	Home Educational Resources Index	4.34	(1.49)	8.18	(3.97)
PARENTSC	Percentage parents who participate	−0.03	(0.14)	−0.10	(0.17)
NBOOKS	Estimated number of books at home	0.04	(0.01)	0.04	(0.01)
CULTPOSS	Index of Cultural Possessions at home	17.11	(1.95)	24.70	(4.32)
EDUSHORT	Index of school infrastructure problem	−7.36	(2.57)	−5.78	(2.25)
STAFFSHORT	Index of teaching staff problem	2.79	(2.82)	2.55	(2.93)
STUBEHA	Index of student behavior as a problem	−2.56	(2.66)	−2.79	(3.09)
TEACHBEHA	Index of teacher behavior as a problem	4.95	(2.33)	4.97	(2.75)
ECACT	Index of Extra-curricular activities	6.18	(2.54)	4.20	(2.98)
ICTRES	Index of ICT Resources at home	1.55	(1.67)	12.58	(3.92)
USESCH	Index of ICT Resource use at school	−11.23	(0.00)	−12.17	(1.99)
ENTUSE	Index of ICT use outside of school	2.39	(1.12)	1.68	(2.08)
INTICT	Index of student interest in ICT	6.82	(1.33)	5.48	(2.78)

With PISA calibrated at mean of 500 and standard deviation of 100, a difference of ten points can serve as a heuristic for economic significance of impact size of a tenth of a standard deviation, though the heteroskedasticity consistent standard errors reported in Table 6 can be used to examine statistical significance. As ESCS and HOMEPOS

(economic and social status and wealth indices) are treated as random effects, they are discussed separately in Figure 4. In the OLS model ESCS has a positive effect and HOMEPOS has a negative effect. We have modeled ESCS and HOMEPOS as random slopes, pertaining to each school in the sample. This allows us to examine for the relationship with equity from the attainment perspective as well as from the economic or livelihood perspective.

FIGURE 4 Random coefficients compared across distribution

Figure 4 presents a panel of three rows of two graphs, with each dot representing a school. The dots vary in size depending on the total enrollment of the school. The topmost row records the random coefficient of the intercept term on the vertical axis, the middle row records the coefficient for ESCS on the vertical axis and the bottom row has the HOMEPOS coefficient on the vertical axis. We computed two variables to give an idea of the respective concentrations of low performers and high performers within a school. On the left hand side, the horizontal axis of the three graphs indicates the percentage of students from the *bottom* national quintile of the respective variable. In the top row, this is the CLPS test score - considering the mean of the ten plausible values to determine group membership. The cut-off to define this level was a CLPS score of 405, about one standard deviation below the OECD mean. On the right hand side, the horizontal axis captures the higher end of the performance spectrum - the proportion of students at the school who were in the topmost CLPS score quintile - high performers beyond a cut-off of 546 points - this is equivalent to third level and higher in the OECD/PISA scale. We also examine the aspect of regional economic disadvantage by looking at the bottom third in terms of per capita regional GDP - in each graph, the colored dots represent schools located in federal districts that are in the bottom third of GDP per capita amongst regions of the Russian Federation.

The top row of Figure 4 depicting the coefficient for the intercept term serves as a benchmark for the other two rows. The top row merely reflects a mathematical artefact. Clearly, the lower the proportion of low performing students in a school, the higher will be the random intercept value - this is because the school with the higher random intercept value has a higher average performance level. Conversely, a school with high percentage of low performers, that is further to the right on the horizontal axis, will have a lower (and in some cases negative valued) intercept term. The top left hand panel shows a negative slope in the scatter plot. Similarly, the top right hand graph shows the mirror image for high performing students. The more there are high performing students within a school, the higher will be the value of the random intercept term for that school. The only diagnostic element in the top panel is shown by the use of color representing regions with low per capita GDP. The graphs in the top row do not show any clustering of colored points. If "geography were destiny" the colored points would have been clustered at the right end of the left hand side graph and the right hand side of the right hand graph. But we do not see such a pattern, which is an important policy consideration in a large federal country like the Russian Federation.

The four other graphs in Figure, showing the value of the random coefficients for ESCS and HOMEPOS are remarkable in the lack of pronounced slope as compared to the benchmark of the first row showing the intercept terms. There is something quite interesting about the comparison between the left panel and right panel for both slope coefficients. On the left hand graphs, notice that there are very few schools in the right hand size of each graph. With few exceptions, there are no school which cluster students from the lower quintile of ESCS and HOMEPOS. On the right hand side, the scatter is evenly spread out along the horizontal axis. For ESCS, with most of the coefficients being positive, this means that having a higher ESCS helps a student obtain a higher score, but that tendency is not much affected by the proportion of either low ESCS student or high ESCS students. For HOMEPOS, the sign of the coefficient is negative for the majority of the schools. More wealth actually implies poorer performance - this finding can be explained, for instance through possible negative effects of wealth on motivation for student effort.

Turning to the results regarding the fixed coefficients from Table 6, we find that the most sizable effects are from gender, with an advantage for girls, the variable for large city location, the index for cultural possessions and the index of ICT resource used at school, though the last variable comes in with a negative coefficient. It is notable to find a negative correlation between use of computers in school and collaborative problem solving skill performance, tested in digital environment as described in the annex to this paper. This might be an indication of inadequacies in the

curriculum or methodology of integration of computers as part of school instruction. The result is positive from an equity viewpoint - the negative association between school resources use and performance means that those who are deprived of greater school use of computers may actually be benefiting from a kind of blessing in disguise. The home use of computers (ICTRES) is uncorrelated with score, but there are positive effects of the use of computers for entertainment purposes, and of the student interest. The findings regarding ICT indicate the need for deeper investigation of this theme, especially as digital skills are considered very important for the future.

An interesting comparison can be made about the coefficients on the variables regarding home endowment (HEDRES, PARENTSC, NBOOKS and CULTPOSS) and the variables regarding school endowment. These are EDUSHORT, STAFFSHORT, STUBEHA, TEACHBEHA, and ECACT. Three of the home endowment variables, typically outside of purview of educational policy have highly unequal distribution (Table 5) and are statistically and economically significant. A fourth variable - PARENTSC is kind of a bridge between home and school and is not significant. From the school endowment variables, we can consider three sets of variables. EDUSHORT, which represents infrastructure quality is a significant predictor of performance. However, STAFFSHORT and STUBEHA are not significant and TEACHBEHA has the 'wrong' sign, meaning the school with greater teacher problems as measured in PISA actually does slightly better in performance. Finally, we find that ECACT, the constructed IRT index of extra-curricular activities at school has a small but positive impact on test score.

5 | CONCLUSIONS AND RECOMMENDATIONS

5.1 | Main Conclusions

1. Collaborative Problem Solving Skills is a new area of educational assessment, measured for the first time in PISA 2015 and results released in December 2017. The achievement level of Russian fifteen year olds on CLPS is lower than the OECD average, whereas for the traditional subjects, the performance equals or even exceeds the OECD average, as is the case for mathematics. This lower level is mainly driven by low performance at the upper end of the distribution - there are relatively few high achievers on CLPS in Russian Federation as compared to the OECD. From a forward-looking national competitiveness perspective, the lower relative performance on CLPS is an issue of concern.
2. In traditional subjects, Russian equity performance is better than OECD because Russian Q1 or poorest students do better than their OECD counterparts in a context where except for Science, Russian performance exceeds the OECD average. However, for CLPS, Russian equity performance is better than OECD for the wrong reason - at the upper end of the distribution, very few of the Q5 richest students attain high performance levels. The problem with CLPS is thus to deal with issue of level as well as distribution.
3. The assessment of CLPS is done through the scoring of decisions made by children in collaborative problem solving scenarios with artificial intelligence agents. They are less stressful than exams which test knowledge, but provide an accurate, reliable and valid estimate of an important 21st century competency. There is a high correlation between performance on CLPS and performance in traditional subjects. It is possible that the kind of CLPS testing that places less burden on the students and is difficult to be gamed through test preparation may show the way for all testing in the future.
4. In spite of the vast geographical distances and differences that characterize the Russian Federation, the difference in student achievement between Economic Regions and Federal Subjects is relatively mild. More careful study with detailed data on expenditures and outcomes by region will be useful, but from the currently available data it

appears that cross regional variation, while important, may not be the critical policy issue as it has been for some other large federal countries.

5. In order to uncover insightful policy analytical findings, it is often productive to make a deeper analysis than is afforded by simple mean comparisons and least squares regressions. While the analysis does require an additional effort from both the research team and the policy audience, there appear to be useful rewards in terms of findings and conclusions. The key conclusions from the random coefficients regression model are: (i) Socio-economic status and wealth are drivers of educational performance in Russia just as in other countries - however, there is evidence that the issue is not a serious or critical policy issue, for instance there appear to be weak clustering effects at work in Russia; (ii) Being an immigrant or from an immigrant group often has a negative consequence on educational performance and consequent negative social and economic effects - but we find a surplus effect for immigrants rather than the large deficit seen for OECD countries as a group; (iii) Very interesting findings about the possible negative effects on performance of ICT at the school level pointing to weaknesses in curriculum and delivery, combined with positive effect of entertainment use such as in the production by children of creative digital products; (iv) Evidence about the equitable nature of parental participation at school - possibly arising from the high level of education of Russian parents and grandparents as compared to the OECD average and (v) There does not appear to be a problem for Russia often seen in some OECD countries the teacher behaviors and the relationship with colleagues on school performance, in Russia it might be the case that a bit of dissent on the part of the teachers may actually be good for student learning!

5.2 | Main Recommendations

1. **Development of testing methodologies for 21st century skills** The Russian Federation should continue to make investments in deepening an already sound commitment to standardized assessment and international comparisons. The CLPS methodology of assessment developed by the OECD holds great promise and its use should be deepened through national and local assessments. With the rich experience now garnered in testing for traditional subjects, policy makers in the Russian Federation should turn their attention to the development of modern testing methods - they may have the benefit of being less intrusive and more accurate to determine skill levels. A sustained research program, with international cooperation and new forms of collaboration between traditional psychometric experts and researchers with deep knowledge of fields such as human computer interface for game design, may prove to be very productive.
2. **Equity in infrastructure provision across and within regions** Differences in educational infrastructure drive performance - especially in a high performance education system with well qualified teachers and an educated parent population. Investments in aspects such as the attention to lighting and temperature control recently uncovered in other research has relevance to educational equity. While differences between regions are not insignificant, more equitable educational infrastructure within regions is likely to yield benefits down the road.
3. **Engagement of Teacher Community in Education Reform** Teacher performance problems and discipline related issues may not be key issues for the Russian Federation. Rather, policy should be directed at re-examining a possibly rigid curriculum and methodology and the effect that has on teacher motivation. Teachers who have their own views and are possibly assertive about them may bring about a much needed diversity of thought with regard to the learning experience for the child. Parents may be allies in this regard, as parent across the socio-economic spectrum appear to be actively engaged in their children's education.
4. **ICT reform in curriculum and provision** There needs to be a detailed review and reform in the way that ICT related

literacies are imparted across educational levels, starting from Pre-School and going all the way through college and university With the digital economy assuming a very salient position in Russia's development strategy, the key input of skilled human resources requires close study. Children are often highly motivated to use ICT in new ways such as uploading and sharing creative content and the education system needs to catch up with such uses to be effective. The World Bank is actively engaged on this front with a report soon to be released about children learning coding around the world and in Russia.

5. **Equity within school and extra-curricular activities** With the lack of high level of segregation across schools, policy effort needs to be directed to address equity within schools. In particular, the performance impact of assigning high performing or perceived high performing children in certain sections may be to their detriment as well as to other students. High performers can be challenged within group and project activities that are at the center of modern pedagogy. The lack of equitable access to extra-curricular activities within and outside of school hours needs to be addressed. This topic is another one for which the World Bank is engaging with partners in the Russian Federation.

References

International Commission on Education for the Twenty-First Century (1996) *Learning, the Treasure Within: Report to UNESCO of the International Commission on Education for the Twenty-first Century: Highlights*. Unesco Pub.

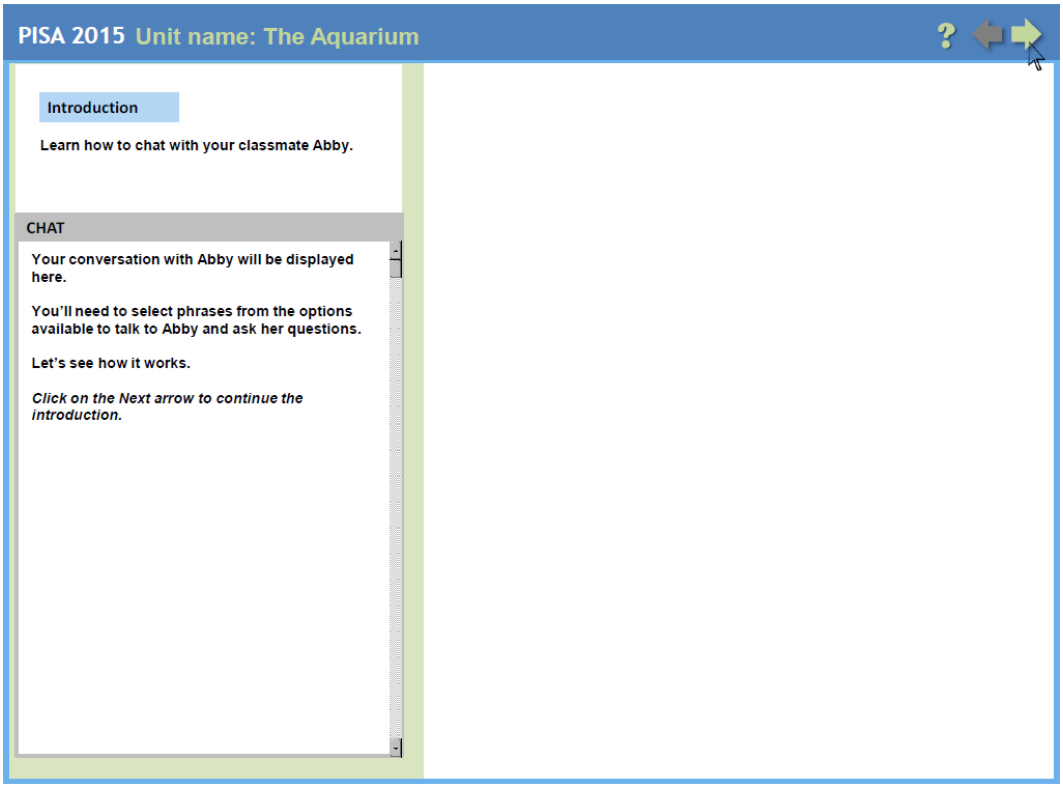
Kapuza, A., Kersha, Y., Zakharov, A. and Khavenson, T. (2017) Educational attainment and social inequality in russia: Dynamics and correlations with education policies. *Educational Studies Moscow*, 10–35. URL: `https://vo.hse.ru/en/2017--4/213247668.html`.

Kyriakides, L. and Creemers, B. P. (2018) Investigating the quality and equity dimensions of educational effectiveness. *Studies in Educational Evaluation*, **57**, 1 – 5. URL: `http://www.sciencedirect.com/science/article/pii/S0191491X17303231`. Research on Equity in Education: Implications for School Evaluation.

Oecd (2017) PISA 2015 Results (Volume V): Collaborative Problem Solving. URL: `http://dx.doi.org/10.1787/9789264285521-en`.

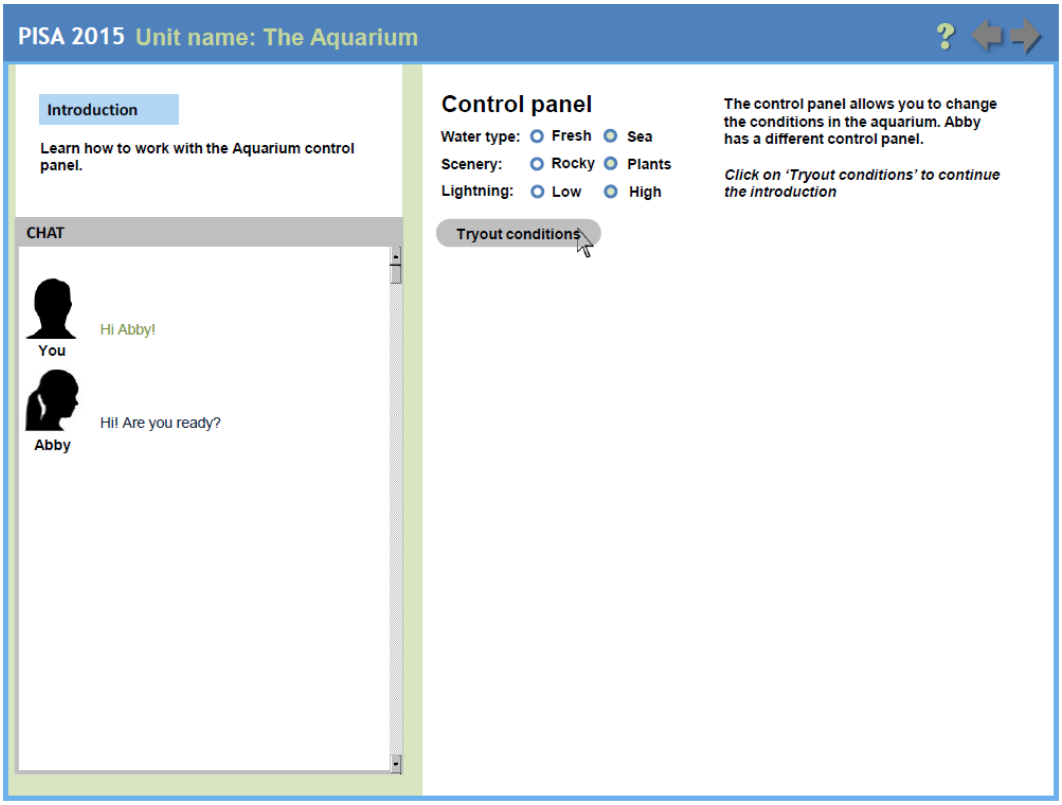
Tawil, S. and Cougoureux, M. (2013) *Revisiting Learning: The Treasure Within–N 4–Assessing the impact of the 1996 'Delors Report'*. UNESCO.

A | ANNEX 1



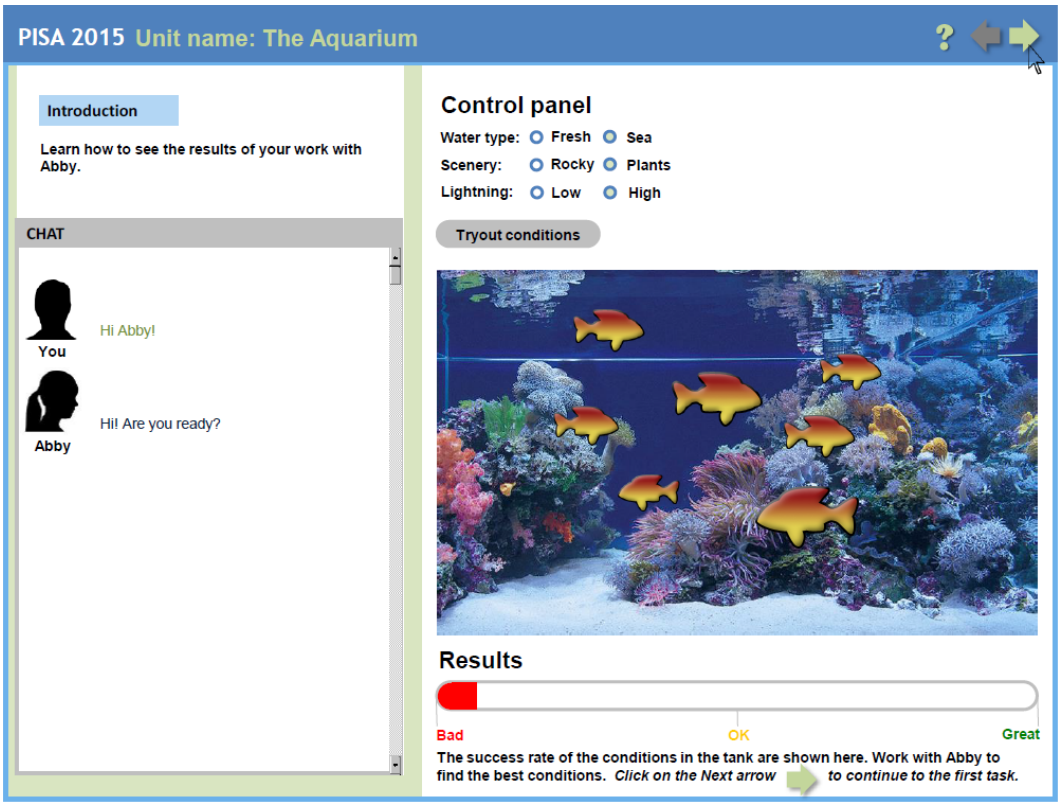
Source: OECD 2017b

FIGURE A.1 Sample unit The Aquarium: Introduction



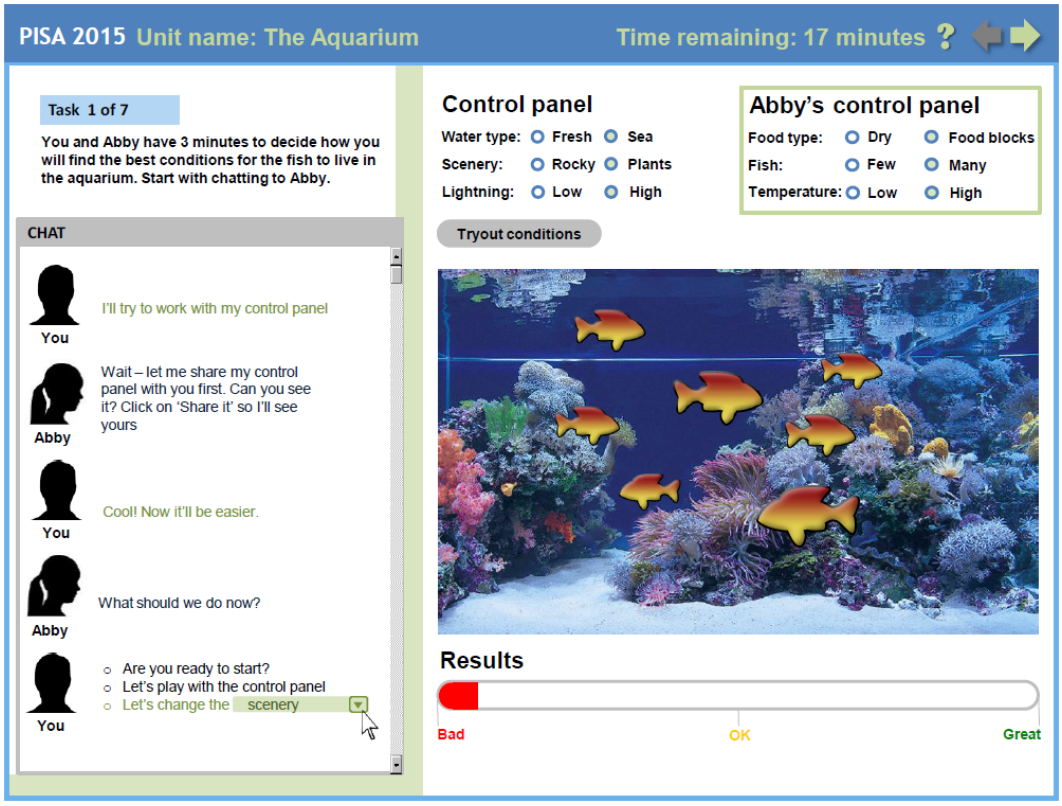
Source: OECD 2017b

FIGURE A.2 Sample unit The Aquarium



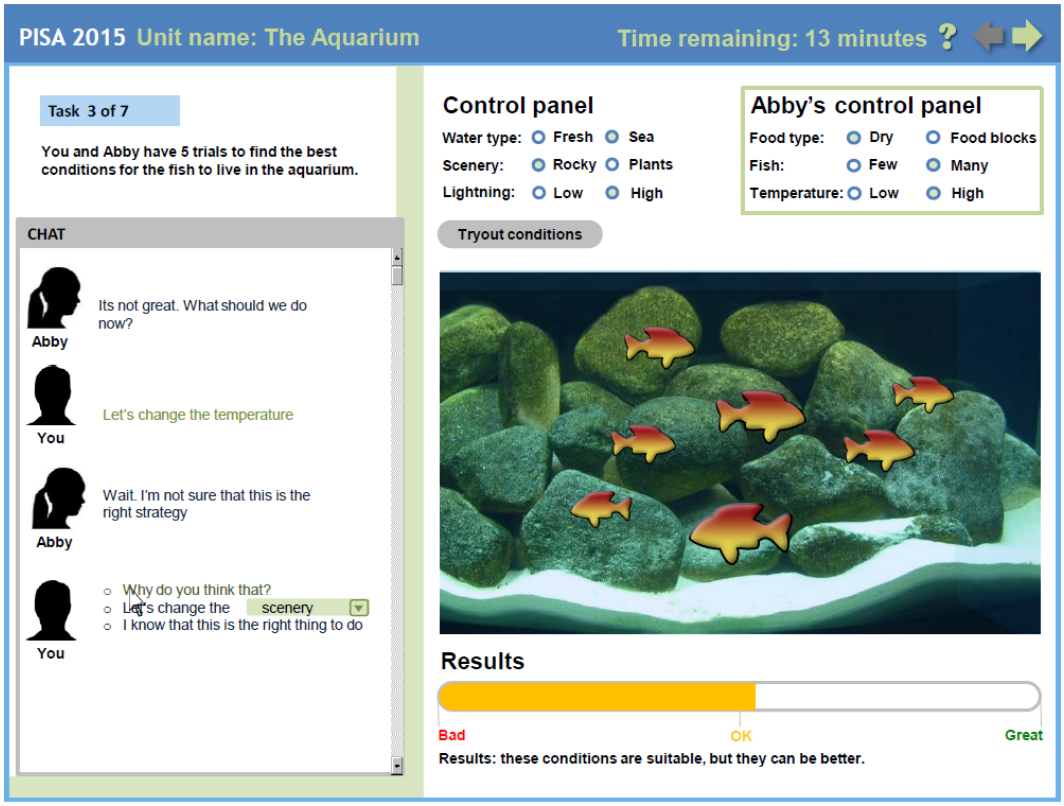
Source: OECD 2017b

FIGURE A.3 Sample unit The Aquarium



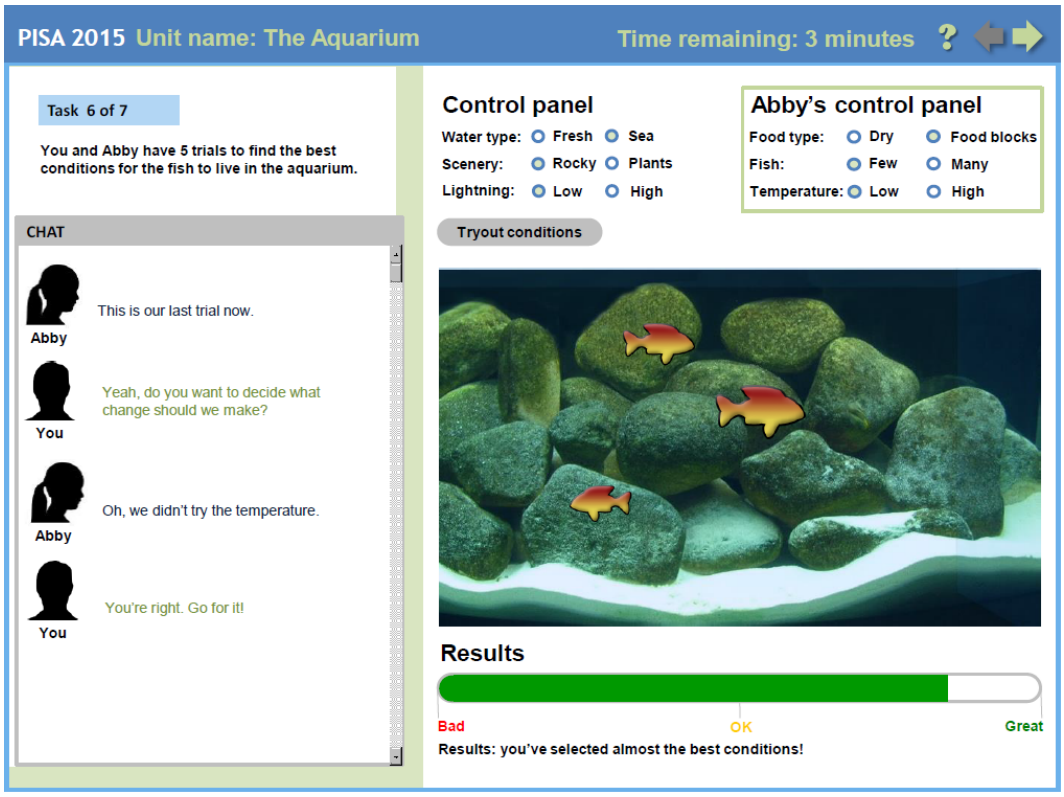
Source: OECD 2017b

FIGURE A.4 Sample unit The Aquarium



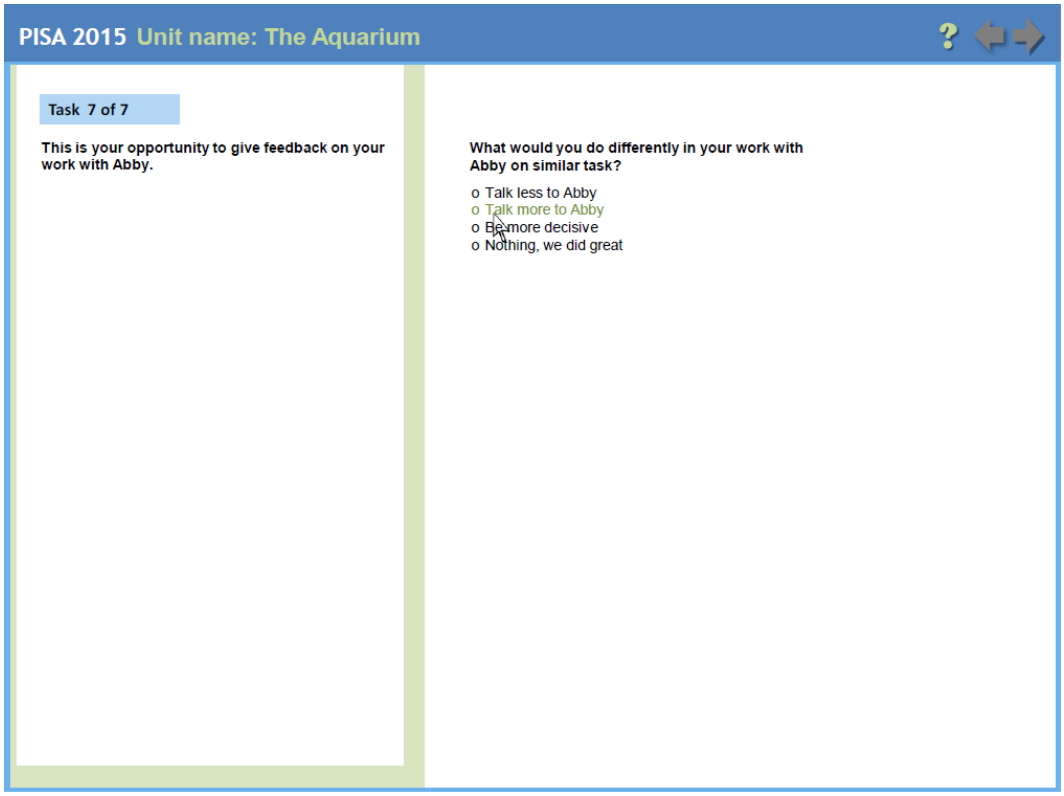
Source: OECD 2017b

FIGURE A.5 Sample unit The Aquarium



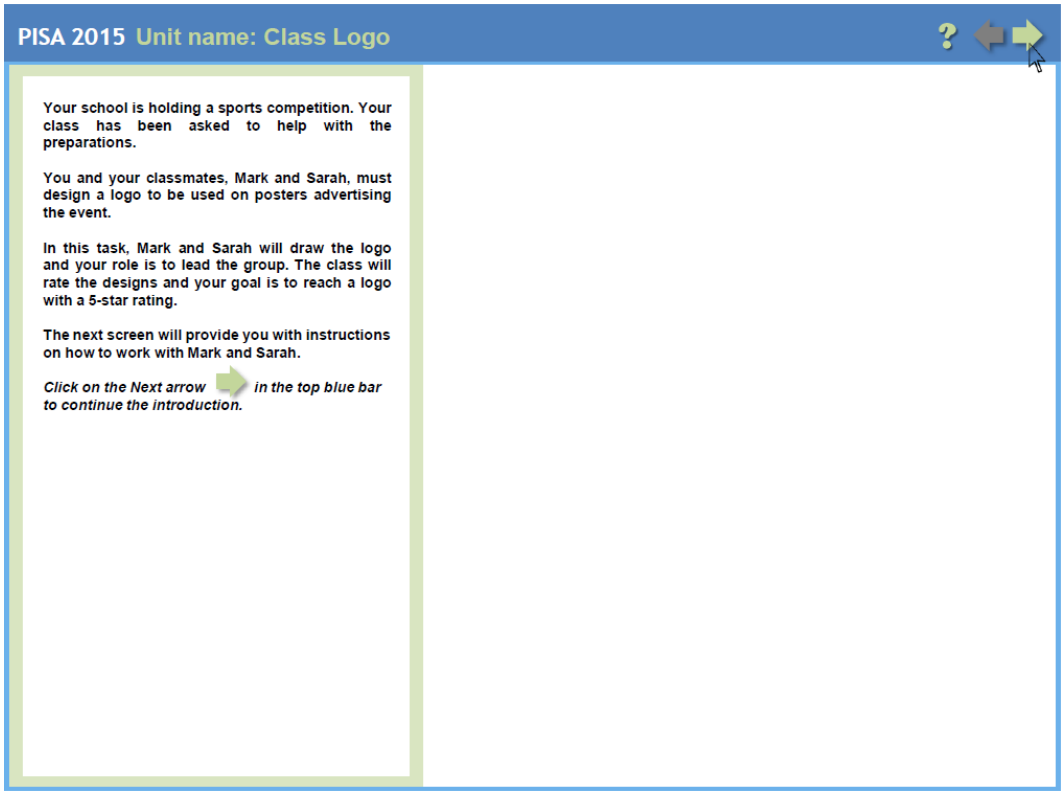
Source: OECD 2017b

FIGURE A.6 Sample unit The Aquarium



Source: OECD 2017b

FIGURE A.7 Sample unit The Aquarium



Source: OECD 2017b

FIGURE A.8 Sample unit Class Logo : Introduction to next sequence

B | ANNEX 2

TABLE A1 Distribution of Science Proficiency

	Below Level 1a		Level 1a		Level 2		Level 3		Level 4 +		Mean	
	%	(S.E.)	%	(S.E.)	%	(S.E.)	%	(S.E.)	%	(S.E.)	Mean	(S.D.)
Russian Federation	3.1	(0.4)	15.3	(1.0)	31.0	(0.8)	30.9	(0.9)	19.8	(1.0)	487	(82)
OECD	6.0	(0.2)	17.5	(0.3)	25.5	(0.3)	25.6	(0.3)	25.5	(0.4)	493	(100)
Russia Q1 Poorest	5.1	(1.1)	22.5	(2.1)	37.0	(2.3)	25.3	(2.8)	10.0	(1.5)	456	(76)
OECD Q1 Poorest	11.6	(0.4)	29.5	(0.5)	30.9	(0.5)	19.2	(0.6)	8.9	(0.4)	435	(86)
Russia Q5 Richest	1.8	(0.6)	10.5	(1.3)	24.6	(1.6)	31.3	(1.9)	31.9	(2.0)	515	(86)
OECD Q5 Richest	1.4	(0.4)	6.5	(0.4)	16.1	(0.4)	27.8	(0.4)	48.2	(0.4)	549	(93)

Source: Calculations from OECD/PISA data; Level 4 + denotes Levels 4 and higher

TABLE A2 Distribution of Reading Proficiency

	Below Level 1a		Level 1a		Level 2		Level 3		Level 4 +		Mean	
	%	(S.E.)	%	(S.E.)	%	(S.E.)	%	(S.E.)	%	(S.E.)	Mean	(S.D.)
Russian Federation	3.5	(0.5)	12.7	(1.1)	27.3	(1.0)	30.7	(1.0)	25.8	(1.3)	495	(87)
OECD	7.0	(0.2)	14.9	(0.3)	24.1	(0.4)	26.9	(0.3)	27.0	(0.5)	493	(100)
Russia Q1 Poorest	5.7	(0.8)	18.8	(1.7)	34.3	(1.9)	26.8	(2.2)	14.4	(1.8)	463	(82)
OECD Q1 Poorest	12.8	(0.5)	25.0	(0.5)	30.6	(0.7)	21.4	(0.6)	10.3	(0.5)	437	(90)
Russia Q5 Richest	2.1	(0.6)	8.5	(1.2)	21.2	(1.5)	29.5	(2.1)	38.8	(2.3)	524	(91)
OECD Q5 Richest	1.8	(0.2)	6.0	(0.4)	15.1	(0.7)	28.0	(0.8)	49.1	(1.0)	544	(91)

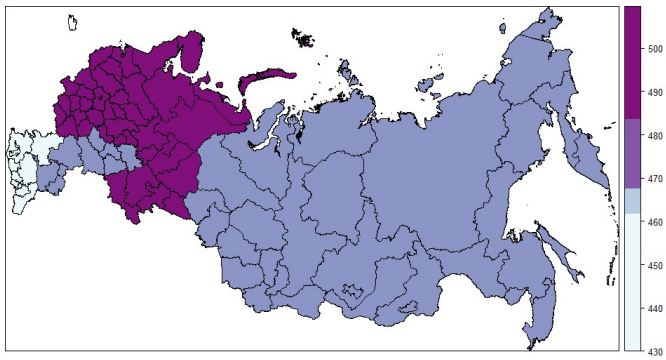
Source: Calculations from OECD/PISA data; Level 4 + denotes Levels 4 and higher

TABLE A3 Distribution of Mathematics Proficiency

	Below Level 1		Level 1		Level 2		Level 3		Level 4 +		Mean	
	%	(S.E.)	%	(S.E.)	%	(S.E.)	%	(S.E.)	%	(S.E.)	Mean	(S.D.)
Russian Federation	5.2	(0.7)	13.6	(0.8)	25.4	(0.9)	27.4	(0.9)	28.3	(1.4)	494	(83)
OECD	10.9	(0.3)	17.4	(0.3)	23.4	(0.3)	23.0	(0.3)	25.3	(0.4)	490	(100)
Russia Q1 Poorest	8.9	(1.2)	17.1	(1.6)	29.8	(1.5)	25.1	(1.7)	19.1	(2.0)	470	(81)
OECD Q1 Poorest	21.4	(0.6)	27.0	(0.5)	26.0	(0.5)	16.4	(0.5)	9.2	(0.4)	427	(85)
Russia Q5 Richest	2.9	(0.9)	9.8	(1.4)	21.6	(1.7)	26.9	(1.8)	38.8	(2.1)	518	(84)
OECD Q5 Richest	2.7	(0.3)	7.6	(0.4)	17.1	(0.6)	26.3	(0.7)	46.3	(0.9)	532	(86)

Source: Calculations from OECD/PISA data; Level 4 + denotes Levels 4 and higher

C | ANNEX 3

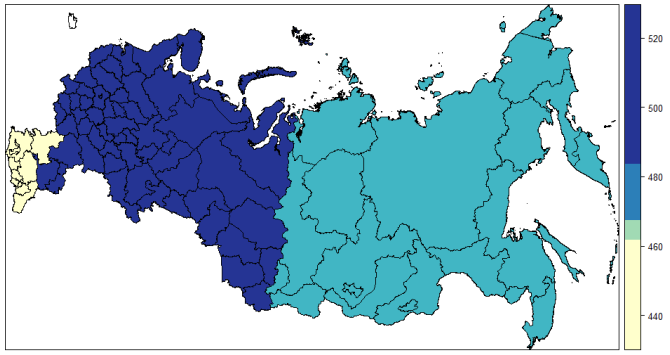


Source: OECD/PISA

FIGURE A9 PISA 2015 SCIENCE Proficiency by Economic Region

Source: OECD/PISA

FIGURE A10 PISA 2015 MATH Proficiency by Economic Region



Source: OECD/PISA

FIGURE A11 PISA 2015 READING Proficiency by Economic Region

D | ANNEX 4

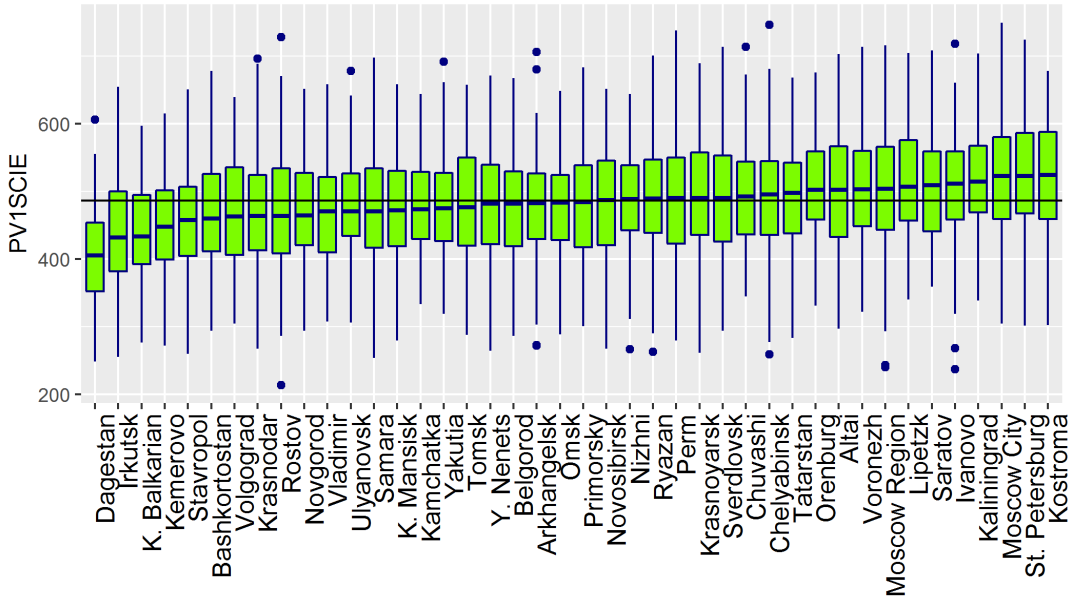


FIGURE A12 PISA 2015 SCIENCE Proficiency by Federal Subject

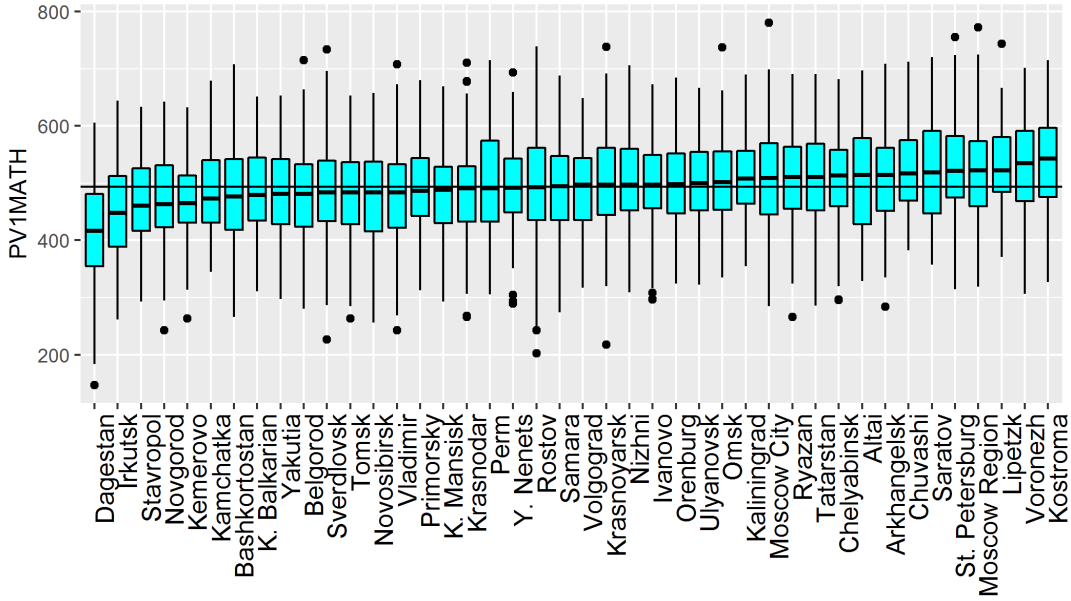


FIGURE A13 PISA 2015 SCIENCE Proficiency by Federal Subject

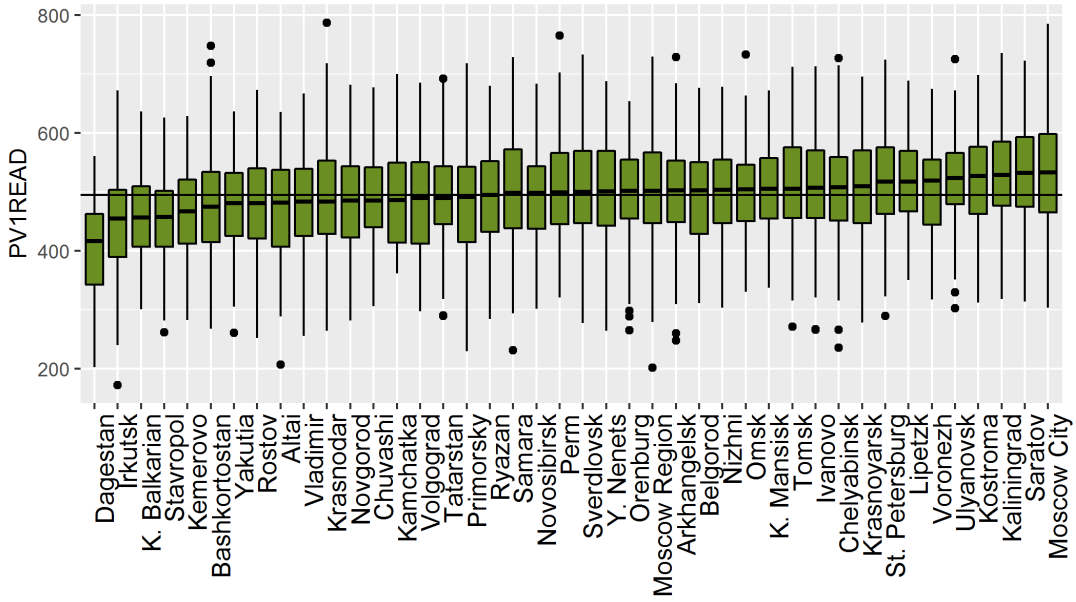


FIGURE A14 PISA 2015 MATH Proficiency by Federal Subject

Federal Subject	School n	Student n	CLPS	SCIENCE	MATH	READING
Ivanovo Oblast	4	154	0	2	0	1
Irkutsk Oblast	6	175	0	3	8	0
Lipetsk Oblast	4	86	0	2	10	0
Nizhny Novgorod Oblast	6	169	0	11	19	8
Orenburg Oblast	4	86	0	5	11	6
Ulyanovsk Oblast	4	116	0	0	12	3
Stavropol Krai	4	130	1	12	21	0
Kemerovo Oblast	4	103	1	0	0	0
Khanty-Mansi Autonomous Okrug - Yugra	4	119	1	1	2	3
Republic of Dagestan	6	135	2	18	21	19
Chuvash Republic	4	93	4	0	0	4
Ryazan Oblast	4	113	4	3	0	14
Arkhangelsk Oblast	4	129	5	5	1	7
Omsk Oblast	4	120	5	4	5	0
Kaliningrad Oblast	4	150	6	8	2	6
Kamchatka Krai	4	109	6	1	0	2
Kabardino-Balkar Republic	4	111	7	31	34	21
Primorsky Krai	4	123	7	19	14	29
Kostroma Oblast	4	115	7	11	14	18
Republic of Bashkortostan	7	183	10	10	17	21
Sakha Republic - Yakutia	4	96	10	27	24	17
Vladimir Oblast	4	142	10	11	16	4
Novgorod Oblast	4	89	10	0	0	11
The City of Moscow	10	373	10	7	11	6
Volgograd Oblast	4	103	12	10	6	15
Samara Oblast	6	191	12	11	10	12
Perm Krai	6	189	15	17	25	14
St. Petersburg	7	245	16	18	14	14
Yamalo-Nenets Autonomous Okrug	4	90	17	24	6	25
Belgorod Oblast	4	120	18	8	6	10
Tomsk Oblast	4	79	18	5	2	13
Moscow Oblast	8	286	21	13	11	9
Republic of Tatarstan	7	129	22	23	30	27
Altai Krai	4	98	22	34	34	25
Sverdlovsk Oblast	7	232	24	18	14	24
Krasnodar Krai	7	173	27	14	20	18
Krasnoyarsk Krai	6	168	27	21	15	28
Voronezh Oblast	4	81	30	47	50	43
Novosibirsk Oblast	4	112	32	31	28	21
Saratov Oblast	4	109	36	18	13	17