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New Skills for New Century:
Regional policy

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New Skills for a New Century: Informing Regional Policy

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Acknowledgments

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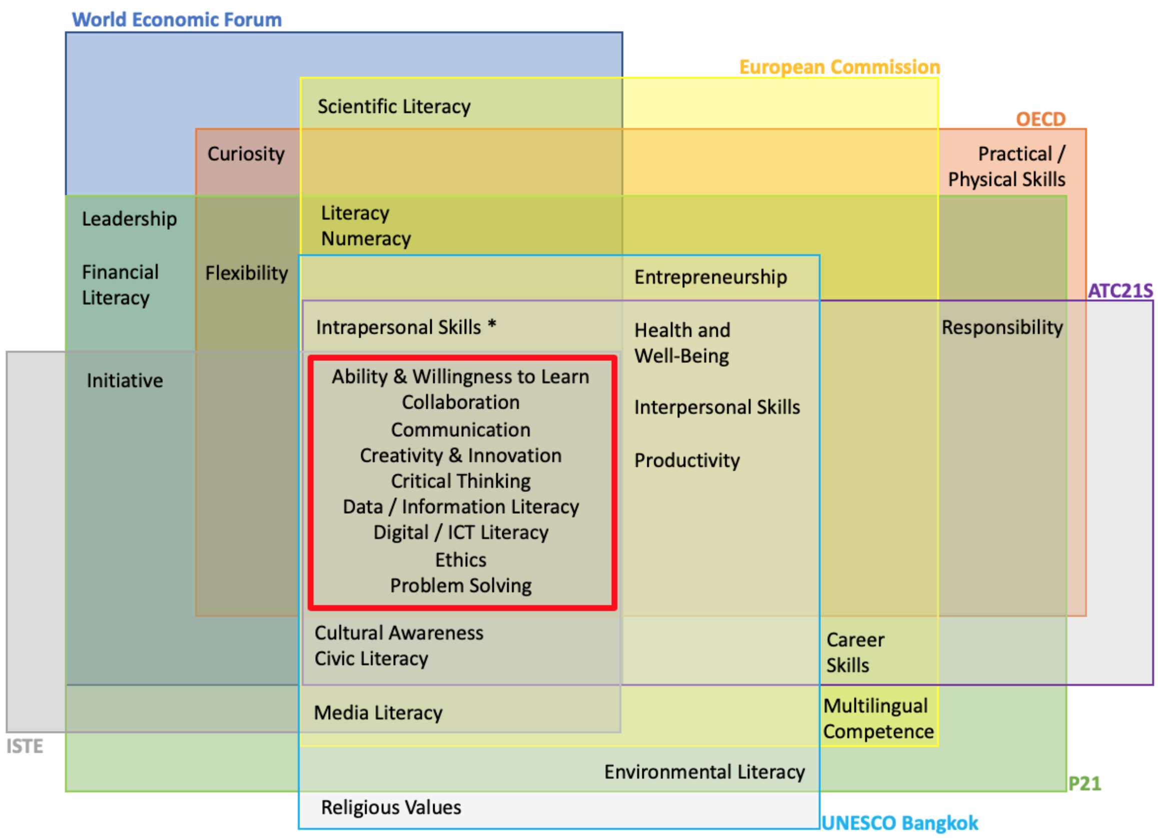
Executive summary

Countries and development organizations around the world are focusing their efforts on adapting existing education systems to meet evolving labor market needs. There is a common understanding that traditional schools are able to equip students with foundational academic skills but need to do more to help them excel in life. In the World Development Report 2018: Learning to Realize Education's Promise, the World Bank suggested a framework where a combination of cognitive, socio-emotional, and technical skills were the most relevant skills that education system should develop in students. In this report, we suggest using the term 21st-century skills to represent the combination of skills, knowledge, and expertise that students must master to succeed in life and work, given the rapidly changing demands of the 21st century. The report explores how these skills are defined in different international institutional frameworks and identifies the nine core skills that are mentioned in all of the frameworks, which we attempt to investigate in depth in this research.

Twenty-first Century Skills as Defined in International Frameworks



* Intrapersonal skills include self-awareness, self-management, self-direction, self-efficacy, self-regulation, self-discipline, self-motivation, and persistence.

According to the literature, learning 21st- century skills is critical to ensure students' future employment and success in their careers.[1/2] Studies in Russia have confirmed that having access to workers with these skills is also critical for the success, growth, and productivity of businesses.

[1] https://doi.org/10.3102/0013189X19890600

[2] https://link.springer.com/chapter/10.1007/978-981-15-7018-6_7

Although Russia has a well-performing and efficient mass education system, Russian education policy is not yet focused on developing 21st-century skills. Although the international data suggest that the performance of Russian students in terms of collaborative problem-solving skills is below the OECD average, existing policies do not pay enough attention to enabling them to develop this kind of skill. However, the findings of World Bank team studies on education equity[3], extracurricular education[4], and learning environments[5] showed that the existing system might improve teaching and learning if it encompassed the building of 21st-century skills. When we examined the definition of these skills in the various existing international institutional frameworks, we found nine aspects that were common to them all: the ability and willingness to learn, collaboration, communication, creativity and innovation, critical thinking, data/information literacy, digital/ICT literacy, ethics, and problem-solving.

This study used the data of Trends in Mathematics and Science Study (TIMSS), Information and Communication literacy (IC literacy), and School User Survey (SUS) studies combined with the qualitative data derived from teacher interviews. The team analyzed the collected data using comprehensive statistical methodologies to seek to find answers to the following questions:

- How does the teaching and learning in Russian schools relate to the learning outcomes of students in both content and cognitive TIMSS domains as well as in terms of information and communication literacy?
- If teaching and learning practices are adapted to stimulate problem-solving, decision-making, critical thinking, communication and collaboration, and project work, will there be any spillover effects on the subject and cognitive domains of TIMSS?
- What physical and non-physical characteristics of the learning environment in Russian schools affect student learning outcomes?
- What support do Russian teachers need to practice diverse teaching and learning methods in their work?

The report confirms that the way in which the teaching is delivered, the physical characteristics of the learning environment, and the school's psychological climate all affect how well students learn. The study identified new aspects of how teaching style impacts the development of 21st-entury and digital skills as follows:

- **Teaching, learning, and student performance.** The study shows that most Russian teachers use the direct instruction style. Modern teaching practices, such as team teaching and group work, are also used in Russian schools too but have not been widely adopted. The results of the OECD's School User Survey (SUS) suggest that there is a potential to increase the application of modern teaching methods in Russian schools by providing the necessary resources and creating the appropriate learning environments for conducting such lessons. To find out more, the team created a learning environment index to look at the connection between teaching styles and test scores of Russian students on the cognitive domains in the Trends in International Mathematics and Science Study (TIMSS). The students in schools where teachers practice modern learning styles scored up to 30 test

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[3] Shmis, T; Parandekar, S. 2018. Education Equity in the Russian Federation: Summary Report (English). Washington, D.C.: World Bank Group. http://documents.worldbank.org/curated/en/139291530189329351/Education-Equity-in-the-Russian-Federation-Summary-Report

[4] Russian Federation - Doing Extra-Curricular Education: Blending Traditional and Digital Activities for Equitable Learning (English). Washington, D.C.: World Bank Group. http://documents.worldbank.org/curated/en/341991561976813788/Russian-Federation-Doing-Extra-Curricular-Education-Blending-Traditional-and-Digital-Activities-for-Equitable-Learning

[5] Shmis, T; Ustinova, M; Chugunov, D. 2020. Learning Environments and Learning Achievement in the Russian Federation: How School Infrastructure and Climate Affect Student Success. International Development in Focus; Washington, DC: World Bank. https://openknowledge.worldbank.org/handle/10986/32598 License: CC BY 3.0 IGO

points higher than their peers in schools where teachers use traditional teaching methods most of the time. We concluded that both modern and traditional educational models are conducive to improving students' grades not only in math and science but also in applying and reasoning in math and science. The findings also indicated that aspects of the built environment, including both the quality of the furniture and the use of technology in the classroom, also improve the academic achievement scores of students who are taught using a modern teaching style.

- **Twenty-first skills and cognitive achievement.** The team hypothesized that teaching and learning that stimulates socio-emotional and higher-order cognitive skills would produce better scores in the subject domains of TIMSS 2019 and in the cognitive domains of "reasoning" and "applying." The team found that, in the case of all skills except communication and collaboration, if teachers fostered them often enough, this had a strong and positive impact on students' subject and cognitive scores. The effect was more substantial when we focused on students in the bottom 40 of the socioeconomic distribution.
- **The use of the school environment by teachers and students and its impact on learning.** According to the TIMSS/SUS data, most Russian teachers use only the classroom for teaching. In contrast, the students use classrooms in combination with the canteen and the school's corridors for their learning activities. In modern schools where the teachers practice group work and team teaching, students and teachers use the common space for group work and classroom with direct access to other rooms slightly more often than in traditional schools. While the teachers confirmed that they were able to re-arrange the furniture to accommodate different learning parameters, they did not find it easy to move the technology equipment. The data suggest that the existence of this equipment varies among schools and that its use still lags behind its availability.
- **The importance of physical characteristics such as air quality, temperature, visual clarity, and auditory comfort** The perceptions of students and teachers of air, temperature, visual, and auditory comfort remain important and reconfirm the pilot TIMSS/SUS 2019 study, while students reported dissatisfaction more often than teachers. The team created a physical environment index based on 21 variables of physical infrastructure from the OECD's School User Survey (SUS), including temperature inside the classroom when it is cold/hot outside, visual and acoustic comfort, noisiness, smell, and the comfort of desks and chairs. The results of the regression analysis confirmed the strong positive relationship between a comfortable physical environment and student test scores.
- **School environment and climate.** A positive and supportive atmosphere in schools is important for children's learning. To assess the quality of schools' psychological environment, the team created a school environment index and a bullying index based on the TIMSS student's questionnaire. The analysis showed that students' perceptions of their safety in school and their scores in math, applying, and reasoning are related. The less students are bullied, the better their learning outcomes are. Bullying was experienced more frequently by students from lower socioeconomic households. The difference in math and science scores between students who are bullied and those who are not can be as great as the equivalent of one year of schooling. Preventing bullying can solve many problems faced by education systems, and it is important to target anti-bullying efforts to students from the bottom 20 percent of the socioeconomic distribution.
- **ICT in schools and information and communication literacy.** The application of ICT by teachers in their day-to-day teaching practice is one of the predictors of their students' information and communication literacy. The information provided by teachers in the School User Survey study showed that students' most common ICT-related activity is homework, which is mainly unrelated to teachers. Activities such as collaborations with other students or online research were rarely reported. The most commonly mentioned activities were watching the videos, preparing presentations, creative expression, and assessing and practicing skills. According to the students' self-assessments of their IC literacy skills, most are proficient in all activities, from finding the information that they need, to creating texts and presentations, to keeping the computer safe from viruses. It is

not confirmed by the actual test though, as most of the students in the sample do not reach high level proficiency in IC literacy. More students with a low level of IC literacy never use the computer or other devices during their leisure time. However, there is no correlation between the socioeconomic status of students and their ICT literacy level. These findings show that there is scope for increasing students' ICT literacy.

- **Qualitative perspective of modern teaching and learning in Russia and the impact of the COVID-19 pandemic.** To understand the practices that teachers use in Russian schools, the team conducted interviews with selected teachers who had been identified as practicing modern methods in the OECD's SUS study. According to these interviews, it became clear that team teaching happens in some schools but only once or twice a year and mostly during extracurricular activities. Usually, the team is a combination of teachers of science, and/or math, and/or foreign languages (English or French). Making team teaching a more common school practice requires advanced planning and cooperation between teachers and the principal. Group work is often used in daily teaching but requires light and flexible furniture to easily adjust the classroom or other learning environments to the group format. The current COVID-19 safety measures in Russian schools are decreasing the possibility of circulating throughout the school space and of working in groups, which means that learning losses are continuing despite the return of students back to schools.

The analysis in this report shows that schools in Russia could do more to help students excel. Most of our findings point to actions that are implementable and can improve teaching and learning practices and outcomes in Russian schools, in such areas as the curriculum framework, teacher training, and the promotion of a culture of collaboration between teachers. .

The recommendations discussed in the report are as follows:

- High-quality teaching can be delivered using both traditional and modern styles. The effectiveness of each will depend on the specific school context.
- Modern teaching practices can be supported by expanding the use of technology and enhancing the quality of furniture in classrooms.
- As the Russian education system has sufficient capacity to expand modern teaching, policymakers may utilize existing domestic and international innovative methodologies to promote modern teaching and learning.
- Technology should be made available in schools on an equitable basis to improve student learning and enhance teachers' professional development.
- Teachers should be encouraged and supported to adopt innovative teaching methods and to share their experiences among themselves.
- Education policymakers should prioritize the prevention of bullying and the development of supporting measures to ensure a positive school climate.
- COVID-19 is changing how teachers can teach and reducing the extent to which they can adopt innovative approaches given safety restrictions on circulating throughout the school space and working in groups. This means that learning losses are continuing despite the return of students back to schools. Therefore, new equipment, ICT, and new ways of teaching are needed to enable teachers to improve their practices and compensate for these learning losses.

1. Preface

As part of the World Bank's analytical support program in Russia, the team has been working with their Russian counterparts on collecting and analyzing data in order to gather evidence to inform coherent policies and strategies for creating modern schools and for promoting 21st-century teaching and learning in Russia.

Both goals are being pursued through a series of national projects aimed at: (i) modernizing teaching and learning; (ii) putting Russia in the top 10 countries in terms of scores on international assessments; and (iii) expanding school infrastructure to ensure full-day schooling throughout the country.

Since 2015 when the OECD published a report on collaborative problem-solving skills (CLPS), the topic of these 21st-century skills has gained traction in Russia. The OECD report devised and presented a comprehensive measure of the ability of students to approach a task as a team and solve problems as a group rather than as separate individuals. Since then, collaborative problem-solving has become the latest international large-scale measure of socio-emotional skills in Russia. Shmis and Parandekar (2018) found that the level of CLPS among Russian students was low on PISA 2015 compared to OECD average and fell behind their performance in core PISA subjects. Other studies attempted to shed some light on the issue of the 21st century skills and the role of schools in their development.[6] Dobryakova et al (2018) found that teachers' goals were oriented towards fostering students' subject knowledge and ability to think critically, analyze, and learn for themselves, whereas they viewed collaboration and communication, respect for others, and other socio-emotional skills as the family's responsibility. Families, in turn, thought that teaching most socio-emotional skills were the responsibility of schools.

This new report presents a rigorous analysis of the data collected as part of the Trends in Mathematics and Science Study (TIMSS) in 2019 complemented by data on Russia from the OECD's School User Survey (SUS), which was also fielded in 2019. The team added the SUS to the study as part of its collaboration with its Russian counterparts. The total sample represents all general education systems in the Russian Federation. This report also includes data from Information and Communication (IC) Literacy Test[7] conducted in 2020 combined with the SUS. The two datasets are not related but both cover 21st-century skills and Russian students.

This report analyzes the various 21st-century skills that it was possible to analyze using data from the TIMSS and IC Literacy Test**.** The analysis provides descriptive statistics related to the learning environments and teaching practices in Russia and draws some correlations between learning environment variables and learning outcomes. Furthermore, the study shows how different teaching styles affect student learning in the mathematics, science, and cognitive (reasoning and applying) domains of TIMSS. The team also analyzed the wellbeing construct included in TIMSS 2019. They found that the cognitive domains of reasoning and applying were well aligned with the 21st-century skills that can be measured directly by TIMSS. This study also attempts to use self-reported data from TIMSS student and teacher questionnaires and construct measures to stimulate teaching and learning activities related to 21st-century skills development. The study also assesses the impact of such measures on student performance across subject and cognitive domains. In exploring IC literacy and ICT technology in schools, the report analyzes key characteristics of the school environment, the use of ICT in schools, the use of technology by teachers with different mindsets towards modern education, and students' performance on the IC Literacy Test with an analysis of the context of the questions.

[6] XXI century skills in Russian school: view from teacher's and parent's angle / M. Dobryakova, O. Yurchenko, E. Novikova; Higher School of Economics, Institute of Education. — M.: НИУ ВШЭ, 2018. https://ioe.hse.ru/pubs/share/direct/408113173.pdf

[7] The Information and Communication (IC) Literacy Test is designed to measure the level of information and communication (IC) competence of a primary school graduate (Ictlit.com).

The qualitative data that the team has collected as part of the study come from interviews conducted with several teachers from Russian regions who use a range of different teaching approaches.

Based on the data collected and analyzed in this report, the team provides recommendations for policymakers in Russia on how best to develop 21st-century skills among Russia's 21st-century students.

2. Background.

Technological progress is drastically changing the economic environment around the world and having a particular impact on labor markets and productivity (World Bank, 2019). The development of robotics and automation technologies are changing how workplaces are organized and are even put the existence of certain professions at risk. As a result, there is a demand for new skills that workers must acquire and constantly develop during their working lives to remain productive. According to the World Bank's World Development Report (WDR) 2019, "advanced cognitive skills such as complex problem-solving, socio-behavioral skills such as teamwork, and skill combinations that are predictive of adaptabilities such as reasoning and self-efficacy" are becoming increasingly vital for labor market participation and employability (World Bank, 2019).

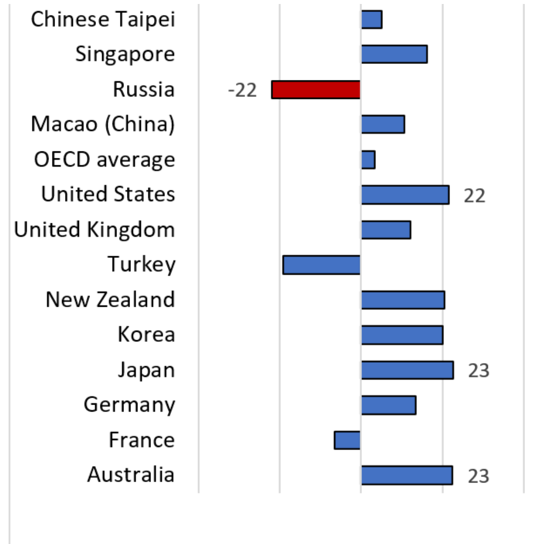
In an effort to ensure that this demand can be met, many countries have started improving their national education systems and adapting them to teach these skills. All levels of education need to be adapted, including preschool, because laying the foundations for developing new socio-emotional and collaborative problem-solving skills has to begin at a very early age.

Education is a significant contributor to Russia's human capital. While the scores of Russian students on various international assessments of mathematics, reading, and science ranks the country among the top 25 economies around the world (according to the Harmonized Learning Outcome index in 2018 and 2020), they are underperforming in the area of 21st-century skills. This needs to be remedied because the development of these skills will fuel the competitiveness of Russia's future labor force.

The Russian Federation is implementing an ambitious set of national projects in the education sector that aim to: (i) put Russia among the very top performers on international student assessments; (ii) introduce the universal full-time school model across the country; (iii) increase enrollment in early childhood development; and (iv) build new teaching and learning approaches. While these are all important goals, it will also be necessary to systematize good practices and collect evidence on outcomes related to critical areas of these education reforms throughout all of the regions of Russia.

In 2013, the World Bank conducted an analysis that demonstrated the importance of 21st-century skills for productivity and employability in Russia (Vasiliev et al, 2013). The study found that innovative employers in Russia are seeking such skills as problem-solving, communication and collaboration, and the ability to work independently, but the Russian curriculum and teaching approaches still need to be updated to include those skills. Unfortunately, as currently designed, the national projects do not pay sufficient attention to the need to nurture 21st-century skills. However, recent studies by the World Bank team on education equity, extracurricular education, and learning environments suggest that teaching and learning may be improved by adapting the school system to include 21st-century skills-building. Efforts towards this end would involve: (i) creating more open and flexible learning environments to enable collaboration and communication; and (ii) understanding the extent of students' information and communication (IC) literacy to tailor their learning experiences.

Figure 1: Russia's Comparative Performance in Collaborative Problem-solving Compared to its Performance in PISA Science, Reading, and Mathematics.



Source: OECD (2017).

Countries need instruments to evaluate the effectiveness of their learning environments. Learning environment development is an emerging discipline, and there is still little empirical evidence on how spaces are currently used and how this impacts student outcomes and teacher productivity (Blackmore et al, 2011). In 2019, the World Bank team published a comprehensive review of research on learning environments from an evidence-based perspective and found out that the number of empirical studies is still scarce and mostly focused on developed countries (Barrett et al, 2019). This lack of empirical studies on what works in learning environments is worrisome given the amount of funding spent on school infrastructure globally.

The Russian government has begun to implement a national project entitled "Contemporary digital learning environment in the Russian Federation" to promote digital technologies and online learning in primary and secondary education. Focusing on teaching methods, distance learning, and the promotion of massive online open courses (MOOCs), the project may lead to adaptations to the conventional spatial arrangements of classrooms and the design of schools in the future. These changes will need to be based on a thorough evaluation of students' and teachers' needs as well as of the effectiveness and sufficiency of existing learning environments.

Russian experts estimate that the quality of the spatial organization and usability of classrooms in Russian schools are only average as measured by the internationally recognized tools. For example, a study of schools in Moscow based on the School-Age Care Environment Rating Scale (SACERS) found that Russian schools had the lowest scores on the following parameters: "Space and Furnishing," "Physical Activity and Time of Conduct," and "Special Needs," in other words, the creation of appropriate learning conditions for students with special education needs (Ivanova and Vinogradova, 2018). The study noted a lack of alignment between social and pedagogical needs and existing school designs. The design of new buildings often does not take into account the needs of the pedagogical community, students, parents, or the municipality, which hinders the development of contemporary learning environments and has a seriously negative effect on the quality and comfort of modern schools.

International best practices and a growing pool of scientific evidence suggest that only a holistic approach to school design and planning can guarantee the high quality of education facilities and of the education provided or the well-being of students and teachers (Barrett et al, 2019).

In 2018, the World Bank conducted a pilot study on school learning environments in three Russian regions using two international instruments: the OECD's School User Survey (SUS) and the pilot of the Trends in Mathematics and Science Study (TIMSS) (Shmis et al, 2019). The authors' findings confirmed that the physical characteristics of a school's infrastructure, the way that the school is organized and used daily by the students and teachers, the school's psychological climate, and the teaching styles applied in these conditions have a notable impact on learning outcomes. The School User Survey had previously been piloted in Norway and is currently being used for school infrastructure assessments in the Belarus Republic and Chile. However, the Bank's study was the first attempt to analyze school infrastructure characteristics in relation to learning outcomes and teaching practices.

In 2019, the same team had an opportunity to extend the sample to cover all of the country and thus to produce more reliable results. The new findings further strengthened existing research on learning environment quality both nationally and internationally and contributed to the policy discussion on the most enabling environments for the development of 21st-century skills.

The question of 21st-century skills has long been discussed both in Russia and globally. Therefore, they have been given different names – including skills of the future, socio-emotional skills, and higher-order cognitive skills. In this research, we propose to analyze existing definitions or frameworks and drill down to those skills that are most essential for Russian national policy.

3. Definition of and Frameworks for 21st Century Skills

Twenty-first century skills enable individuals to navigate and thrive in today's rapidly evolving, technology-mediated, and interconnected world. The concept of 21st-century skills generally encompasses a combination of:

- **Cognitive skills**: Use of logical, intuitive, and creative thinking, such as verbal ability, numeracy, problem-solving, memory, and mental speed.
- **Socio-emotional skills**: Beliefs, personality traits, and behavioral skills.
- **Technical skills**: Manual dexterity and use of methods, materials, tools, and instruments, including those related to specific occupations or trades.

Several policy and advocacy organizations developed frameworks to promote a common understanding and definition of for 21st-century skills and to advocate for them to be prioritized in school curricula. These research-informed models usually describe the skills, knowledge, and expertise that students must master to succeed in life and work given the rapidly changing demands of the 21st century. Realizing the importance of these skills for the development of a healthy society and skilled future workforce, a growing number of countries have incorporated them into their education systems. While there are considerable differences in the breadth of competencies included in each framework, there are also significant overlaps. The four skills most commonly mentioned in national policy documents are communication, creativity, critical thinking, and problem-solving.[8]

The following frameworks have been included in our analysis:

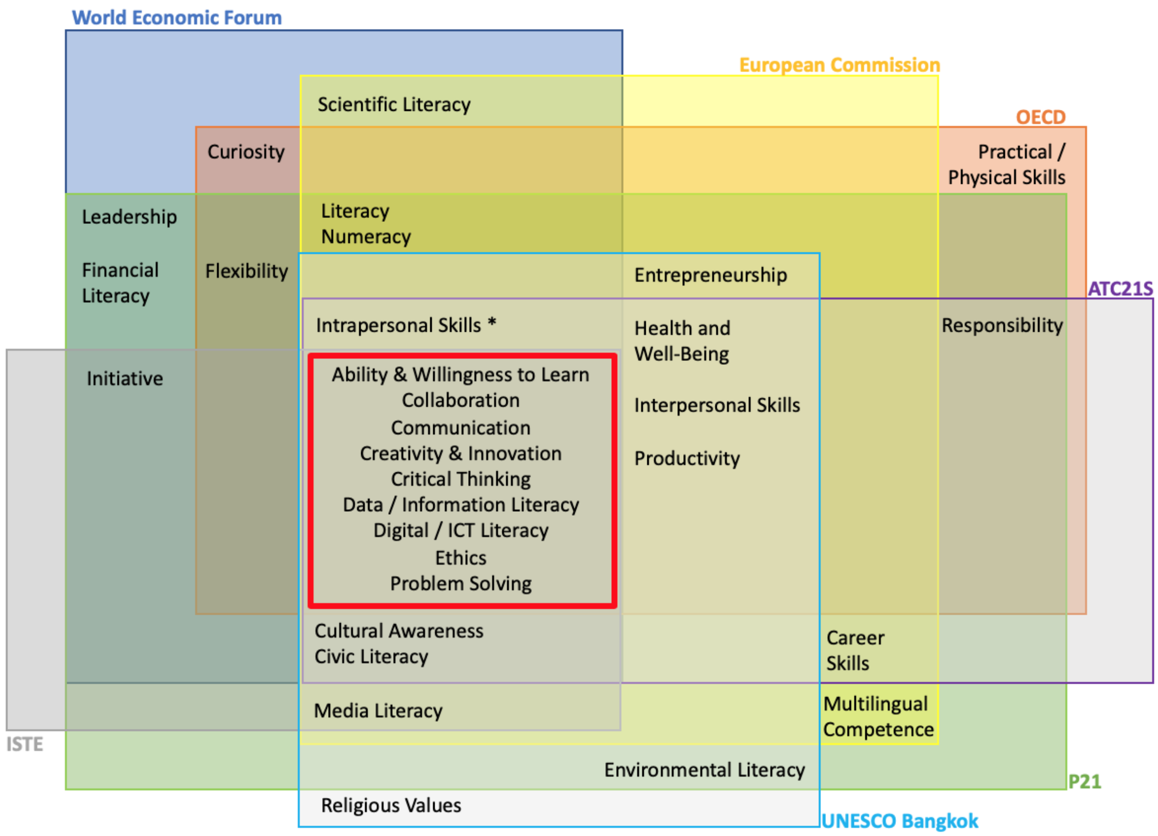
- The Partnership for 21st Century Learning's *Frameworks for 21st Century Learning*
- The OECD's *The Future of Education and Skills 2030 Learning Framework*
- *International Society for Technology in Education (ISTE) Standards*
- *The European Reference Framework of Key Competences for Lifelong Learning*
- The World Economic Forum's *New Vision for Education*
- *Assessment and Teaching of 21st Century Skills (ATC21s)*
- UNESCO's Bangkok Asia and Pacific Regional Bureau for Education's *Framework on Transversal Competencies*.

Figure 2 below illustrates the nine skills that are common to all of the frameworks that we studied.[9] As captured in the red square, they are: the ability and willingness to learn, collaboration, communication, creativity and innovation, critical thinking, data/information literacy, digital / ICT literacy, ethics, and problem-solving.

[8] https://www.brookings.edu/wp-content/uploads/2018/11/Education-system-alignment-for-21st-century-skills-012819.pdf

[9] In some cases, the exact terminology used in different frameworks differed but were merged to one common name based on shared characteristics in the definition of the competency.

Figure 2: Skills Common to All 21st-century Frameworks Studied



* Intrapersonal skills include self-awareness, self-management, self-direction, self-efficacy, self-regulation, self-discipline, self-motivation, and persistence.

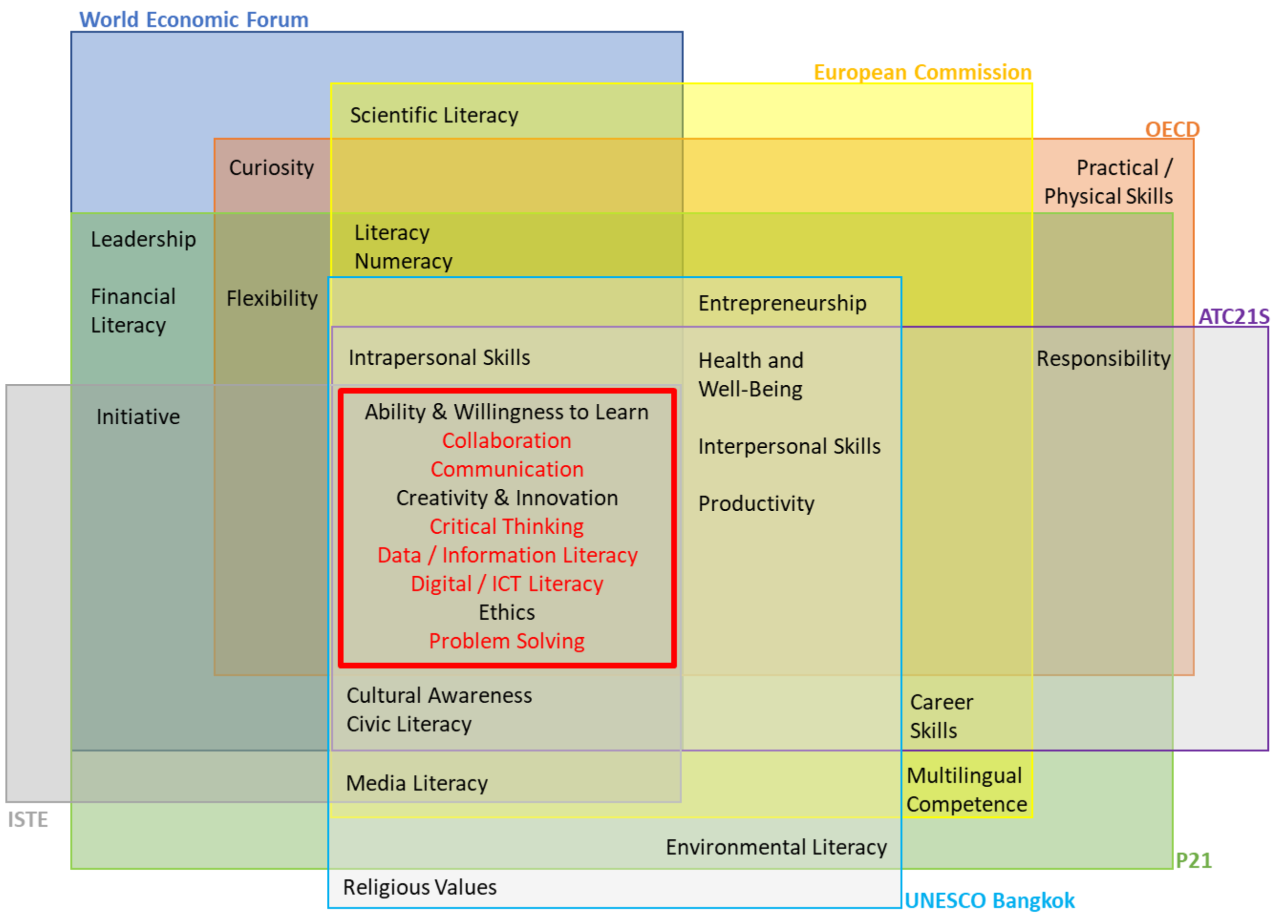
Although some countries and organizations have included the development of 21st-century skills in their strategic education policy objectives, there is still no clear answer to the question of how to assess these skills as many countries do not have any tools to specifically measure 21st-century skills.[10] In some of the frameworks, assessment has not been included. For example, the OECD emphasizes that its Future of Education and Skills 2030 Learning Framework is a learning framework, not an assessment framework and offers a broad vision of the types of skills that students will need to thrive in the workplace in 2030 instead of what kind of skills should or can be measured. Other organizations, such as ATC21s, acknowledge that traditional forms of assessment may not be suitable for measuring many 21st-century skills, especially those that might be considered non-cognitive. However, the International Association for the Evaluation of Educational Achievement (IEA) and the OECD have started to expand their assessments beyond literacy, numeracy, and science to include 21st-century skills such as problem-solving, financial literacy, computer and information literacy, global competence, and civic and citizenship education. The dearth of measurement tools might be related to the lack of a consensus on what constitutes "21st-century skills," without which it is difficult to design a single global instrument to measure the possession of these skills.

[10] https://neqmap.bangkok.unesco.org/wp-content/uploads/2020/09/Assessment-of-TVC-Current-Tools-in-Asian-Region.pdf

One way to proceed might be to extend and adapt existing assessment tools instead of creating new assessment tools from the ground up.[11] Existing assessment instruments –including large-scale assessment programs such as PISA, TIMSS, PIRLS, PIAAC, and ICILS – can capture students' progress in learning critical cognitive 21st-century skills and measure the impact of teaching methods designed specifically for these skills. After all, the transferable nature of 21st-century skills implies that these skills can be taught through and used in existing academic programs.[12]

From among the nine skills that all of the frameworks share, we have identified six that can be captured or partly captured by the assessment tools used in this study: (i) collaboration; (ii) communication; (iii) critical thinking; (iv) data/information literacy for decision-making; (v) digital/ICT literacy; and (vi) problem-solving.

Figure 3: Prioritization of the Skills Common to All Frameworks Studied



While Russia does not have a formal framework for 21st-century skills, the National Education Project, launched in 2019, aims to incorporate 21st-century skills (referred to as soft skills) into its federal education standards. The project is also developing a new methodology for measuring and assessing student learning of 21st-century skills and basic literacy in areas such as financial, data, legal, and health competency.[13] It further emphasizes the importance of digital literacy and the use of technology to support learning. Under this project,

[11] https://neqmap.bangkok.unesco.org/wp-content/uploads/2020/09/Assessment-of-TVC-Current-Tools-in-Asian-Region.pdf

[12] https://www.brookings.edu/wp-content/uploads/2020/07/OAA-Part-5_Final.pdf

[13] Meeting Minutes, Project Committee on the Main Direction of Strategic Development of the Russian Federation.

soft skills are defined as a set of non-subject-specific knowledge and skills necessary to manage life and work successfully. Soft skills, in contrast to professional skills in the traditional sense, are independent of a particular role or profession and are closely related to personal qualities and attitudes. Among them are cognitive problem-solving skills (analytical and creative thinking), collaboration skills (teamwork, communication), and self-management skills (self-regulation and self-organization). Many of these soft skills overlap with those included in international frameworks that define 21st-century skills.

There are also some positive ongoing efforts in Russia to revise the curriculum for and assessment of some critical 21st-century skills:

- ***Sberbank: 4K of the contemporary world***. Led by the biggest private bank of Russia – Sberbank – and its charity foundation, "Investment in the Future," this project focuses on the development of creativity, critical thinking, communication, and cooperation. The aims of the project are to: (i) develop classroom tools and methods to improve the learning process by including modules on "joint problem solving" and (ii) develop an instrument to monitor interdisciplinary and personal **[student?]** outcomes in these domains.[14] Additionally, the foundation supported the establishment and operation of a private school, "Horoshkola," whose curriculum focuses on 21st-century skills development.[15]
- ***Sirius school***. This is an experimental school for gifted children focused on 21st-century skills development.[16] It includes a 24-day educational program in the fields of science, technology, engineering, arts, and mathematics (STEAM), as well as sports. The school is based in Sochi, but its educational model is currently being replicated across Russia.
- ***Technological parks Kvantoriums***. The main aim of this project is to facilitate the extracurricular education of Russian children in STEM subjects (science, technology, engineering, and mathematics) by implementing effective learning methods and technologies that can be replicated in all regions of the country.[17]

Most of these activities are on a small scale and have not been evaluated for impact. Further investments will need to be made in conducting impact evaluations of these initiatives before it will be feasible to define effective skill development policies on a national scale.

As part of this study, our goal has been to understand what effect the development of these selected 21st century skills can have on students' performance in cognitive domains using the data from international student assessments.

4. Research Questions and Methodology

The current study, building on the previous work, seeks to answer the following questions:

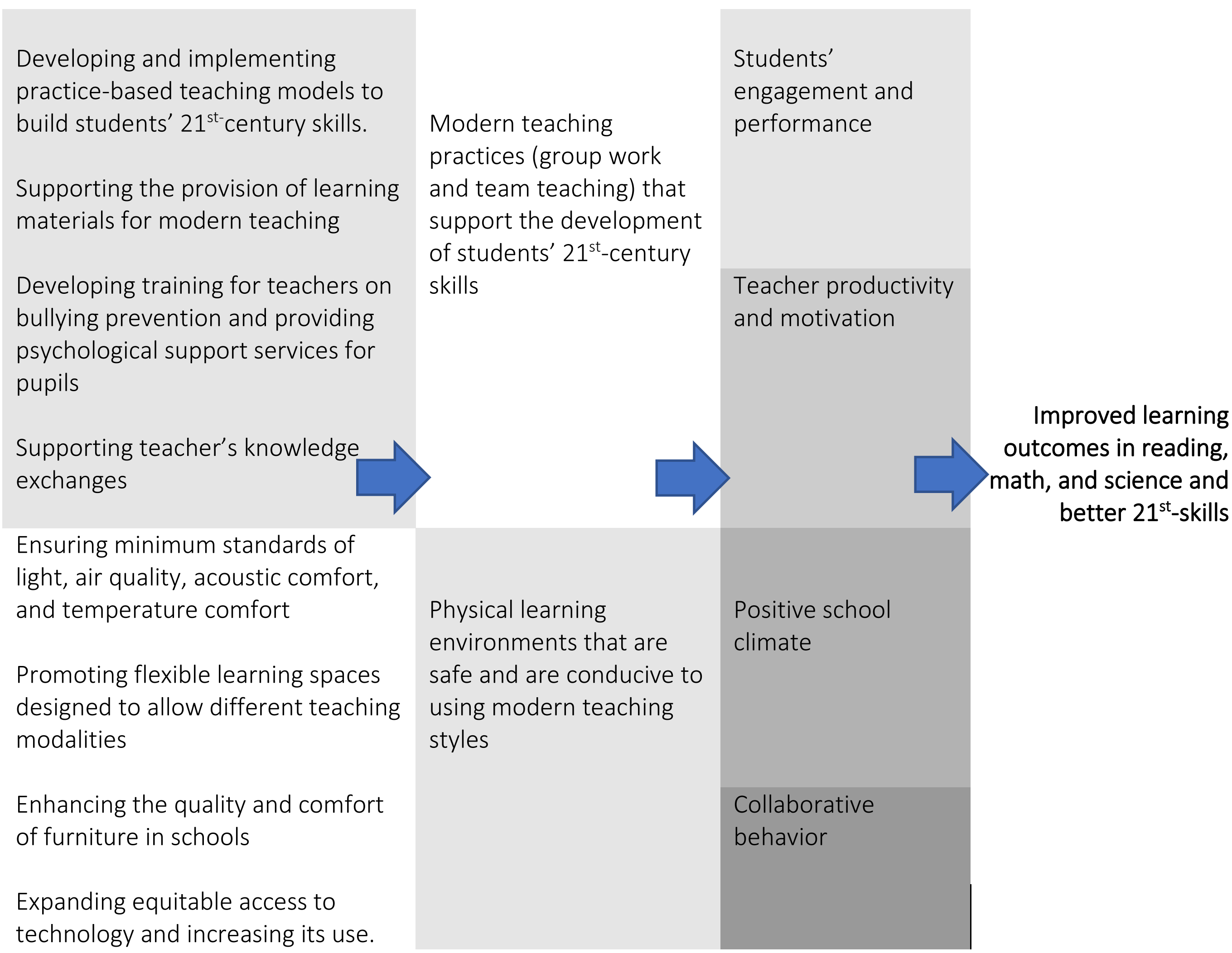
1. How does teaching and learning in Russian schools relate to the learning outcomes of students in both content and cognitive TIMSS domains as well as in terms of information and communication literacy?

[14] https://vbudushee.ru/education/arkhiv-programm-i-proektov/proekt-4k-sovremennogo-mira/
[15] https://hi.horoshkola.ru/about
[16] https://sochisirius.ru/o-siriuse/obschaja-informatsija
[17] https://www.roskvantorium.ru/en/

2. If teaching and learning practices are adapted to stimulate problem-solving, decision-making, critical thinking, communication and collaboration, and project work, will there be any spillover effects on the subject and cognitive domains of TIMSS?
3. What physical and non-physical characteristics of the learning environment in Russian schools affect student learning outcomes?
4. What support do Russian teachers need to practice diverse teaching and learning methods in their work?

Figure 4 shows the structure of the analysis in this report. It emphasizes the importance of improving the learning outcomes and building the 21s-century skills of Russian students. The study shows that this long-term goal can be reached if two necessary pre-conditions are in place, namely: (i) modern teacher practices and (ii) supportive and high-quality physical learning environments (see columns 2 and 3 on Figure 4). Based on the evidence that we collected, we identified several important practical steps that can be taken to ensure that these preconditions are put in place, including enabling more teacher training and knowledge exchanges, making efforts to reduce bullying in schools, providing more comfortable and flexible furniture and learning materials, ensuring more equitable access to ICT, and increasing the digital literacy of both teachers and students (see Figure 4).

Figure 4: Structure of the Analysis



4.1 Student Performance and Datasets

To measure student performance, the World Bank used the TIMSS 2019 study and the IC literacy study carried out in 12 Russian regions.

The TIMSS 2019 study was conducted in April-May 2019 and included 4th and 8th grade students in 590 schools in 49 Russian regions. For our study, we used data for 8th graders only. The 8th grade sample for TIMSS 2019 constituted 3,901 students from 204 schools in 43 regions. The overlap in samples between the School User Survey (SUS) and TIMSS is 84 percent, with 3,725 tested students, 833 associated teachers, and 169 school principals replying to the SUS questionnaire. The outcome results for TIMSS 2019 were weighed and scaled to ensure comparability with other international results. The TIMSS score ranged between 0 and 1,000 points, with 500 points being the average across all countries. Every student did the full set of tasks included in the test.

The IC literacy study was conducted by the National Training Foundation (NTF) in 12 regions of Russia and covered 792 schools. The sample for all 12 regions consisted of 14,990 students and 4,962 teachers. The survey and testing took place between October 1 and November 15, 2020. In two of the sample regions, some results had been collected in the early spring of 2020.

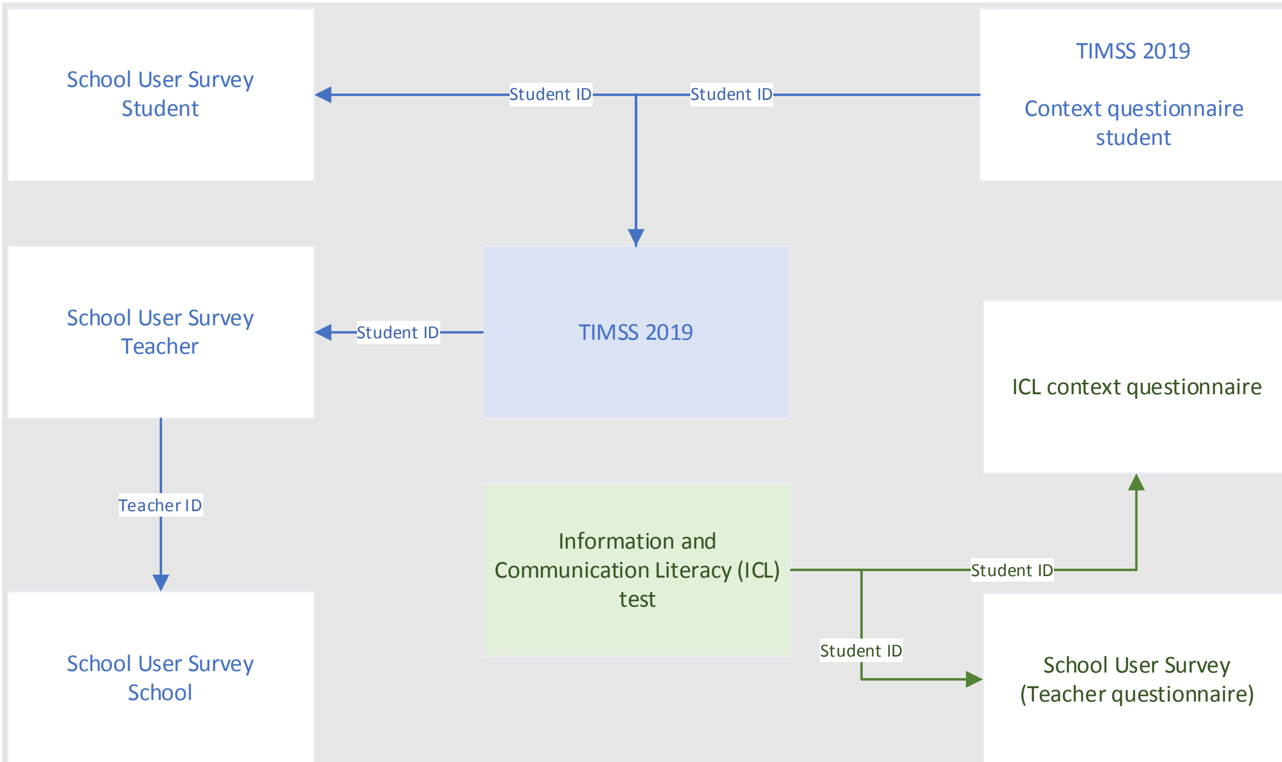
4.2 Data Collection and Methodologies

Every student who took the TIMSS in the sampled schools filled out the SUS student questionnaire. Teachers of the students who took the TIMSS testing also filled out the SUS teacher questionnaire, and their school principals filled out the SUS school questionnaire. The testing in the schools lasted for two days. The TIMSS testing took place during the first day, and the next day was used to complete the SUS forms. The questionnaires were completed in digital form.

The IC Literacy Test was conducted at the school level and was computer-based. Students took the test and filled out the questionnaires during the same day. Their teachers also filled out the teacher questionnaire. The school-level questionnaire was not collected in this part of the study.

The samples for TIMSS 2019 and the IC literacy study do not overlap, so all conclusions from these two samples will be considered separately.

Figure 4: Data Overlaps



Source: TIMSS, ICL, and OECD SUS frameworks.

Given the limitations of the TIMSS study with regard to the 21st-century skills, the team has identified the skills that combined both traditional math and science, which this study refers to as content domains, and the applying and reasoning skills emphasized by TIMSS 2019, which this study refers to as cognitive domains.[18] Table 1 shows how the TIMSS framework measures applying and reasoning in math and science.

Table 1: Definitions of the Content and Cognitive Domains in TIMSS 2019

Content domains		
	Mathematics	Science
TIMSS 2019 for 8th grade students generalized for Mathematics and Science	Number 30% Algebra 30% Geometry 20% Data and Probability 20%	Biology 35% Chemistry 20% Physics 25% Earth Science 20%
Cognitive domains		
	Mathematics	Science
Applying in Mathematics and Science: focuses on the ability of students to apply knowledge and conceptual understanding to	Focuses on the ability of students to apply knowledge and conceptual understanding to solve problems or answer questions. This domain includes the following skills:	Focuses on using this knowledge to compare, contrast, and classify groups of objects or materials; relating knowledge of a science concept to a specific context; generating explanations; and solving practical problems. This domain includes the following skills:

[18] https://timss2019.org/wp-content/uploads/frameworks/T19-Assessment-Frameworks.pdf

solve problems or answer questions	• Determine efficient/appropriate operations, strategies, and tools for solving problems for which there are commonly used methods of solution. • Represent/model and display data in tables or graphs; create equations, inequalities, geometric figures, or diagrams that model problem situations; and generate equivalent representations for a given mathematical entity or relationship. • Implement strategies and operations to solve problems involving familiar mathematical concepts and procedures.	• Compare/contrast/classify, identify, or describe similarities and differences between groups of organisms, materials, or processes; and distinguish, classify, or sort individual objects, materials, organisms, and processes based on characteristics and properties. • Relate knowledge of an underlying science concept to an observed or inferred property, behavior, or use of objects, organisms, or materials. • Use models, like a diagram or other model to demonstrate knowledge of science concepts, to illustrate a process, cycle, relationship, or system, or to find solutions to science problems. • Interpret Information and use knowledge of science concepts to interpret relevant textual, tabular, pictorial, and graphical information. • Provide or identify an explanation for an observation or a natural phenomenon using a science concept or principle.
Reasoning for Mathematics and Science: goes beyond solving routine problems to encompass unfamiliar situations, complex contexts, and multistep problems.	It goes beyond solving routine problems to encompass unfamiliar situations, complex contexts, and multistep problems. This domain includes the following skills: • Analyze and determine, describe, or use relationships among numbers, expressions, quantities, and shapes. • Integrate/Synthesize Link different elements of knowledge, related representations, and procedures to solve problems. • Evaluate alternative problem-solving strategies and solutions. • Draw conclusions and make valid inferences on the basis of information and evidence. • Generalize and make statements that represent relationships in more general and more widely applicable terms. • Justify by providing mathematical arguments to support a strategy or solution.	Includes using evidence and an understanding of science to analyze, synthesize, and generalize, often in unfamiliar situations and complex contexts. This domain includes the following skills: • Analyze and identify the elements of a scientific problem and use relevant information, concepts, relationships, and data patterns to answer questions and solve problems. • Synthesize and answer questions that require consideration of a number of different factors or related concepts. • Formulate questions/ hypothesize/predict Formulate questions that can be answered by investigation and predict results of an investigation given information about the design; formulate testable assumptions; use evidence and conceptual understanding to make predictions about the effects of changes in biological or physical conditions. • Design investigations and plan procedures appropriate for answering scientific questions or testing hypotheses; and describe or recognize the characteristics of well-designed investigations in terms of variables to be measured and controlled and cause-and effect relationships. • Evaluate alternative explanations; weigh advantages and disadvantages to make decisions about alternative processes and materials; and

		evaluate results of investigations with respect to sufficiency of data to support conclusions. • Draw conclusions and make valid inferences on the basis of observations, evidence, and/or understanding of science concepts; and draw appropriate conclusions that address questions or hypotheses and demonstrate understanding of cause and effect. • Generalize and make general conclusions that go beyond the experimental or given conditions; apply conclusions to new situations. • Justify by using evidence and science understanding to support the reasonableness of explanations, solutions to problems, and conclusions from investigations.

We believe that the cognitive domains (applying and reasoning) in TIMSS are similar to the 21st-century skills described in section 3 of this report. Therefore, the analysis of TIMSS 2019 data in this study includes the performance of students on content domains (mathematics and science) and on cognitive domains (applying and reasoning that are merged for mathematics and science).

This study used multiple analytical techniques, including:

1. A correlation analysis of questionnaire factors and learning outcomes using indexes created by principal component analysis (PCA).
2. A regression analysis of the impact of various student-level and school-level characteristics on student learning outcomes.
3. Structural equations modeling (SEM) as multivariate analysis.
4. Qualitative research that involved identifying and interviewing of teachers who use modern teaching methods.

Using the variables from the context questionnaires of TIMSS and School User Survey, the team constructed a physical environment index, a modern teaching environment index, a school atmosphere index, and a bullying index.

The report is based mainly on the regression and correlation analyses. The structural equation modelling is based on conditional correlations that indicate the magnitude of the effect but not causation. A causal model would require a controlled experiment that would have been difficult to perform as it would have required a sample of schools with different levels of environmental and teacher quality with students being randomly assigned to schools and with pre-testing and post-testing to determine the causal effect. It might have been possible to approximate a causal effect using longitudinal or time-series data of the single cross-section that we used of the combined TIMSS and SUS data. In such a model, estimated values from regressions of earlier cross-sections could serve as instruments for later cross-sections. This could be done in the setting of a Bayesian path model. However, the conditional correlations that we have presented do not come with any statistical evidence of causality. Rather, we have relied on the theoretical model indicated by the path diagram (Figure 23 below) as well as the additional qualitative data to suggest the possibility of a causal relationship. Repeated applications of the joint TIMSS-SUS study in the future would generate a time-series of data that would make it possible to confirm or reject causality in the relationship between various school and teacher inputs and student outcomes.

The structural equations modeling (SEM) exercise combines confirmatory factor analysis (CFA) with regression analysis as modeled in the path diagram. The estimation is performed simultaneously using maximum likelihood estimation. The model posits the existence only of the effects displayed in the path diagram; therefore, in this model, the teacher quality cannot influence learning outcomes in the model without impacting their attitudes and beliefs of the students themselves. The reason why we chose a multigroup SEM procedure was because we wanted to explore differences in the pathways of modern and traditional teaching styles. In this iterative procedure, we at first constrained the model to have equal effect parameters and then compared the constrained model to an unconstrained model that allowed the parameters to vary. The models needed to be nested in this way to enable scientifically accurate and valid comparisons of various measures of model goodness-of-fit.[19]

SEM analysis is based on a model of how the world works as it is posited or proposed by the researchers. Empirical support for the researcher's hypothesis is based on a set of accepted measures that are built around the concept of goodness-of-fit. In using this approach, we knew the actual values of the dependent variables, and we knew what the model that we built predicts – typically, there will be an error because a model is an abstraction that captures only part of the effects in the real world. Since the differences would be either positive or negative, they can be added by taking the square root of the mean of the squared error terms (RMSE). A model with a lower RMSE is said to dominate a model with a higher RMSE, but these comparisons can only be done meaningfully for nested models.

5. Results and Discussion

This chapter covers the various areas of analysis that the team used to answer the research questions. These areas are: (i) the physical environment of schools and their impact on learning; (ii) the school environment and climate; (iii) teaching and learning and student performance; (iv) the performance of Russian students in 21st-century skills on TIMSS; (v) the availability and use of ICT in schools and students' information and communication literacy; and (vi) a qualitative perspective on modern teaching and learning in Russia.

5.1 School Physical Environment

A school's physical environment refers to its classrooms, science laboratories, and sport, leisure, and administrative spaces inside and outside the educational building within which teacher and students interact and daily activities occur. The frequency with which these spaces are used by students and teachers can provide us with valuable information about the organization and practices of teaching and learning in the school.

According to the data from the TIMSS/SUS study, 80 percent of Russian teachers use only classrooms for teaching, while students use classrooms in combination with the canteen and the corridors for their learning activities. Both teachers and students reported that in a typical week during lesson time, they use only their classrooms (see Figure 5 below). Ninety percent of the teachers teach in classrooms assigned to them at least two to four times a week, and 90 percent of students had been taught in a single classroom over the previous week.

[19] The estimating procedure was conducted with a help of lavaan, which is an R software package for SEM. The missing values were imputed using the Amelia software package that uses a bootstrapped EM algorithm. All of the analyses include controls for students' socioeconomic status. The R code for this investigation is available here: https://bitbucket.org/zagamog/edsus/src/master/. This code provides end-to-end replicability of the results depicted in this report from the raw data of TIMSS and the SUS.

Only 16 percent of teachers reported using the school canteen for teaching purposes at least two to four times a week, whereas 62 percent of students reported having been taught in the canteen over the previous week. Fifteen percent of teachers reported using the space in a corridor outside the classroom to teach, while 77 percent of students reported having used the same space for learning during the previous week. This may point to an important difference in perception of what learning means for teachers and students as well as how students really learn in schools.

Figure 5: Frequency of Use of Spaces by Students and Teachers in a Typical Week

Use of spaces by students during lesson time over the previous week

Frequency of use of spaces by teachers in a typical week

Source: OECD's SUS data.

In this report, we examine differences between modern teaching styles and traditional ones to understand how school spaces are used in each case. These styles are defined in Table 1 below.

Table 2: Definition of Teaching Styles

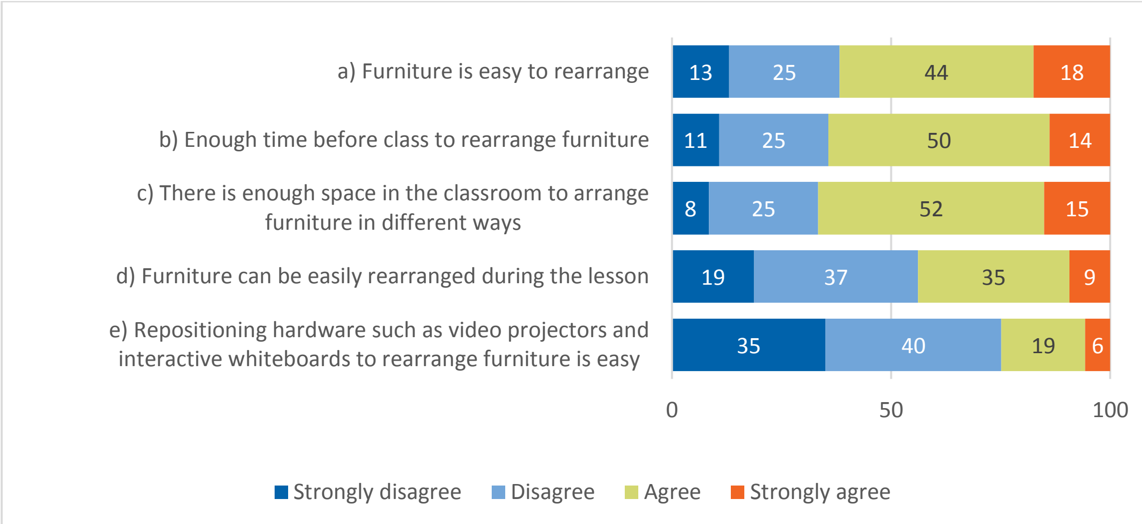
Data Source	Question Numbers	Variable	*Measurement Details*
SUS (Teachers)	24, 26	Teaching style	*Traditional style*: If students reply that teachers use layouts that support explicit instruction/presentation or individual work every day <u>and</u> never need to rearrange tables, chairs, or other aspects of the space (e.g., sliding partitions) prior to the start of a lesson because a previous user had them in a different position. *Modern style*: If at least one of the above-mentioned criteria is not met.

In modern schools, students and teachers use the common space for group work and classrooms with direct access to other rooms slightly more often than in traditional schools.

In terms of the flexibility and adjustability of the spaces (ease of arranging and re-arranging furniture) (see Figure 6 below), 62 percent of teachers agreed that it was easy to move the furniture, while only 38 percent of teachers disagreed with this statement. Sixty-seven percent of teachers also agreed that there was enough space to arrange furniture in different ways, and 44 percent of them agreed that the furniture could easily be moved during lesson time.

Teachers did not find it easy to move the technology equipment, such as LCD projectors and whiteboards, to support different teaching arrangements. Only 25 percent reported that they found it easy – 40 percent disagreed, and 35 percent strongly disagreed.

Figure 6: Teachers' Agreement with Statements about Moving Furniture

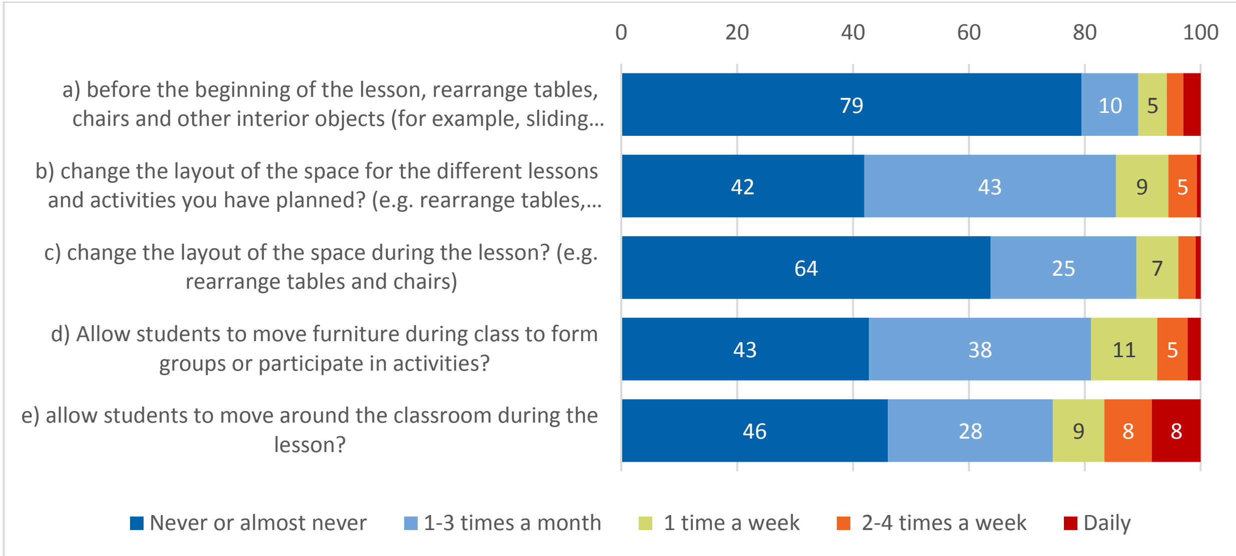


Source: OECD's SUS data.

More than half of all teachers in the sample (64 percent) said that there was enough time to rearrange the furniture before classes began. This is why teachers generally did not encourage students to move around in the space during a class or to move the furniture to suit group work (see Figure 7 below). Only 8 percent of teachers encouraged students to move around the space during a class at least two to four times a week, whereas fewer than a third (28 percent) of the teachers encouraged students to do so one to three times a month.

Almost a half (43 percent) of teachers encouraged students to move furniture during class several times per month to facilitate group work or participation in activities, while 11 percent did so at least once a week. Teachers themselves moved furniture around less frequently, either before or during classes. The majority (79 percent) of the teachers never rearranged tables, chairs, or other elements of the space (such as sliding partitions) prior to the start of a lesson, and 10 percent of teachers did so only one to three times a month.

Figure 7: Frequency of Teachers Changing the Spatial Arrangements of Teaching Spaces



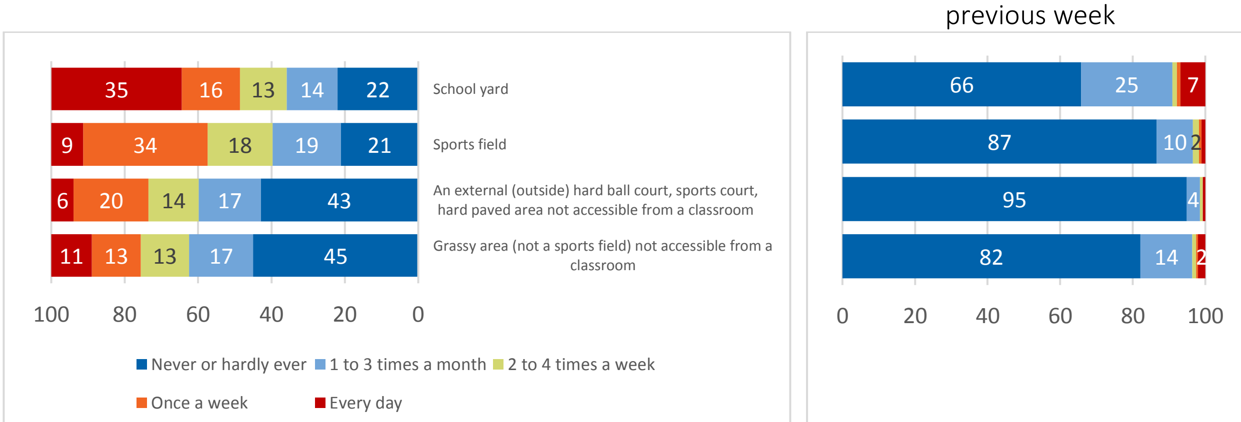
Source: OECD's SUS data.

With regard to the use of outdoor spaces for teaching purposes, while 39 percent of students claimed that they had been taught in these areas during the previous week, 95 percent of teachers said that they never teach in these spaces (see Figure 8). Students are using diverse school spaces during their school day, the gap between teachers and students shows a lot of potential for more diverse teaching and learning if teachers would step out from traditional classrooms and utilize spaces more intensively with students.

Figure 8: Use of Outdoor Spaces by Students and Teachers

Use of outdoor spaces by students during class times over the previous week

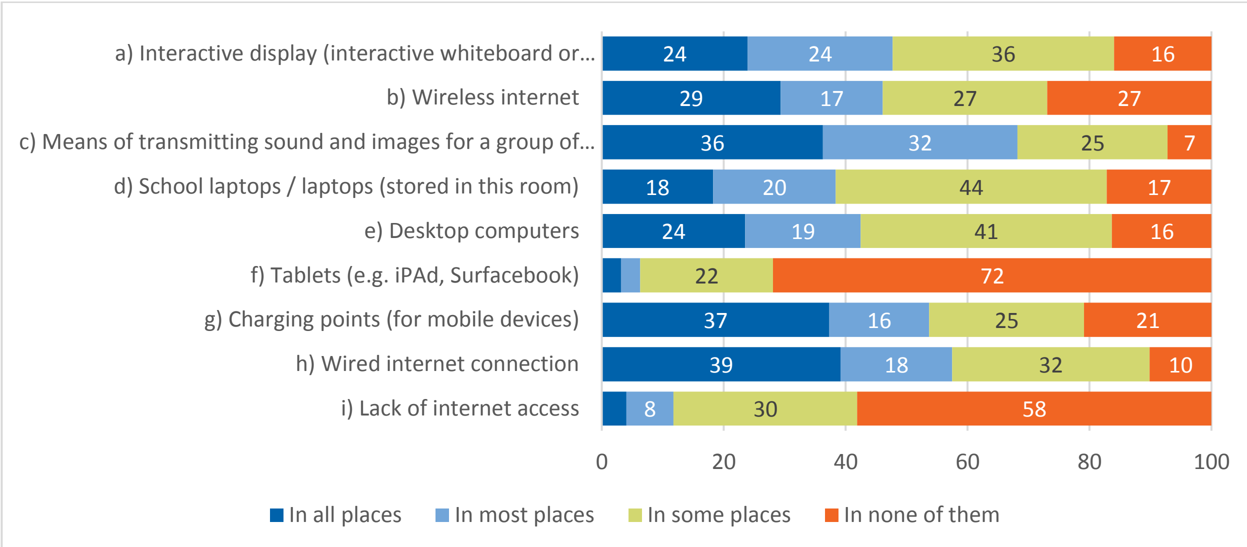
Use of external/outside spaces by teachers during class times over the previous week



Source: OECD's SUS data.

Technological equipment in schools is an important dimension of education policy in Russia. The data suggest that the existence of this equipment varies among schools and that its use still lags behind its availability. Whiteboards (interactive boards) are not available in the classrooms of 16 percent of teachers, and 72 percent of teachers reported that they had no tablets. The most common pieces of equipment are laptops and desktop computers, which are available in 82 and 84 percent of schools respectively. While a wireless or wired internet connection is generally available, 58 percent of teachers reported a lack of internet access in school spaces.

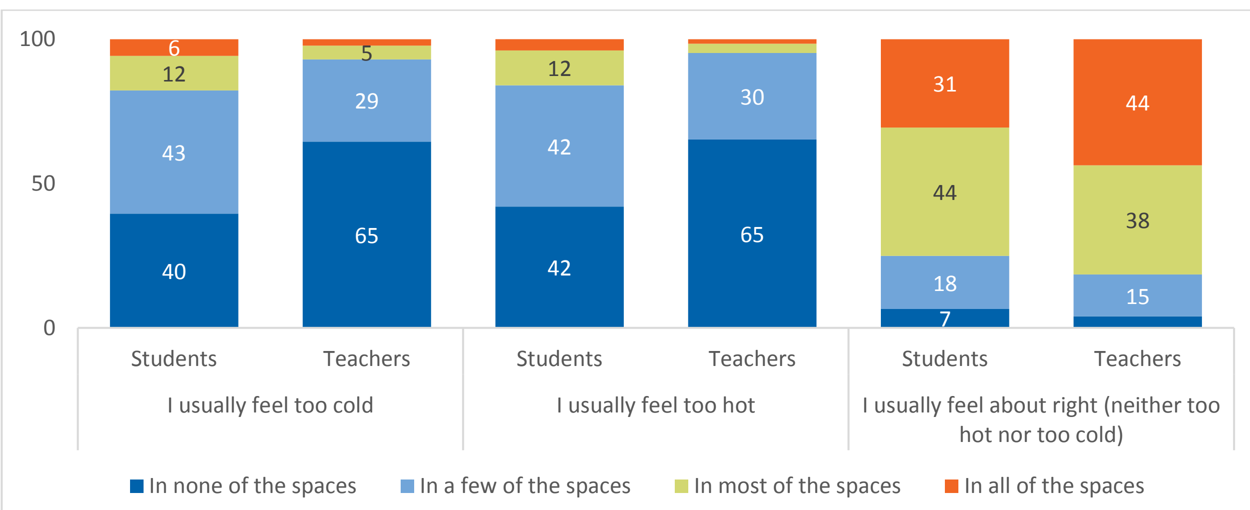
Figure 9: Availability of Technology Equipment and Frequency of Use



Source: OECD's SUS data.

As far as the physical characteristics of the learning space are concerned, the results of how respondents perceived temperature were similar to our earlier findings[20]. Students and teachers had different perceptions of temperature. While in 18 percent of cases, students said that they felt too cold in most or all of the spaces, teachers showed more resilience claiming the same only in 7 percent of the cases. A similar pattern is observed in relation to the perception of hot spaces. As research has shown, comfortable temperatures are a strong contributor to students' academic performance, which is especially important in Russia, which is a cold country in most of its regions.

Figure 10: Perceived Temperature in Learning Spaces When It Is Cold [or Hot?] Outside

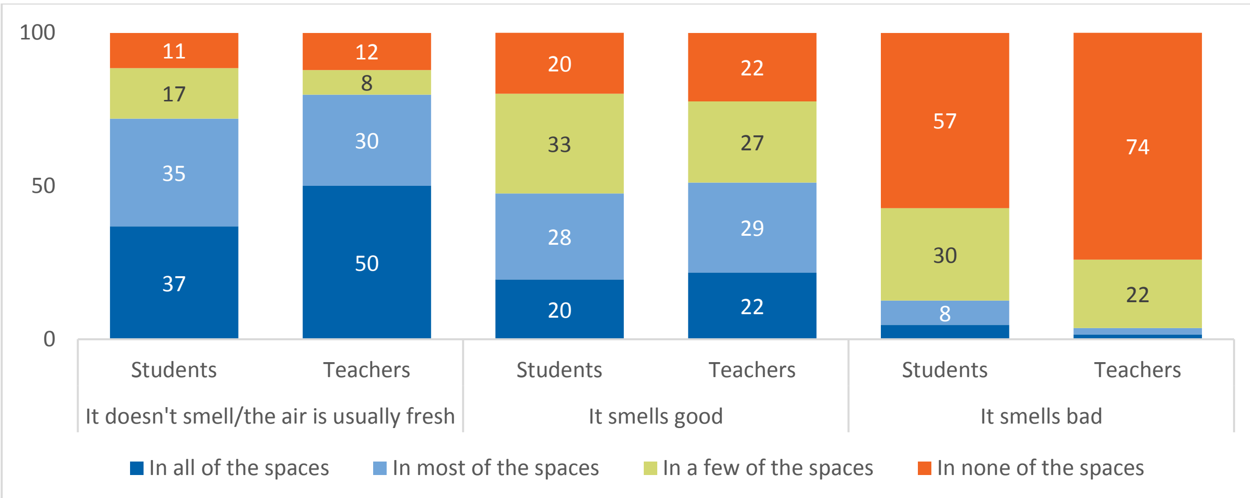


Source: OECD's SUS data.

[20] http://hdl.handle.net/10986/32598

Students and teachers also differed in terms of their perception of the air quality in learning spaces. While students tended to complain about the air quality, most teachers considered the air to be fresh, and they were less likely than students to notice bad smells (see Figure 11). Fresh air is a key part of the equation for improving students' learning outcomes, so there is a need to ensure that the air in all learning spaces is fresh.

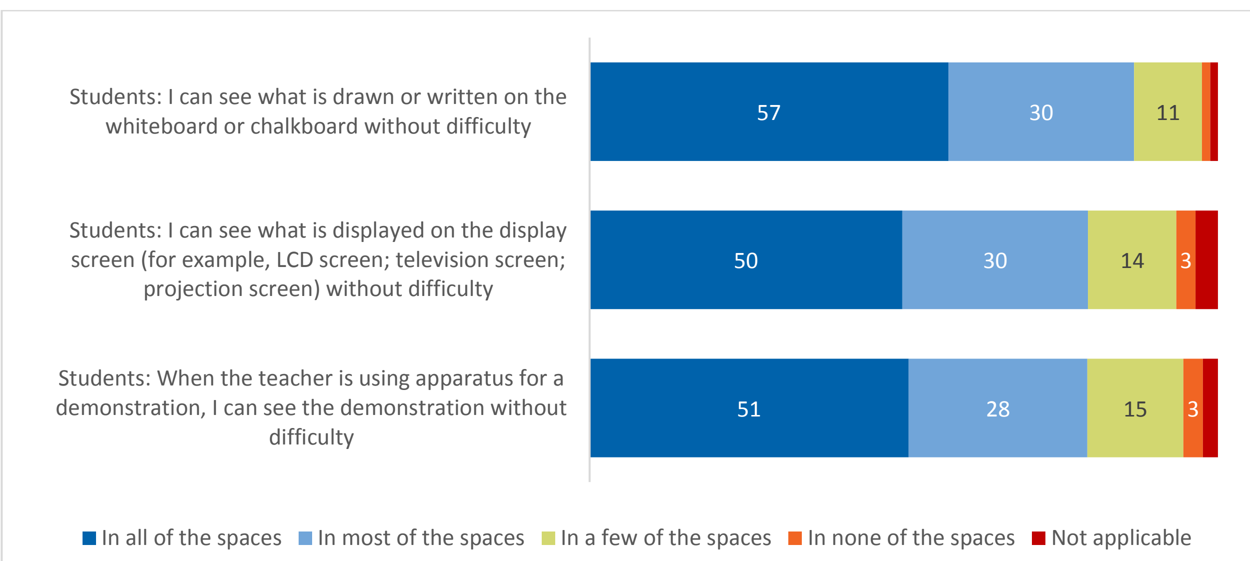
Figure 11: Perceived Air Quality in Learning Spaces



Source: OECD's SUS data.

As far as the lighting of learning spaces is concerned, students tended to claim that light was uncomfortable more often than teachers. It is surprising that they reported the lighting was too bright more frequently than being too dark. It is also worrisome that up to 20 percent of students reported that they could not see the demonstrations by the teachers when they used traditional boards, LCD projectors, or other technology (see Figure 12).

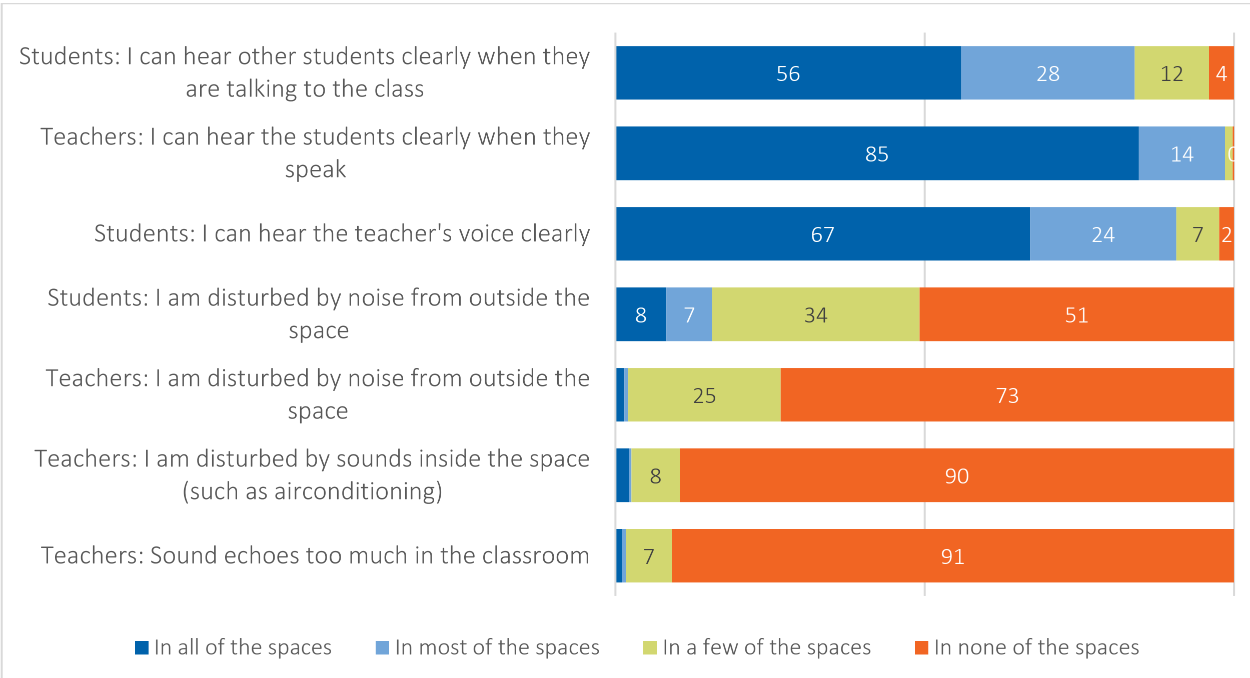
Figure 12: Students' Perceptions of Visibility in Learning Spaces Lit by Natural Daylight



Source: OECD's SUS data.

Auditory comfort is important for students to be able to understand what teachers say. The data show that most students could hear the teacher and their peers well, but both students and teachers were often irritated by noise coming from outside the learning space.

Figure 13: Perceived Auditory Quality of Learning Spaces



Source: OECD's SUS data.

To reach a deeper understanding of the data, the team created a physical environment index based on the physical infrastructure variables in the School User Survey (see Table 3).

Table 3: Components of the Physical Environment Index

Question	Answer options
11. When it is COLD outside, what is the temperature in the rooms where you have lessons or where you study on your own? a) Usually it's too cold for me there b) I'm usually too hot there c) Usually I feel comfortable there (neither too hot nor too cold)	1) In all of the spaces 2) In most of the spaces 3) In a few of the spaces 4) In none of the spaces
12. When it is HOT outside, what is the temperature in the rooms where you have lessons or where you study on your own? a) Usually it's too cold for me there b) I'm usually too hot there c) Usually I feel comfortable there (neither too hot nor too cold)	1) In all of the spaces 2) In most of the spaces 3) In a few of the spaces 4) In none of the spaces
13. What is your opinion of the air quality in the rooms where you have lessons or where you study on your own? a) Usually it doesn't smell like anything b) Usually there is a pleasant smell c) Usually there is an unpleasant smell	1) In all of the spaces 2) In most of the spaces 3) In a few of the spaces 4) In none of the spaces
14. When it is light outside, how do you rate the quality of lighting in those rooms where you study in class or on your own? a) Usually the light is too bright	1) In all of the spaces 2) In most of the spaces 3) In a few of the spaces

b) It's usually too dark in there c) Usually there is normal lighting (neither too bright, nor too dark)	4) In none of the spaces
15. Do you hear everything well in those rooms where you have lessons or where you study on your own? a) I can hear well what the teacher is saying b) I can clearly hear what other students say when they answer in the lesson c) I am disturbed by external noise	1) In all of the spaces 2) In most of the spaces 3) In a few of the spaces 4) In none of the spaces
16. Can you see everything that is taught clearly in different rooms? a) I can clearly see what they write or draw on the board " b) I can clearly see what is shown on the screen (LCD screen; TV screen; movie screen) c) When the teacher shows something with the help of a projector, I can see everything well	1) In all of the spaces 2) In most of the spaces 3) In a few of the spaces 4) In none of the spaces
17. How comfortable are the desks/tables and chairs in the rooms you use? a) The chairs are comfortable to sit in. b) I can choose a chair or adjust the seat height. c) I can select a table/desk or adjust its height.	1) In all of the spaces 2) In most of the spaces 3) In a few of the spaces 4) In none of the spaces

The physical environment index includes 21 variables for among others the temperature inside the classroom when it is cold/hot outside, visual and acoustic comfort, noise levels, smell, and the comfort of desks and chairs.

The results of the regression analysis confirmed the strong positive relationship between the physical environment in schools and students' test scores. The coefficients of the physical environment variables were positive and statistically significant in all of the model specifications that we tested. We controlled for student gender, age, and socioeconomic status (SES).[21] In models 2 to 3 and 5 to 6, we also controlled for school territory effects[22] to take into account all unobserved differences between schools, which led to the coefficient being halved. This is an indication of the homogeneity of schools in terms of students' SES, with the difference between the average and median student in terms of their SES being close to zero (-0.03).

A 10 percent improvement in the physical environment index is associated with a 0.9-1.0 improvement in TIMSS test scores other things being constant[23]. Students in the top 60 percent of schools by the physical environment index scored on average 15 test points higher, which is equivalent to roughly 3/4 of a year of schooling (see Table 4).

Table 4: OLS Regressions on Russian Students' TIMSS-2019 Test Scores in Math and Science

Dependent variable:	Math test scores			Science test scores		
	(1)	(2)	(3)	(4)	(5)	(6)
Log physical environment index (PEI)	20.86*** (5.14)	21.61*** (4.69)		22.34*** (4.59)	23.43*** (4.42)	

[21] The SES index combines background information on students' families such as the parents' educational attainment, the number of books at home, the possession of a computer or tablet, a study desk, their own room, an Internet connection, their own mobile phone, any musical instruments, a vehicle, an apartment with four or more rooms, and a dishwashing machine.

[22] Unit fixed effects regression models are used for causal inference with longitudinal or panel data (i.e., the data that tracks the same sample at different points in time) in the social sciences (e.g., Angrist and Pischke 2009). Many researchers use these models to adjust for unobserved, unit-specific, and time-invariant confounders when estimating causal effects from observational data. In our study, we use territorial fixed effects by including dummy variables (equal to 0 or 1) for schools in the regressions to capture all unobserved differences between educational institutions.

[23] For example, for Math scores in model (1): log(1.1)*20.86=0.863.

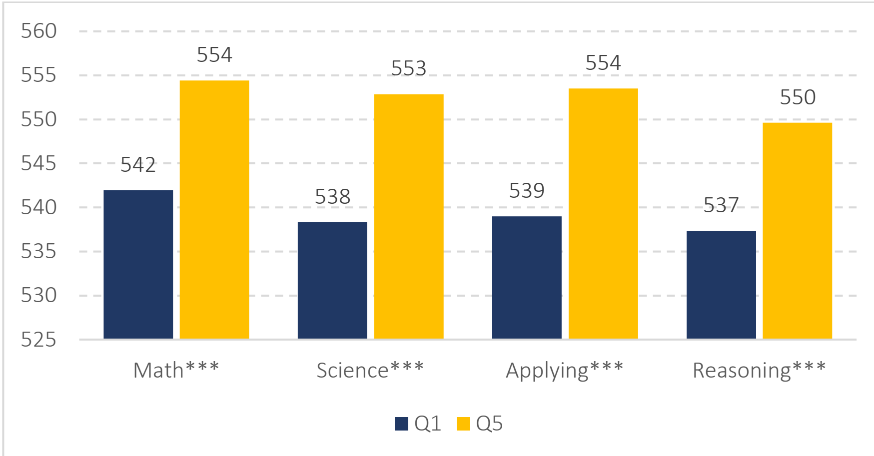
Log PEI Q2			5.67			7.03
			(4.55)			(4.29)
Log PEI Q3			14.72			13.39***
			(4.80)			(4.52)
Log PEI Q4			15.55			16.33***
			(4.78)			(4.51)
Log PEI Q5			14.33			16.37***
			(4.90)			(4.61)
Fixed territory effects (school)	No	Yes	Yes	No	Yes	Yes
Number of obs	1,747	1,747	1,747	1,747	1,747	1,747
Adj R-squared	0.16	0.48	0.48	0.17	0.43	0.43

Dependent variable:	Applying test scores			Reasoning test scores		
	(1)	(2)	(3)	(4)	(5)	(6)
Log physical environment index (PEI)	22.70***	23.59***		21.01***	22.14***	
	(4.87)	(4.53)		(4.62)	(4.31)	
Log PEI Q2			7.65*			6.58
			(4.40)			(4.18)
Log PEI Q3			15.16***			12.55***
			(4.64)			(4.41)
Log PEI Q4			18.22***			16.54***
			(4.62)			(4.40)
Log PEI Q5			15.89***			14.70***
			(4.73)			(4.50)
Fixed territory effects (school)	No	Yes	Yes	No	Yes	Yes
Number of obs	1,747	1,747	1,747	1,747	1,747	1,747
Adj R-squared	0.18	0.47	0.47	0.16	0.46	0.46

Source: Authors' estimations based on TIMSS-2019 and SUS-2019 data for Russia.
Notes: Standard errors are reported in parentheses. *** Statistically significant at p<0.01. ** Statistically significant at p<0.05. * Statistically significant at p<0.1

To depict this difference and its statistical significance, Figure 14 shows the difference in performance between students in schools with a good physical environment and students that reported issues with their schools' physical environment.

Figure 14: TIMSS 2019 Scores by Students in Schools with Good and Bad Physical Environments



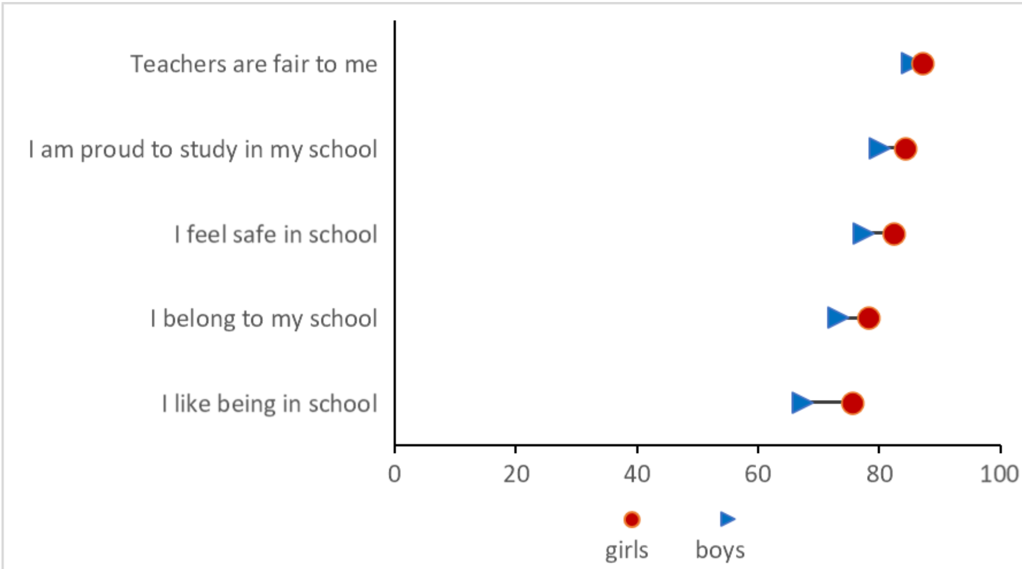
Source: Authors' calculations based on data from the SUS and TIMSS 2019.

5.2 School Atmosphere

Another important factor affecting school life and learning experiences is the atmosphere that prevails in schools. The extent to which students like to be in school or experience hardships or violence in school will affect their progress in learning and their wellbeing. Schools with a positive and supportive atmosphere for the students are those that are safe and free of violence. This kind of psychological climate is a key factor in fostering children's ability to learn.

To assess the quality of the psychological atmosphere, we constructed a school atmosphere index based on the TIMSS student's questionnaire. We built the index by using principal component analysis (PCA) on students' responses on a scale from 1 ("Disagree a lot") to 4 ("Agree a lot") to the following statements: (i) "I like being in school;" (ii) "I feel safe in school;" (iii) "I feel that I belong to this school;" (iv) "My teachers are fair to me;" and (v) "I am proud to study in my school" (see Figure 15).

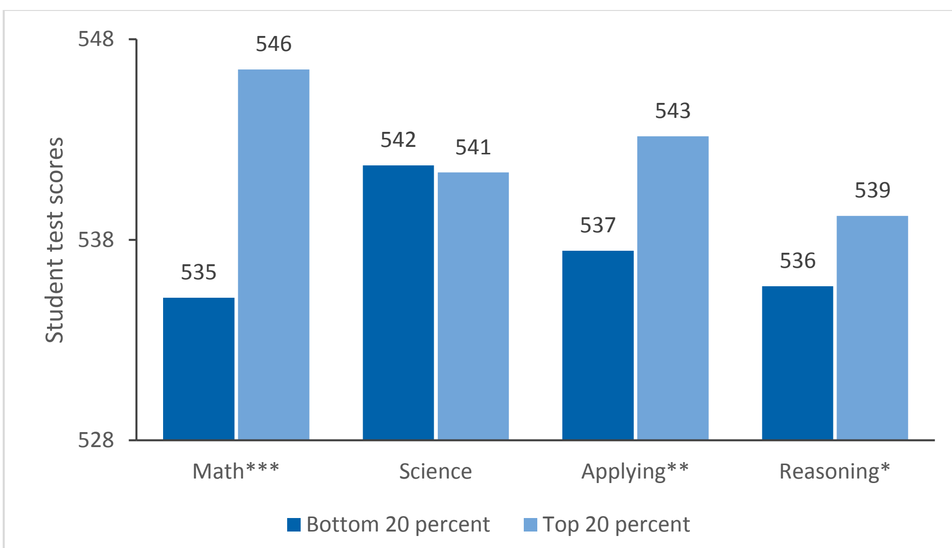
Figure 15: School Atmosphere Index Components – Gender Differences



Source: TIMSS survey data.

Students' perceptions of the school's atmosphere affect their learning outcomes. Our analysis showed that this was the case for their TIMSS scores on mathematics, applying, and reasoning. Scores in math were 11 points higher for students in those schools where the atmosphere was considered safer and more respectful towards the students than those from schools where the climate felt less accepting and supportive. There was also a statistical significance between the scores of these two groups in applying and reasoning, though less strong with a 6 and 3 point difference respectively. Again, this confirms that there is potential to improve the climate within some schools to better support learning (see Figure 16).

Figure 16: Student Scores by School Atmosphere Index Quintiles

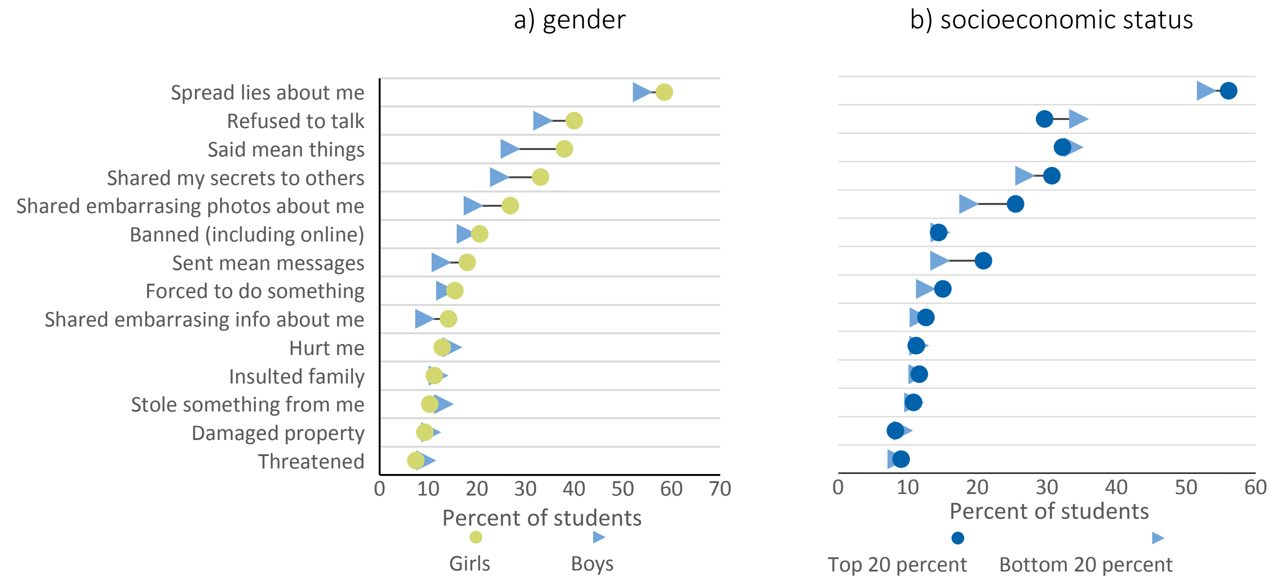


Source: Authors' calculations based on TIMSS and SUS data.

Similar to the school atmosphere index, we also created a bullying index using principal component analysis (PCA). The index consisted of students' responses on the scale from 1 to 3 (3 meaning at least once a week, 2 meaning one to two times per month, 1 meaning several times per year, and 0 meaning never) to the following nine statements, "Other students: (i) made fun of my clothes; (ii) said mean things about me; (iii) shared my secrets with others; (iv) refused to talk with me; (v) spread embarrassing information about myself (including photos); (vi) threatened me; (vii) hurt me; (viii) excluded me from groups, including online; or (ix) damaged my belongings on purpose."

According to the results, more bullying occurs between boys, mostly violent acts and verbal abuse. Girls spread lies, share each other's secrets, or refuse to talk more often than boys. However, the difference in the bullying index between girls and boys is not statistically significant (see Figure 17 below).

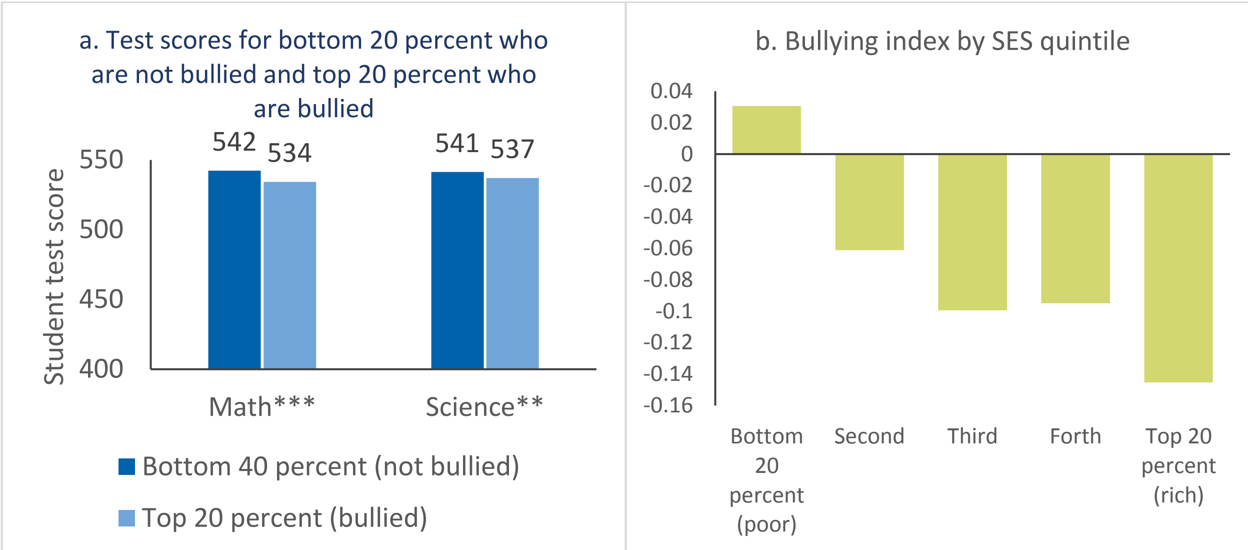
Figure 17: Prevalence of Bullying by Gender and Socioeconomic Status of Students



Source: OECD's SUS data.

More bullying occurs in schools with more students from low SES backgrounds. The SES of students plays a role in the frequency of this bullying as well. The distribution between quintiles shows that the maximum amount of bullying happens to students in the bottom 20 percent of the SES distribution.

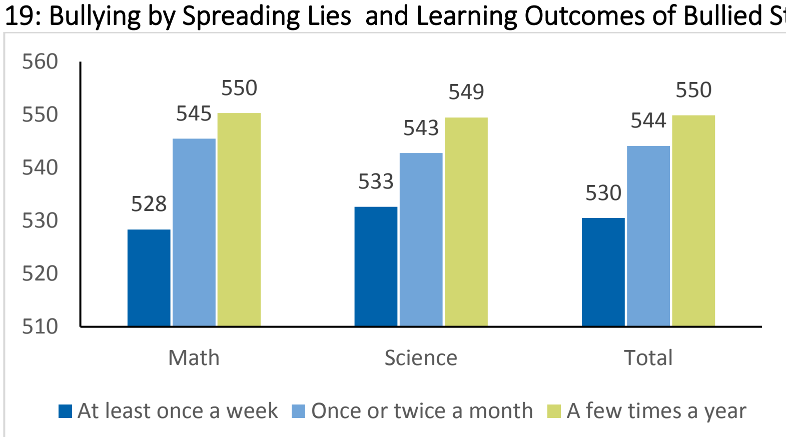
Figure 18: Bullying Index and Students' Test Scores, and Socioeconomic Status



Source: Authors' estimates based on the OECD's SUS data.

The most common type of bullying is by spreading lies and rumors, and the index shows that the impact of this bullying is significant (see Figure 19). The less the students are bullied, the better their learning outcomes are. The students who are bullied every week had the lowest math and science scores compared to those who suffered from bullying a few times per month or per year. The difference was as high as 22 points in math scores and 20 points in science, which is equivalent to almost a full year of schooling. Therefore, bullying is not only an issue of security and safety in schools, but it holds students back and impairs their ability to learn.

Figure 19: Bullying by Spreading Lies and Learning Outcomes of Bullied Students



Source: OECD's SUS data and TIMSS scores.

Thus, the issue of bullying is a multidimensional problem related to safety and security, learning outcomes, and equity. Tackling the issue of bullying can help to solve many problems faced by education systems and targeting the effort to students from the bottom 20 percent of the SES distribution is crucially important. The methods of bullying prevention and encouragement of positive attitudes among students, development of better social and communication skills should become a focus of teacher training programs.

A few other factors related to the climate in Russian schools emerged from the TIMSS data. For instance:

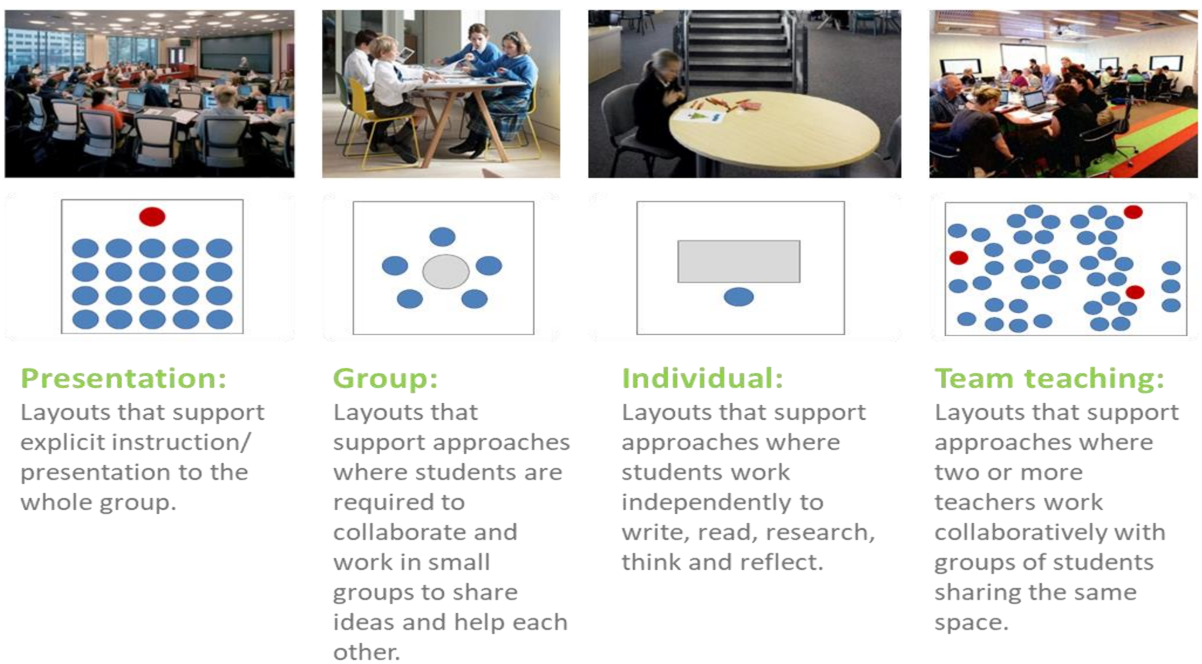
a) Only 62 percent of the sampled schools reported having any facilities or special infrastructure for students with disabilities, while 38 percent said that they had no such facilities.

b) Forty-three percent of girls and 37 percent of boys claimed that they came to school tired every day or almost every day according to TIMSS.
c) Twenty-nine percent of girls and 19 percent of boys said that they feel hungry every day or almost every day.

These statistics are worrisome and point to the need for education authorities to ensure that the basic needs of children are satisfied. It will need work with families and schools on tackling the fatigue and hunger. The inclusion needs specific attention as Russian schools strive to be 100 percent inclusive and accessibility is critical for the school infrastructure.

Teaching styles are another important component of schooling that greatly affect learning outcomes. The OECD's School User Survey categorizes four types of learning styles and related learning spaces: (i) presentation is the traditional transmission of knowledge via direct instruction; (ii) group work is the arrangement of students into smaller groups for discussions and joint work; (iii) individual work is self-paced independent learning; and (iv) team teaching is when a team of teachers works with a large group of students. According to this classification, these four teaching styles require different learning spaces and furniture (see Figure 20).

Figure 20: Types of Teaching and Learning Styles as Defined by the OECD's School User Survey



Source: OECD's SUS data.

This full-scale TIMSS/SUS study showed that most Russian teachers favor the direct instruction style, using it either every day (77.6 percent) or at least two to four times per week (11.6 percent). Individual work is also common for the schools. This shows that the traditional form of teaching prevails in Russian schools.

Modern teaching practices, such as team teaching and group work, are used in Russian schools too but, as previous studies suggested, are not a common practice. Team teaching is still rare in Russian schools, with 63.6 percent of teachers saying that it never happens in their schools, 21.3 percent saying it is used one to three times a month, and 2.4 percent saying it is used every day. To gain a deeper understanding of team teaching in Russian schools and how teachers perceive it, we asked teachers how they collaborate and use the learning spaces (see Section 6.5). Group work is used in the sampled schools to different degrees but not every day.

Table 5: Frequency of Use of Different Teaching Styles by Teachers in their Practice

TEACHING STYLE	Never	1-3 times per month	1 per week	2-4 per week	Every day	Missing
Direct instruction (presentation)	1.1	3.1	3.7	11.6	77.6	2.9
Small group instruction	20.5	40.3	19.1	12.0	3.2	4.8
Individual learning	28.3	23.5	19.0	15.6	8.8	4.8
Team teaching	63.6	21.3	4.3	2.8	2.4	5.6

Source: OECD's SUS data.

The results of SUS survey suggest that there is potential for increasing the application of modern teaching methods in Russian schools. Teachers reported that they would like to use these pedagogical methods if they received the necessary resources and had access to the appropriate learning environments to conduct such lessons (see Table 6).

Table 6: Teachers Willing to Implement Traditional and Modern Teaching Styles

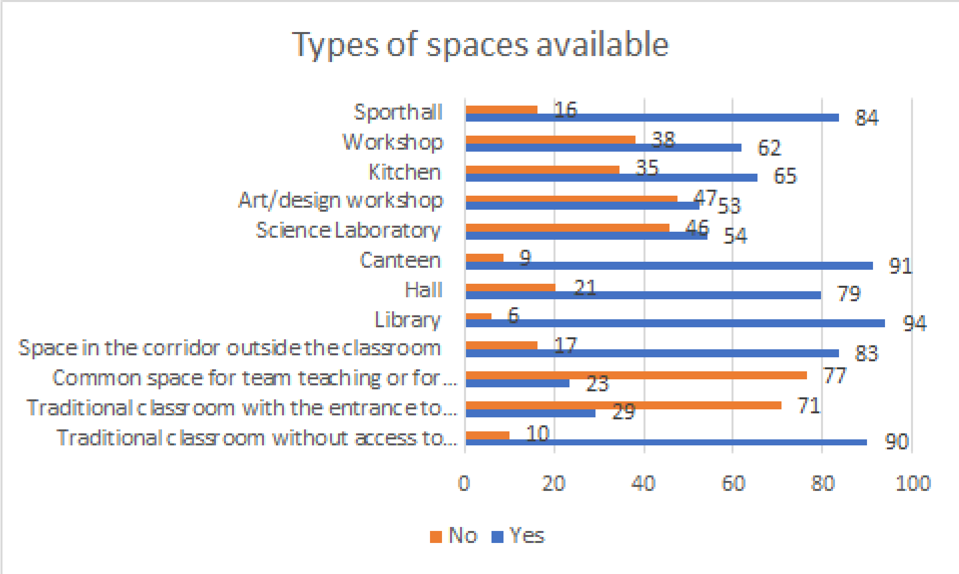
TEACHING STYLE	Never	1-3 times per month	1 per week	2-4 per week	Every day	Missing
Direct instruction (presentation)	1.2	5.9	11.0	23.2	56.3	2.4
Small group instruction	5.4	26.5	29.1	26.7	8.6	3.7
Individual	7.0	22.7	29.4	22.6	14.8	3.6
Team teaching	34.1	42.5	9.7	6.4	2.6	4.7

Source: OECD's SUS data.

When asked about the ability to rearrange spaces in schools, teachers said that few spaces in school allow for a diversity of teaching styles. Most spaces are designed for direct teaching, though some rearrangement is usually possible to accommodate group work, but very few of them provide the necessary flexibility for team teaching.

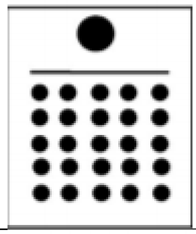
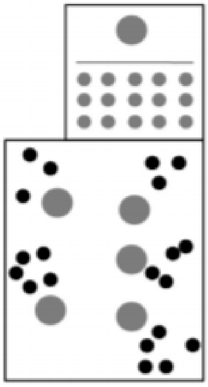
Another question in the SUS asked about the availability of certain types of spaces in schools. This question alone revealed the extent of the deficits in Russian schools. For example, 77 percent of schools have no common spaces for arranging team teaching, 71 percent have no classrooms with access to breakout spaces or smaller rooms to enable small group work, 46 percent have no art/design workshops, 46 percent have no science labs, 38 percent have no workshops, and 35 percent have no kitchens (see Figure 21).

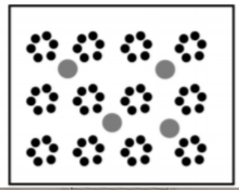
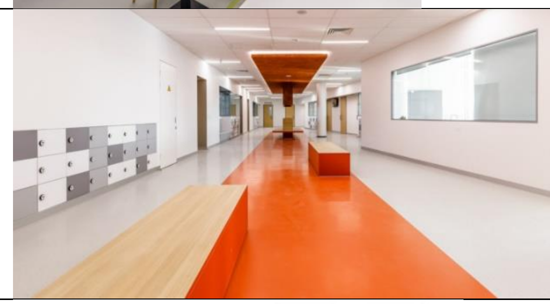
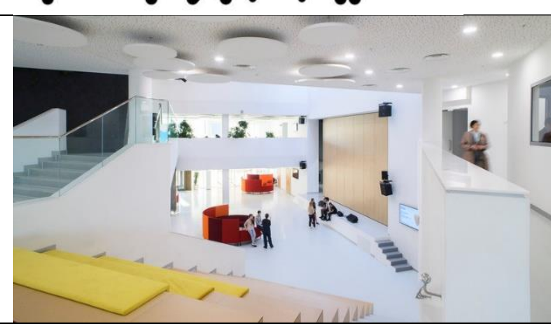
Figure 21: Types of Spaces Currently Available in Russian Schools According to Teachers, (percentage)



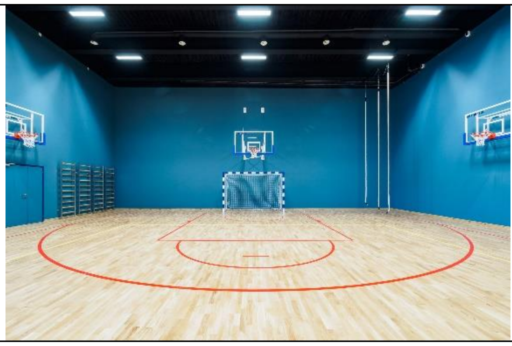
Source: OECD's SUS data.

Table 7: Spaces and Layouts

Traditional classroom with no access to other rooms/additional spaces	
Traditional classroom with the entrance to other spaces (for group or individual work)	 

Common space for team teaching or for interaction of teachers and pupils, for group or individual work	 
Space in the corridor outside the classroom	
Library	
Hall	

Canteen	
Science Laboratory	
Art/design workshop	
Kitchen	
Workshop	

Sport hall	

Source of pictures: Letovo school (Moscow oblast), Horoshkola school (Moscow), Chicago School of Woodworking.

As discussed above, most Russian teachers still tend to use traditional pedagogical methods, although some teachers do try to apply modern methods. However, they are often unable to do so because of these inadequate learning facilities. Our findings demonstrate the need to develop learning environments that support team teaching and group work and to devise other incentives to encourage teachers to use modern methods more regularly.

Earlier we have established a link between the existence of a diversity of teaching styles and student performance. The full sample of TIMSS 2019 in Russia allowed us to look back at those findings and expand on them, including the cognitive domains of reasoning and applying. In order to analyze the relationship between modern teaching and learning and student scores, we built a modern teaching environment index, again using principal component analysis (see Table 8). This index comprises three variables consisting of: (i) the frequency of use of direct teaching; (ii) the frequency of use of individual work teaching practices; and (iii) a dummy variable that equals 1 when furniture is being moved in the classroom during lessons (as reported by students).

Table 8: Components of the Modern Teaching Environment Index

Question	Answer options
19. How often do you work in classrooms that match the space/furniture layouts shown in the picture above? a) Type A: Furniture arrangement designed for one teacher/student to speak to the entire group of students b) Type B: Furniture arrangement for small group learning c) Type C: Furniture arrangement for independent student work d) Type D: Furniture arrangement for team teaching (by several teachers)	1) Never or hardly ever 2) 1-3 times a month 3) once a week 4) 2-4 times a week 5) Everyday
20. Do you have to rearrange the furniture in the areas where you work most often to ensure that the organization of the space suits your activities?	1) Yes 2) No

The results of our regression analysis confirmed the strong positive relationship between the teaching and learning environment and student test scores. The coefficients of the variables for the modern teaching environment index were positive and statistically significant in all of the model specifications that we tested. We controlled for students; gender, age, and socioeconomic status. In models 2 to 3 and 5 to 6, we also controlled for school territory effects to take into account all unobserved differences between schools. On this index, boys outperformed girls in all subjects by six to seven test points. The SES coefficients were statistically significant in all of the model specifications, although controlling for school territorial effects (in models 2 to 3 and 5 to 6) led to the coefficient being halved. This is an indication of the homogeneity of schools in terms of students' SES, with the difference between the average and the median student's SES index being close to zero (-0.03).

A 10 percent improvement in the learning environment index is associated with a 1.0-1.2 improvement in TIMSS test scores other things being constant[24]. Students in schools where teachers practice modern learning styles (top 40 percent of the modern teaching index, i.e. Q4-Q5) scored up to 30 test points higher than their peers in more traditional schools where teachers use direct teaching methods most of the time.

Table 9: OLS Regressions on TIMSS-2019 Test Scores in Math and Science

Dependent variable:	Math test scores			Science test scores		
	(1)	(2)	(3)	(4)	(5)	(6)
Gender (girl=1)	-5.53	-6.36**	-5.57*	-6.22**	-5.79**	-4.93*
	(3.45)	(2.88)	(2.89)	(3.08)	(2.71)	(2.72)
Age	4.55	-0.12	-0.48	7.14**	-0.18	-0.60
	(3.16)	(2.77)	(2.77)	(2.82)	(2.61)	(2.61)
Log SES index	128.11***	58.59***	57.12***	115.42***	60.43***	59.29***
	(7.74)	(7.64)	(7.67)	(6.92)	(7.20)	(7.22)
Log modern teaching index (MTI)	26.72***	23.52***		26.60***	24.95***	
	(5.04)	(4.40)		(4.50)	(4.15)	
Log LEI Q2 (dummy variable)			4.62			4.55
			(4.53)			(4.27)
Log LEI Q3 (dummy variable)			17.09***			16.72***
			(4.62)			(4.35)
Log LEI Q4 (dummy variable)			8.82*			14.05***
			(4.96)			(4.67)
Log LEI Q5 (dummy variable)			26.32***			29.88***
			(4.79)			(4.51)
Fixed territory effects (school)	No	Yes	Yes	No	Yes	Yes
Number of obs.	1,747	1,747	1,747	1,747	1,747	1,747
Adj R-squared	0.16	0.48	0.48	0.17	0.43	0.43

Source: Authors' estimations based on TIMSS 2019 and SUS 2019 data for Russia.
Notes: Standard errors are reported in parentheses. *** statistically significant at p<0.01. ** statistically significant at p<0.05. * statistically significant at p<0.1.

Table 10: OLS Regressions on TIMSS-2019 Test Scores in Applying and Reasoning

Dependent variable:	Applying test scores			Reasoning test scores		
	(1)	(2)	(3)	(4)	(5)	(6)
Gender (girl=1)	-8.03**	-7.96***	-7.18*	-6.44**	-6.71**	-5.95**
	(3.27)	(2.78)	(2.79)	(3.10)	(2.64)	(2.66)
Age	5.95**	0.14	-0.27	4.79*	-0.13	-0.53
	(2.99)	(2.67)	(2.67)	(2.84)	(2.54)	(2.54)
Log SES index	127.98***	64.46***	62.97***	114.39***	51.70***	50.32***
	(7.33)	(7.38)	(7.41)	(6.96)	(7.02)	(7.05)
Log modern teaching index (MTI)	29.66***	26.47***		25.97***	23.96***	

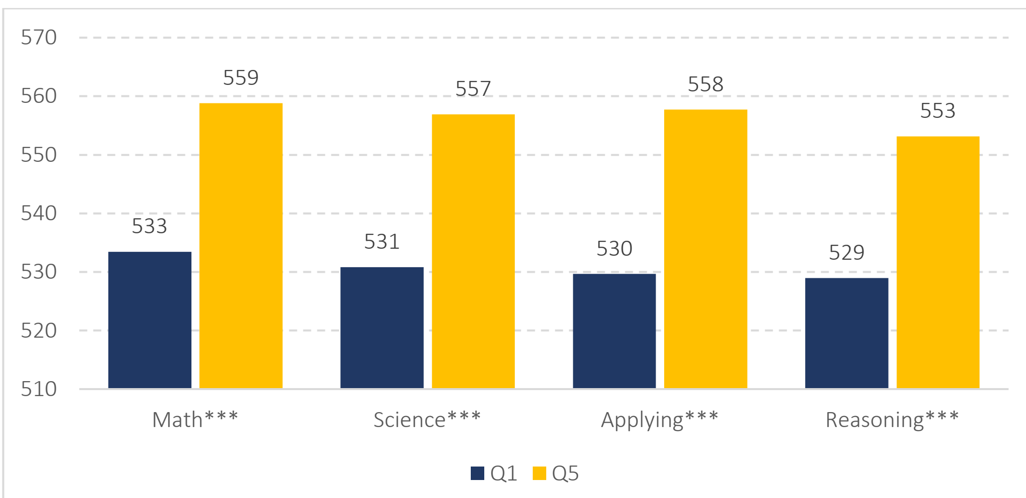
[24] For example, for Math scores in model (1): log(1.1)*53.73=1.106.

	(4.77)	(4.25)		(4.53)	(4.04)	
LEI Q2 (dummy variable)			6.84			5.72
			(4.38)			(4.16)
LEI Q3 (dummy variable)			18.24***			16.19***
			(4.47)			(4.25)
LEI Q4 (dummy variable)			12.41***			11.12**
			(4.79)			(4.55)
LEI Q5 (dummy variable)			29.79***			28.56***
			(4.63)			(4.40)
Fixed territory effects (school)	No	Yes	Yes	No	Yes	Yes
Number of obs.	1,747	1,747	1,747	1,747	1,747	1,747
Adj R-squared	0.18	0.47	0.47	0.16	0.46	0.45

Source: Authors' estimations based on TIMSS 2019 and SUS 2019 data for Russia.
Notes: Standard errors are reported in parentheses. *** statistically significant at p<0.01. ** statistically significant at p<0.05. * statistically significant at p<0.1.

This analysis confirms the findings of our previous studies in a more robust way as the larger sample enabled the team to control for the socioeconomic status of the students. With all controls, it is clear that modern teaching can have a strong effect on student performance (see Figure 22).

Figure 22: TIMSS 2019 Test Scores by Modern Teaching Environment Index



Source: Authors' calculations based on SUS and TIMSS 2019 data.

During the study, we also used a deeper analytical lens to try to capture the particular factors that affect the learning outcomes of students as well as to draw causal links among teacher quality, students' learning environment, their academic achievements, and their wellness. Specifically, this analysis compares the mediation effects of teacher quality and learning space on students' outcomes through their distinct teaching styles – modern or traditional – in math.

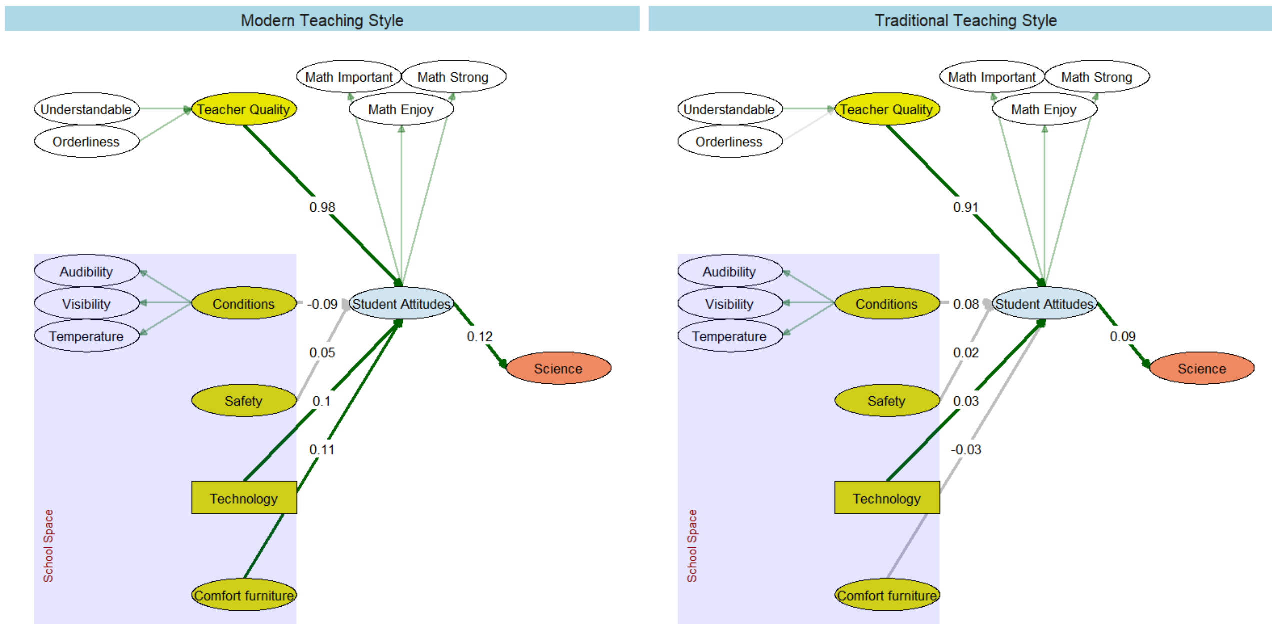
5.3 Teaching and Learning and Student Performance

In previous chapters, we demonstrated a link between a diversity of teaching styles and student performance. The TIMSS 2019 dataset provided us with a representative sample for the entire Russian Federation that allowed us to expand on these links. In this section, we explore the relationships between three variables – teacher quality, the quality of physical space, and students' attitudes towards learning, – and how these variables in turn affected student achievement as measured in TIMSS 2019.

We further seek to understand how, if at all, the nature of these inter-relationships varies between our measures of modern and traditional teaching styles. Since many of these variables are not directly observable, we estimated them as latent constructs. We also posit the existence of sequential or structural relationships between these latent constructs – for instance, we posit that teacher quality affects student motivation, which in turn affects student test scores. Our estimation of latent constructs was based on a method called confirmatory factor analysis or CFA, which is very similar to the PCA method used earlier in the analysis. Both are ways to reduce the dimensionality of the measurement of a construct, with CFA being more appropriate to use in this context. The subsequent estimation of regression equations using the latent CFA constructs is the so-called structural part of the model, and taken together, the set-up is referred to as structural equation modelling or SEM (Pearl, 2012).

The findings of the SEM model are laid out in Figure 23, which is called a path diagram in the SEM literature. The path diagram includes directional arrows, which are conceptually equivalent to the left-hand side and right-hand side of conventional regression equations. The variable at the end of the arrowhead is the dependent variable in the regression, and the variables at the tail end are the independent variables in a regression. (Figure 23 uses science scores as the ultimate outcome variable, while path diagrams for math scores, math applying, and student wellness as outcomes are presented in Annex 1.) A path diagram such as Figure 23 is a simple way to present regression coefficients of a model that is inherently somewhat complicated. The complication arises from the unobserved nature of many of the variables. For instance, we do not have a direct or explicit measure of such constructs as teacher quality or student motivation. Rather, we posit that teacher quality is a variable that reflects qualities such as being well-organized, having an orderly set of teaching materials, and being easily understood by their students when they explain something. This is not an exact measure of good teaching, but it seems reasonable to posit that teaching quality can be meaningfully measured by students' perceptions of a teacher's orderliness and students' understanding of the material, data on both of which are available in the TIMSS dataset. In Figure 23, it is clear that, in the case of both modern and traditional teaching styles, there is a strong relationship between teacher quality and positive student attitudes. The factors are constructed to have a mean of zero and a variance of 1, so this means an effect of nearly 1 for both teaching styles.

Figure 23: Path Diagram with Science Scores as an Outcome



Source: OECD's SUS and TIMSS 2019 data.
Note: Green links depict positive statistically significant effects, while grey links depict statistically insignificant effects.

Data

The data in the path diagram came from the SUS survey and TIMSS study, which were both conducted in 2019 and which we merged in such a way that all observations displayed unique entries representing students so all teacher-related characteristics were averaged by students. Table 11 specifies the measurement details of the variables used in the analysis, while Annex Table 1.1 contains descriptive statistics of the main observed characteristics that we studied.

Table 11: Description of the Variables

Q №	Variable /Construct	Measurement Details
		TIMSS
-	Math and science scores and their subcategories (applying and reasoning)	Reflective factors constructed on the basis of the five plausible values for each subject.
13	Wellness	A reflective factor created on five statements about students' feelings: "I like being at school," "I like to see my classmates at school," "I am proud to go to this school," "I feel I am part of this school," and "teachers at the school are fair to me." The concept sets out students' overall perception of a school, its teachers, and its activities.
16, 19, 20	Students' beliefs and attitudes towards mathematics	A second-order reflective factor is composed of three factors representing whether students enjoy math, if they think math is important, and if they are good at math.
17, 18	Teacher quality	A formative construct, which included two reflective factor components depicting if a teacher is understandable and if classes are well-organized.

SUS Teachers		
24, 26	Teaching style	*Traditional style*: If students reply that teachers use layouts that support explicit instruction/presentation or individual work every day and never need to rearrange tables, chairs, or other aspects of the space (e.g., sliding partitions) prior to the start of a lesson because a previous user had them in a different position. *Modern style*: If at least one of the above-mentioned criteria is not met.
SUS Students		
25	Technology	The number of learning tasks for which technology devices were used in a typical week.
24	Safety	A reflective factor based on manifest variables about feeling at ease in the school.
17	Comfortable furniture	A reflective factor based on items about the comfort of desks/tables and chairs in the rooms that students use.
15, 16, 11, 12	Conditions	A second-order reflective construct composed of three factors: *audibility* (students hear everything clearly in the rooms where they have lessons), *visibility* (students clearly see everything that is shown in different rooms), and *temperature* (the temperature in the rooms is comfortable).

The results of the measurement model (the initial construction of latent variables) indicated that the model presented in Figure 23 is based on latent variables that are uni-dimensional and valid (Hair et al, 2009). All indicators were significantly ($p < 0.001$) loaded on the respective unobserved variables and were comparatively balanced. As maximum likelihood estimation is based on a grid search algorithm that seeks to correctly find a global maximum, we examined a measure called composite reliability, which appeared to be larger than 0.7 for each construct. This indicated the sound convergent validity of the measurement models. The average variance extracted values for all latent variables were above the required cut-point of 0.5, signifying the adequate discriminant validity of the factor solutions. Discriminant validity is another measure of the quality of a model. Overall, these findings are evidence of the good approximating capacity of the models that we used and their internal consistency.

The evaluation of the structural models for each learning outcome also revealed acceptable fit parameters. They encompassed teacher quality components and school environment characteristics as exogenous variables and students' attitudes and learning achievements as endogenous variables. As depicted in Table 12, teacher quality positively affected all outcomes by cultivating students' positive attitudes towards math. Likewise, technology use (operationalized as the number of learning tasks for which technology devices were used in a typical week) demonstrated a positive mediated influence on all outcomes under consideration. The rest of the effects were not statistically significant.

Table 12 (rows 1 through 5) presents the details of the model schematically represented in Figure 23 for science scores as an outcome variable. The table also presents results for overall math scores, for the applying and reasoning domains of the math scores, and for the outcome of student wellness. Statistically significant results are highlighted.

Table 12: Structural Mediated Associations for Full Sample and Subsamples

		Full Sample			Traditional Teaching			Modern Teaching		
		Est	SE		Est	SE		Est	SE	
01	Teacher Quality -> Students' Attitudes -> Science	0.095	0.013	***	0.086	0.016	***	0.119	0.025	***
02	Comfortable Furniture -> Students' Attitudes -> Science	0.000	0.003		-0.003	0.004		0.013	0.008	†
03	Safety -> Students' Attitudes -> Science	0.003	0.004		0.002	0.005		0.006	0.009	
04	Conditions -> Students' Attitudes -> Science	0.003	0.005		0.007	0.005		-0.010	0.010	

05	Technology -> Students' Attitudes -> Science	0.005	0.001	***	0.003	0.002	*	0.012	0.004	**
06	Teacher Quality -> Students' Attitudes -> Math	0.203	0.015	***	0.195	0.018	***	0.230	0.029	***
07	Comfortable Furniture -> Students' Attitudes -> Math	-0.001	0.007		-0.008	0.009		0.023	0.015	
08	Safety -> Students' Attitudes -> Math	0.009	0.009		0.006	0.010		0.013	0.018	
09	Conditions -> Students' Attitudes -> Math	0.006	0.010		0.015	0.012		-0.022	0.020	
10	Technology -> Students' Attitudes -> Math	0.011	0.003	***	0.007	0.003	*	0.023	0.006	***
11	Teacher Quality -> Students' Attitudes -> Wellness	0.348	0.025	***	0.358	0.030	***	0.327	0.042	***
12	Comfortable Furniture -> Students' Attitudes -> Wellness	0.003	0.012		-0.011	0.015		0.035	0.020	†
13	Safety -> Students' Attitudes -> Wellness	0.015	0.014		0.009	0.018		0.018	0.024	
14	Conditions -> Students' Attitudes -> Wellness	0.015	0.017		0.034	0.022		-0.027	0.027	
15	Technology -> Students' Attitudes -> Wellness	0.019	0.005	***	0.014	0.006	*	0.032	0.008	***
16	Teacher Quality -> Students' Attitudes -> Applying	0.199	0.015	***	0.189	0.017	***	0.230	0.028	***
17	Comfortable Furniture -> Students' Attitudes -> Applying	0.000	0.007		-0.008	0.008		0.024	0.015	
18	Safety -> Students' Attitudes -> Applying	0.009	0.009		0.005	0.010		0.013	0.018	
19	Conditions -> Students' Attitudes -> Applying	0.006	0.010		0.015	0.012		-0.022	0.020	
20	Technology -> Students' Attitudes -> Applying	0.011	0.003	***	0.007	0.003	*	0.023	0.006	***
21	Teacher Quality -> Students' Attitudes -> Reasoning	0.204	0.016	***	0.197	0.018	***	0.226	0.029	***
22	Comfortable Furniture -> Students' Attitudes -> Reasoning	0.000	0.007		-0.008	0.009		0.023	0.015	
23	Safety -> Students' Attitudes -> Reasoning	0.009	0.009		0.006	0.010		0.013	0.017	
24	Conditions -> Students' Attitudes -> Reasoning	0.006	0.010		0.015	0.012		-0.021	0.020	
25	Technology -> Students' Attitudes -> Reasoning	0.011	0.003	***	0.007	0.003	*	0.022	0.006	***
Sig: ***$p < 0.001$, ** $p < 0.01$, * $p < 0.05$, † $p < 0.1$; Blue tint refers to the Figure 23										

The results showed that the positive effects of technology on math, science, applying scores, and wellness were greater in magnitude for the modern style than for the traditional teaching model. The comfort of classroom furniture is associated with higher academic achievements in science and wellness, but this applies only to students exposed to modern learning, whereas for the traditional style model, these associations were not shown to differ in the general sample. No statistically significant group discrepancies were identified in the effect of teacher quality on students' academic outcomes and wellness.

The findings allow us to conclude that both modern and traditional educational models are conducive to producing better grades in math and science and also to enhancing the applying and reasoning of mathematical knowledge. The findings also indicate that the built environment – including both the quality of the furniture and the use of technology in the classroom – provides additional achievement-related benefits to students who are taught using a modern teaching style. Within the confines of the modeled environment, these are causal relationships.

5.4 Nurturing 21st-century Skills in Teaching and How This Impacts TIMSS Results

In this carrying out analysis, we have had to contend with a lack of data and instruments for assessing students' acquisition of 21st-century skills. TIMSS 2019 itself does not directly measure socio-emotional skills, but the TIMSS categories of reasoning and applying represent higher-order cognitive skills, so we chose to include them in our analysis. The TIMSS questionnaire also asks a lot of process questions of teachers and students, the answers to which have helped us to make inferences about certain kinds of behavior and abilities that teachers nurture in their students that relate to 21st-century skills.

In this section, we discuss these teaching practices that are related to the stimulation of higher-order cognitive and social skills. We conducted an analysis of the teacher and student context questionnaires provided by TIMSS for the 8th-grade study. The questions were related to certain teaching and learning practices that support the development of five specific 21st-century skills, namely: problem-solving, decision-making, critical thinking, communication and collaboration, and project work. The detailed distribution of the questions and their coding is provided in Table 13 below.

We also constructed indexes for each of these skills with variables corresponding to the questions in TIMSS 2019 and correlated them with the cognitive and subject domains of TIMSS 2019. The indexes were created using teachers' responses about how often they took certain actions during classes as self-reported in their replies to the TIMSS questionnaire. Students were split into two groups using the median values of the indexes for the frequency of actions taken by teachers during their classes.

Table 13: Twenty-first Century Skills and Teaching Practices in Schools

Skill description	Questionnaire type	Question and response option
Problem-solving	Teacher questionnaire (mathematics)	*12. How often do you do the following in teaching this class?*
		C) Ask students to complete challenging exercises that require them to go beyond the instruction
		15. In teaching mathematics to this class, how often do you ask students to do the following?
		g) Work on problems for which there is no immediately obvious solution
	Teacher questionnaire (science)	*12. How often do you do the following in teaching this class?*
		C) Ask students to complete challenging exercises that require them to go beyond the instruction.
		15. In teaching this class, how often do you ask students to do the following?
		b) Observe natural phenomena and describe what they see
		e) Conduct experiments or investigations
		k) Use formulas and laws to solve problems
Decision making	Teacher questionnaire (mathematics)	*12. How often do you do the following in teaching this class?*
		F) Ask students to come up with their own problem-solving procedures

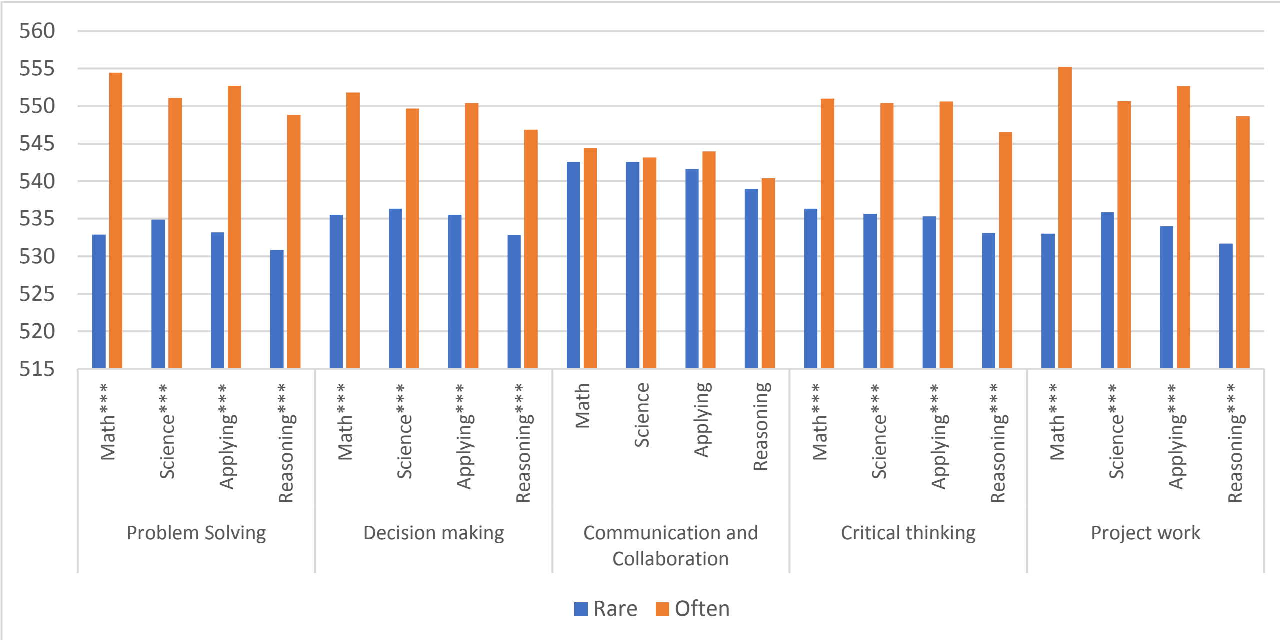
		19. C. How often do you do the following with the mathematics homework assignments for this class?
		b) Have students correct their own homework
	Teacher questionnaire (science)	*12. How often do you do the following in teaching this class?*
		F) Ask students to come up with their own problem-solving procedures
		18. C. How often do you do the following with the mathematics homework assignments for this class?
		b) Have students correct their own homework
Critical thinking	Teacher questionnaire (mathematics)	*12. How often do you do the following in teaching this class?*
		A) Relate the lesson to students' daily lives
		E) Link new content to students' prior knowledge
		G) Encourage students to express their ideas in class
		19. C. How often do you do the following with the mathematics homework assignments for this class?
		b) Have students correct their own homework
		23. In the past two years, have you participated in professional development in any of the following?
		e) Improving students' critical thinking or problem-solving skills
	Teacher questionnaire (science)	*12. How often do you do the following in teaching this class?*
		A) Relate the lesson to students' daily lives
		E) Link new content to students' prior knowledge
		G) Encourage students to express their ideas in class
		15. In teaching this class, how often do you ask students to do the following?
		h) Use evidence from experiments or investigations to support conclusions
		18. C. How often do you do the following with the homework assignments for this class?
		b) Have students correct their own homework
		22. In the past two years, have you participated in professional development in any of the following?
		e) Improving students' critical thinking or inquiry skills
Communication and collaboration	Teacher questionnaire (mathematics)	*12. How often do you do the following in teaching this class?*
		B) Ask students to explain their answers
		D) Encourage classroom discussions among students
		15. In teaching mathematics to this class, how often do you ask students to do the following?
		h) Work in mixed mathematical ability groups
		i) Work in same mathematical ability groups
	Teacher questionnaire (science)	*15. In teaching this class, how often do you ask students to do the following?*
		G) Interpret data from experiments or investigations
		15. In teaching this class, how often do you ask students to do the following?
		m) Work in mixed ability groups
		n) Work in same ability groups

	Student questionnaire	*12. Do you use the Internet to do any of the following tasks for schoolwork (including classroom tasks, homework, or studying outside of class)?*
		c) Collaborate with classmates on various projects
		16. To what extent do you agree/disagree with the following statements about your mathematics lessons?
		n) My teacher asks us to discuss with each other how to solve problems
		21. To what extent do you agree/disagree with the following statements about your biology lessons?
		n) My teacher encourages me to discuss the results of our biology experiments
		25. To what extent do you agree/disagree with the following statements about your earth science lessons?
		n) My teacher encourages me to discuss the results of our earth science experiments
Project work	Teacher questionnaire (mathematics)	*20. How much importance do you place on the following assessment strategies in mathematics?*
		e) Long-term project
	Teacher questionnaire (science)	*19. How much importance do you place on the following assessment strategies in science?*
		e) Long-term project
		15. In teaching this class, how often do you ask students to do the following?
		d) Plan experiments or investigations

Source: Authors' compilation based on TIMSS 2019.

Once we had identified the five skills from the teacher questionnaire, we looked at the effect of the teaching activities designed to stimulate the acquisition of those socio-emotional and higher-order cognitive skills on student learning outcomes. Our hypothesis was that these activities would be producing better learning outcomes in the subject domains of TIMSS 2019 and in the cognitive domains of reasoning and applying. Figure 24 shows the results of the correlations based on the categorization of the use of certain teaching and learning practices as "rare" or "often." It is clear that if teachers use these practices often, then the effect on the subject and cognitive outcomes of students is positive and strong in all skills except communication and collaboration.

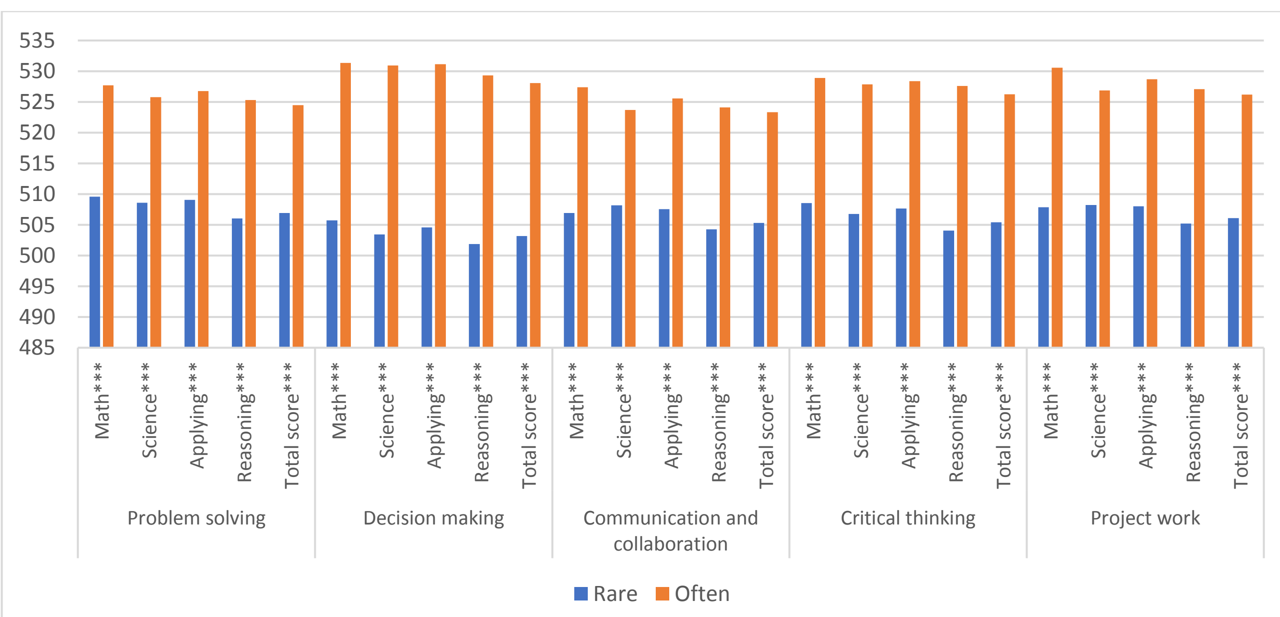
Figure 24: The Interdependence of Stimulated 21st-century Skills and TIMSS 2019 Scores



Source: Authors' estimates based on the TIMSS 2019 data.

While there is a strong correlation between the indexes representing the stimulated skills (apart from the communication and collaboration) and the cognitive and subject domains of TIMSS 2019, we were also interested to see if this correlation held in the case of students from families with low SES. We found a stronger correlation across all tested indexes, including communication and collaboration, but unfortunately, the scores of students from the bottom 40 percent of the socioeconomic distribution were far lower than the average scores in TIMSS 2019 (see Figure 25).

Figure 25: The Interdependence of Stimulated 21st-century Skills and the TIMSS 2019 Scores of Students in the Bottom 40 percent of the Socioeconomic Distribution



Source: Authors' estimates based on the TIMSS 2019 data.

What we conclude from the findings of this analysis is that helping students to acquire 21st-century skills plays a key role in enhancing students' academic performance, especially those from poorer socioeconomic backgrounds. Implementing these teaching and learning practices at scale has the potential to generate enormous gains in learning outcomes in Russia.

5.5 ICT in Schools and Students' Information and Communication Literacy

ICT is widely used in Russian schools, but any issues with availability or connectivity have been exacerbated by the abrupt transition to distance learning because of the COVID-19 crisis. In this process, the Russian government relied on its previous experience with equipping all schools with internet connectivity and reforming the curriculum towards the use of ICT in teaching. While hardware was widely available, software support and learning platforms were not well-developed. The most reliable platform that was being used by Russian teachers was the Moscow Electronic School (https://hundred.org/en/innovations/moscow-electronic-school#1a343044). The Ministry for Education also quickly created the Russian Electronic School (https://resh.edu.ru/) to respond to the sudden massive need for quick and reliable learning materials. This platform will continue to be developed to ensure the education system has the resilience to withstand any future crises.

The use of ICT by teachers in their day-to-day practice is one of the predictors of their students' IC literacy. The statistics provided by teachers in the School User Survey showed that students' most common ICT-related activity is homework, which is mostly unrelated to teachers, and they very rarely use ICT for such activities as collaborating with other students or doing online research. Other ways in which they use ICT are for watching the videos, preparing presentations, creative expression, and assessing and practicing skills, most of which they do at least once a week (Table 14).

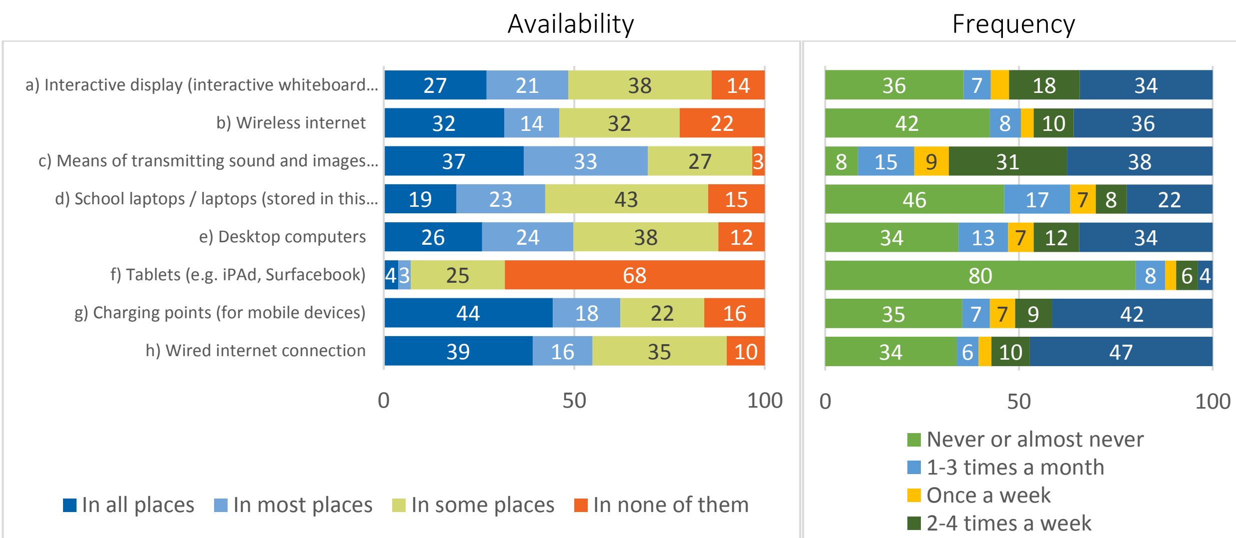
Table 14: Frequency of Use of ICT by Students in Different Activities

	Never	Once a week	2-4 time a week	Every day
a) Online research	54.28	33.25	10.71	1.76
b) Complete an assessment task	21.13	43	25.38	10.5
c) Watch a video	7.49	40.95	33.08	18.48
d) Listen to audio	35.89	31.86	20.4	11.84
e) Complete homework	18	29.13	19.88	33
f) Practice skills	15.38	55	24.38	5.25
g) Express ideas creatively	20.18	55.33	18.65	5.84
h) Prepare presentations/reports	5.74	64.71	22.69	6.86
i) Collaborate with students in other schools	83.86	11.6	3.15	1.39
j) Collaborate with students in other countries	96.46	2.02	1.14	0.38

Source: Authors' estimates based on the OECD's SUS data.

In terms of the devices and equipment available for teaching and learning, the availability is strongly correlated with the use. The most widely available and used devices are projectors and video players. Tablets, laptops, and charging points are not widely available in Russian schools. And tablets are the least used devices. This accords with our finding that the traditional way of teaching – demonstration in classrooms – is the most common teaching approach used in Russian schools.

Figure 26: Availability and Frequency of Use of Types of Technology by Modern Teachers in their Practice



Source: Authors' estimates based on the OECD's SUS data.

At the same time, when we correlated the frequency of technology use in schools with student scores on TIMSS, the results were positive and statistically significant for all technology types.

Figure 28: Frequency of Technology Use and Learning Outcomes by Technology Type

Source: Authors' estimates based on the OECD's SUS and TIMSS 2019 data.

The data suggest that, when teaching is supported by technology, learning outcomes improve. In section 5.4, we showed that technology is a positive contributor to student learning outcomes in science and their wellness.

However, the main factor in that case was the use of the modern teaching approaches and the overall quality of teaching. We also attempted to understand the relationship between students' learning outcomes and their IC literacy. So, we turned to the data from Russia's IC Literacy Assessment. IC Literacy Test is an instrument that measures how well students transitioning from middle school to high school (at the end of grade 9 in Russia) use modern IC technologies in their communication and research activities. The test assesses the level of student skills to operate in ICT rich environment rather than their computer literacy or ability to operate the computer or a device. After completing the assessment, each test taker receives recommendations on how to improve his or her IC literacy. Educators then use the summarized test results to improve the education provided in each classroom and in the entire region.

In 2019, the IC Literacy Test was administered in 11 regions of Russia[25] on a sample of 12,060 grade 9 students. A subset of 4,958 students also filled out the SUS questionnaire related to the learning environment. Because of the data entry errors (duplications or incorrect student IDs), the complete IC Literacy/SUS dataset comprises information only about 3,952 students. The distribution of test-takers by age and gender is provided in Tables 15 and 16.

Table 15: Distribution of Students Taking the IC Literary Test by Age

Age of students	Number of students	As percentage of total	Cum.
12	33	0.84	0.84
13	22	0.56	1.39
14	877	22.19	23.58
15	2,792	70.65	94.23
16	228	5.77	100
Total	3,952	100	

Table 16: Distribution of Students Taking the IC Literary Test by Gender

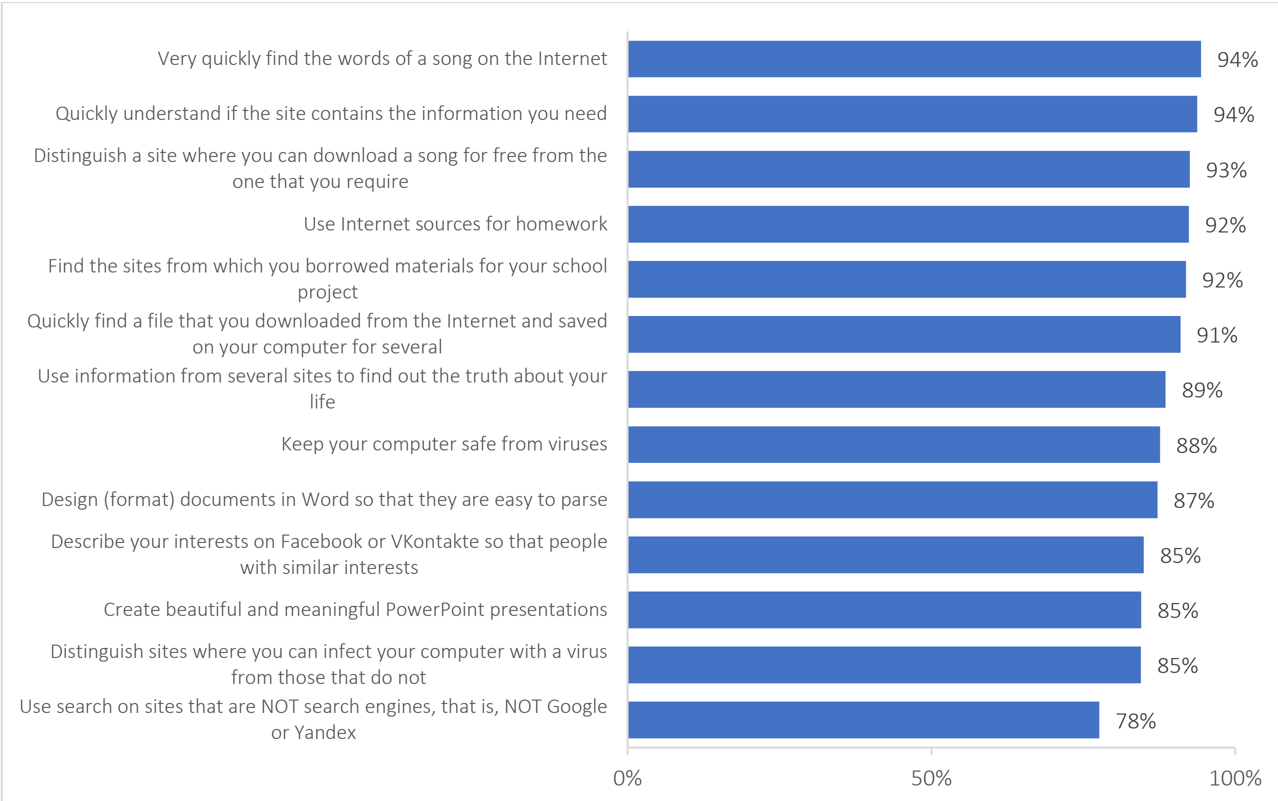
Gender	Number of students	As percentage of total	Cum.
Girls	2,027	51.29	51.29
Boys	1,925	48.71	100
Total	3,952	100	

The majority of students (85 percent) said that they use computers only during information technology classes even though they believed that the use of computers in school facilitates learning. Also, 40 percent of students said that it was important for computers to be used by students themselves rather than just by teachers. In all, 53 percent of students said that they used computers often or in every lesson to search for information in the Internet; 42 percent said they used them to prepare course work; 35 percent for creating presentations; 35 percent for conducting independent work; 33 percent for watching videos; 33 percent for doing group work with classmates; 23 percent for using training simulators; and 20 percent for conducting experiments or doing lab work. Computers are most often used by teachers for projecting presentations (as stated by 71 percent of students) and for demonstrating learning material (as stated by 67 percent of students).

According to the students' self-assessment of their own IC literacy skills, the majority of them are proficient in all activities, from finding the information they need to prepare texts and presentations to keeping the computer safe from viruses (Figure 29).

[25] Altai, Kaliningrad, Krasnoyarsk, Novosibirsk, Pskov, Bashkortostan, Rostov, Tyumen, Chelyabinsk, Yamalo-Nenets Autonomous Okrug, and Yaroslavl.

Figure 29: Self-assessments by Students of Their IC Literacy Skills



Source: Authors' estimates based on the OECD's SUS data and IC Literacy Test.
Note: Answers categorized by "can perform very well," "can perform well," and "able to perform."

The IC literacy test produces the results in five levels ranging from developing to the advanced. Table 17 below provides a quick description of student abilities per level.

Table 17. Description of IC levels

Advanced level	A student who has an advanced level of IC literacy works at a high level with tasks that require the ability to: • correctly formulate the problem, • find information from various sources, • organize information according to specific criteria, • evaluate the quality of information and the reliability of its sources, • compare and summarize information from different sources, • make correct conclusions based on existing information, • transfer information to other people.
Above Intermediate level	A student who has an above intermediate level of IC literacy works at a high level with tasks that require the ability to: • correctly formulate the problem, • find information from various sources, • organize information according to specific criteria, • make correct conclusions based on existing information,

	• transfer information to other people, but can only satisfactorily cope with tasks requiring the ability to: • evaluate the quality of information and the reliability of its sources, • compare and summarize information from different sources.
Intermediate level	A student who has an intermediate level of IC literacy satisfactorily copes with tasks that require the ability to: • correctly formulate the problem, • find information from various sources, • organize information according to specific criteria, • evaluate the quality of information and the reliability of its sources, • compare and summarize information from different sources, • make correct conclusions based on existing information, • transfer information to other people.
Below Intermediate level	A student with an intermediate level of IC literacy satisfactorily copes with tasks that require the ability to: • correctly formulate the problem, • find information from various sources, • organize information according to specific criteria, • make correct conclusions based on existing information, • transfer information to other people, but may not cope with tasks that require the ability to: • evaluate the quality of information and the reliability of its sources, • compare and summarize information from different sources.
Developing level	A student who has a developing level of IC literacy cannot solve problems corresponding to the level of "below average", that is, he cannot cope with tasks that require the ability: • correctly formulate the problem, • find information from various sources, • organize information according to specific criteria, • make correct conclusions based on existing information, • transfer information to other people.

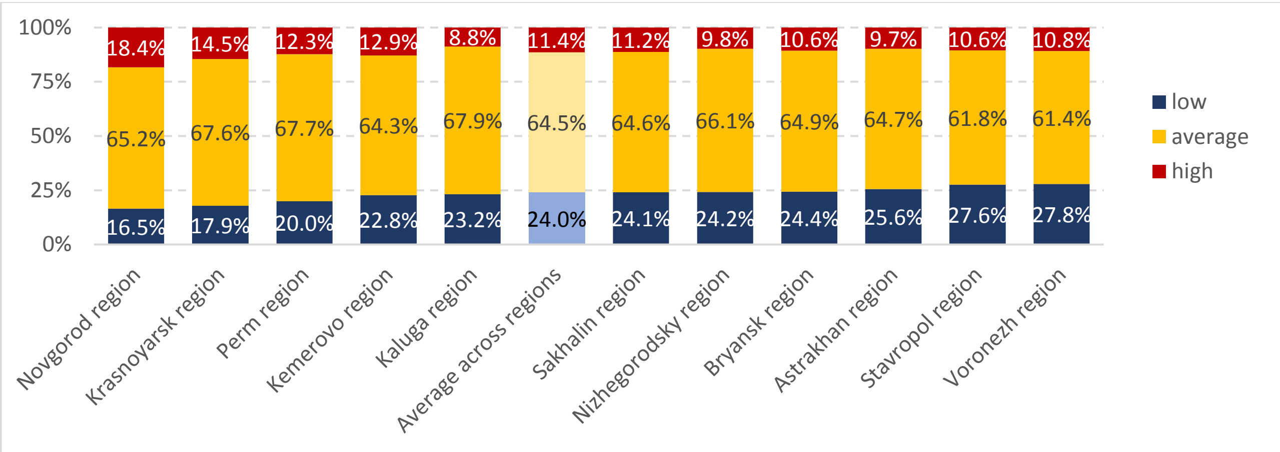
To make it easy to interpret results we proposed the groupings of levels by low, average, and high IC Literacy levels. Based on the description above we suggest including developing level as low, since this level demonstrates functional illiteracy. The average level includes intermediate and below intermediate. Lastly, high level unifies above intermediate and advanced levels.

According to the results of the IC Literacy testing, 24 percent of students from participating regions are not proficient in accessing and using information with means of modern technologies. On average only 11 percent of students scored high. The distribution of scores by regions of Russia is presented in the figure below. Novgorod region is leading because the sample is skewed towards students from urban schools. Krasnoyarsk is an experienced region where the IC Literacy testing was conducted two times on a representative sample. In addition, Krasnoyarsk region (along with Perm, Kaluga, and Stavropol regions) participated in the E-Learning

Support Project[26] (ELSP) in 2004-2008 financed by the loan of the World Bank. The project supported the development of digital learning materials, teacher training in ICT, and creation the regional support networks for urban and rural areas that developed capacity of school systems in ICT education. Therefore, some regions of Russia could be better prepared for such test.

This study hasn't identified differences in IC literacy between boys and girls. It might be an indication of the inclusiveness of ICT in Russian schools or equal access to ICT in Russian families.

Figure 30: IC Literacy levels per participating Russian regions



Source: Authors' estimates based on the IC Literacy Test.

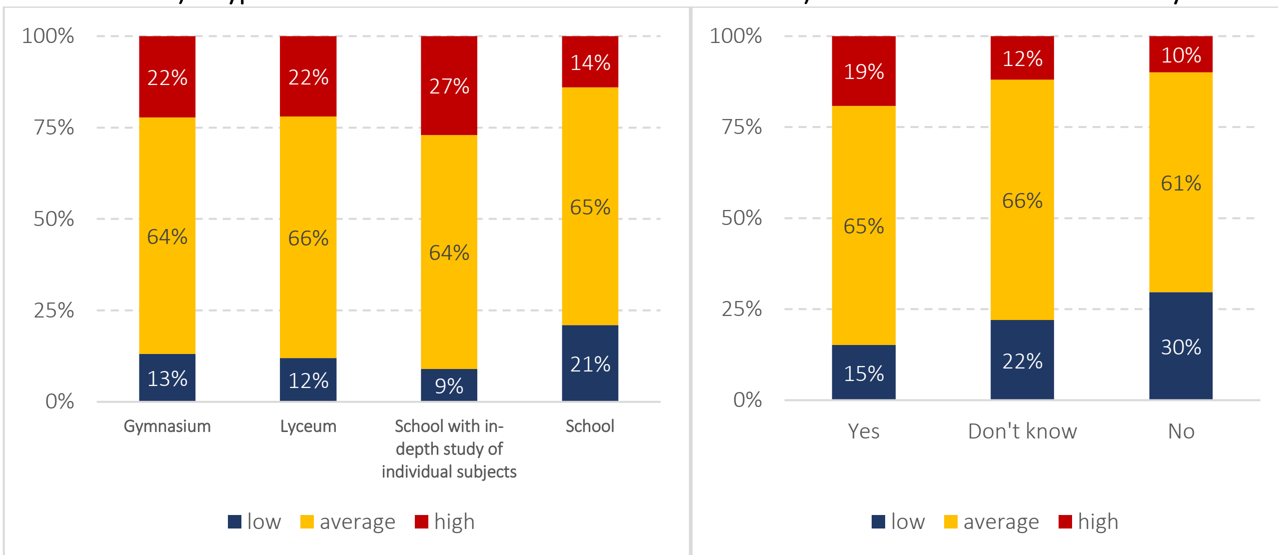
Distribution of IC Literacy scores by school type demonstrates that there is a higher share of students with low IC literacy levels in regular schools (21 percent) compared to specialized schools (9-13 percent). Students in gymnasiums and lyceums have higher shares of students in the top proficiency level (22 percent) compared to regular schools (14 percent). The share of students in the medium/average proficiency level is similar across all school types.

Distribution of IC Literacy scores by students' aspirations to higher education shows that student motivation to enter university is a good predictor of IC Literacy scores. Students that plan to enroll in higher education scored higher – 19 percent with high proficiency level – almost twice more than those who don't intend to continue beyond secondary education.

[26] https://projects.worldbank.org/en/projects-operations/project-detail/P075387

Figure 31: IC Literacy levels by type of school and attitudes towards higher education

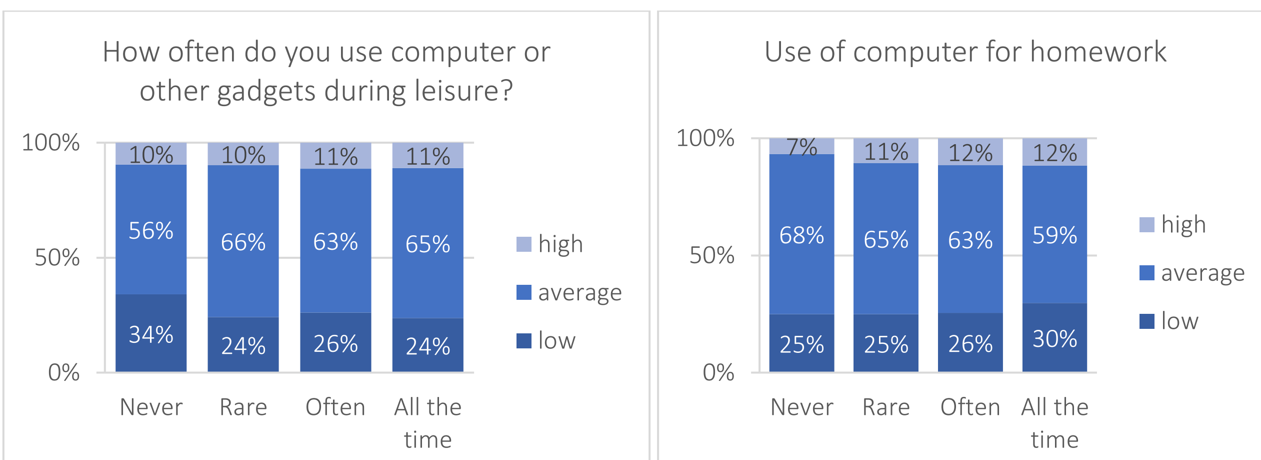
a) Type of school and IC levels b) Intention to enroll in university



Source: Authors' estimates based on the IC Literacy Test.

A high share of students at low IC literacy (34 percent) never uses computers or other gadgets during leisure as compared to 24, 26, and 24 percent respectively for students who use gadgets rare, often or all the time. So, usage or/and access to devices may define a gap of up to 10 percentage ponts between those who have low proficiency.

Figure 32: Impact of Using IT for Leisure and Homework on Students' IC Literacy



Source: Authors' estimates based on the IC Literacy Test.

Surprisingly, there was no statistically significant difference in ICT levels by students' socioeconomic status.[27] This is also true for many other variables that the team studies. It seems that the school level characteristics

[27] The index for socioeconomic status included the following variables: educational attainment of mother and father, the number of books at home, and the possession of a PC/laptop, tablet, smartphone, smartwatch, or e-reader.

are not effecting student IC literacy. It might be the case since the school curriculum does not include the work on information and communication literacy.

It is clear from these results that IC literacy of Russian students need to be developed further. This would require a more frequent use of technologies in teaching practices, the capacity for students to be able to use technology in schools, and deeper integration in general between the ICT and teaching and learning. The topic itself requires a more in-depth analytical work in the future.

5.6 Qualitative Analysis of Modern Teaching in Russian Schools

As has been discussed earlier in the report, the OECD School User Survey gathers information about different teaching styles and physical environments that support and shape each pedagogical practice (see Figure 20 in Section 5.2). According to the answers collected during the TIMSS/SUS pilot study in 2019 and the full-scale TIMSS/SUS study in 2019, Russian teachers use both traditional and modern pedagogical methods. Although the data indicated that the frequency with which teachers use modern methods such as group work and team-teaching in their daily practices remains low, it was not clear to us how exactly teachers define team teaching and in what ways they use group work in their daily classes.

Therefore, we decided to conduct open-ended interviews with teachers to explore these questions. We identified a subset of SUS data, which included a list of schools where the teachers confirmed that they use both team teaching and group work in their classes. Then we developed an interview guide consisting of three sets of thematic questions to be asked during the course of the interview covering team teaching, group work, and the impact of COVID-19 on daily teaching. The structure of the interview was deliberately designed to be flexible in terms of the sequence in which the questions were asked, so that the interviewer could try to gain a more detailed or "in-depth" answer to any particular question ((see Annex 2 for the interview guide).). The regional TIMSS coordinators contacted selected schools and invited a group of 52 teachers to participate in the interviews, and 15 teachers from both urban and rural schools agreed to participate. They represented the following Russian regions: the Republic of Tatarstan, the Republic of Chuvashia, the Republic of Marii El, the Ivanovo region, and the Yaroslavl region. In addition, we interviewed the principal of the school in Moscow City where team teaching is included in the daily curriculum with dedicated learning environments. The average length of each interview was about 40 minutes. The number of teachers present at each interview varied from one to four.

The teachers who were interviewed said that they only used team teaching in their pedagogical practice during extracurricular events, such as Geography Week or Polytechnic Week. Thus, this type of lesson is used only once or twice in each academic year. The usual practice was for two subject teachers to jointly conduct a so-called "integrated lesson" that combined two subjects such as chemistry and biology, English and chemistry, or geography and biology (see Box 1). The teachers tended to work together to teach several classes and divided the students into smaller groups to complete the assignments or experiments set in these integrated lessons. In many cases, these integrated lessons consisted of short thematic lectures and group assignments or were organized in the format of a game for which the teachers served as judges. If their school had children with disabilities, the teachers also tried to involve those pupils in the extracurricular events.

Box1: Example of an Integrated Lesson Conducted during an Extracurricular Event

An integrated lesson called "World Ocean" was taught jointly by the teachers of biology and chemistry. The chemistry teacher talked about chemical elements, while the biology teacher explained about endemic species and how they adapt to their living conditions.

Source: Interview with chemistry teacher, Republic of Marii El.

The teachers confirmed that the preparation for this type of lesson takes more time and coordination among colleagues than traditional teaching practices, and they found it difficult to use it in their daily practice. Some teachers complained that key parts of the curriculum are taught at different times of the school year in different subjects, making it difficult to combine the lessons for team teaching (see Box 2). Thus, to encourage more teachers to adopt team teaching, there is a need to coordinate the teaching schedules of the different subjects before the start of the academic school year (see Box 2).

Box 2: Planning of Integrated Lessons

Biology and chemistry are seemingly related in our educational program. However, the teaching of theory is so scattered across academic year that we have no way to connect it. If I, for example, teach the theory of proteins in the 10th grade, I do so at the beginning of the school year for me as a teacher of biology, while in the chemistry course, this topic is scheduled to be discussed at the end of the school year. But it's still easy for me, because my second specialty is chemistry. And I try to include some part of the meta-knowledge during the biology lesson.

Source: Interview with biology teacher, Ivanovo region (rural school).

During the focus-group interview, only one group of educators representing the same school confirmed that they used team teaching in their daily practice, but this was technically possible only because of the small number of students in that school. To decide whether to include the integrated lesson in the schedule, the teachers assemble together and make an assessment at the end of the academic year to identify any problems with children not understanding the educational material. If it turns out that the students experience difficulties understanding one discipline because of cross-related knowledge in another subject that they have not yet mastered, then the school administrators plan for integrated lessons on the topic to be taught by a team of teachers the following academic year.

Box 3: Team Teaching in Moscow City School

<u>Work format:</u> The approximately 100 to 130 children, who are based in one building and represent a group of classes, get together in an open space. They are divided into several teams consisting of five or six students to engage in project activities. They are assisted by various teachers, usually from two different subject disciplines such as a computer science teacher and a music teacher. The children conduct role-playing games. For example, in the lobby, they design a "city of the future" and build a prototype. The older children (in grade 8) assemble an electric scooter from a special construction set. Before that, they created robotic auto watering stations. These activities are conducted within the framework of a computer science and technology collective lesson. The movement of objects is taught in joint physics and mathematics lessons. Other combinations might be English and technology or literature and social science. We include these lessons in the daily curriculum plan.

<u>Number of teachers:</u> Two teachers for 60 pupils during a collective lesson is better than one teacher for 30. If you can arrange a group of three teachers for 60 pupils, it would be an ideal situation. However, there is no main teacher. These are three equally important teachers. They are not allocated to specific children. A child can come to any teacher and ask a question.

<u>Planning of team-teaching lessons:</u> We start planning a collective teaching lesson for the following academic year in April when the intensive work of preparing for the next year begins. We dedicate May and June to this.

Source: Interview with school principal, Moscow City School.

Usually, the teachers use the halls or science laboratories to conduct these integrated lessons. The teachers claimed that they need bigger learning spaces with adequate capacity to accommodate a substantial number of students to conduct team teaching. Additionally, the teachers confirmed that it is vital to have light and movable furniture, adequate equipment, and enough special material for experiments (particularly in the case of physics and chemistry).

The interviewed teachers said that they also actively used group work during their daily practice within the framework of the standard curriculum. The main aim of using group work is to start learning a new topic or to repeat and master knowledge and skills learned previously. Usually, the teachers divide a class into several small groups (each consisting of two to five students) organized in accordance with the type of experiment or assignment being done. Sometimes, the groups are chosen by seating arrangements of the students in the classroom (the teacher split the students into the groups by rows) or by academic achievement (mixing strong and weak students in one group). The teachers said that the children should feel comfortable in a working group.

All of the interviewed teachers confirmed that they move furniture in order to adapt the learning environment to group work. However, in many cases, they pointed out that standard school furniture is quite heavy, so such rearrangements take a lot of time and effort (see Box 4). The teachers agreed that furniture with wheels would be more useful. Another important piece of equipment is a digital whiteboard, which the teachers actively use in many classes. However, this type of equipment is not distributed equally among the different learning spaces in schools. The teachers also expressed a desire for these digital whiteboards to have wheels to make them easier to move.

Box 4: The Use of Furniture during Group Work

It is difficult [to move furniture] during the lesson, as desks are heavy. Changing furniture is difficult. But when an open event is scheduled, we rearrange the class into groups in advance. If we have prepared a lesson only in the group format, then we shift and change the furniture. When we teach a mini group, we don't move furniture. The first student turns to another student at the desk behind him and so on. They already know how to do it.

Source: Interview with teacher, Yaroslavl region, rural school

One group of teachers were informed that their school would be getting a new combined space for science lessons and group work as part of the national project in education called "Point of Growth." The teachers were involved in the preparation of a technical brief and the development of a design for the learning space and were able to request that the space would have movable and flexible furniture, a request which has been granted.

During the period of quarantine due to COVID-19, all of the teachers confirmed that they worked in a distance mode using various digital tools and platforms. They confirmed that it was difficult to experiment with pedagogical methods, and they spent all of their energy simply on adapting to a new way of remote working. Some of their students had no access to computers or a proper internet connection, while some parents were against distance learning, especially the need for their children to use computers every day. Therefore, the teachers had to adjust the learning process in each case and provide a viable solution to keep children studying (see Box 5).

After the end of lockdown and when the schools were finally open, the Ministry of Education introduced new guidance for onsite operations. In most cases, teachers confirmed that their students are assigned to a classroom and must remain in that one space throughout the school day. The teacher must move between different classrooms and carry around all necessary learning equipment (see Box 5). It has become a challenge for many teachers of science (especially for chemistry and physics teachers) because some of their equipment cannot easily be carried to other places because of their size and for safety reasons. They expressed strong worries that, if students are unable to carry out practical exercises, this will negatively affect their learning outcomes and skills in the long term. In many cases, the teachers are trying to replace real experiments with YouTube videos and other digital materials. One teacher mentioned using a digital resource database called School-collection.edu.ru, which was developed under the E-Learning support project[28] financed by the World Bank in Russia in 2004 to 2008.

Box 5: Teaching Practices during COVID-19
"During distance learning, there were no joint lessons with other teachers. There were classes in which children were not able to access the lesson over Zoom because they lacked the necessary technology in their homes. There were some parents who were against their children learning over the Internet. For these students, the teachers wrote down the lessons in notebooks, and parents fetched the notebooks from the school and brought them back to school for their children's work to be checked. Most students accessed Zoom through their smartphones. A significantly smaller proportion of children used a computer."
Source: Interview with a teacher of geography, Republic of Marii El, Yoshkar-Ola city
"I follow the students. Our classes are all separated. The school is big. We have three floors. There is a recreation area on the right side of the building. Children come out of the building through only one entrance from the stairs. And we have everything planned out. Their arrival at school is planned. Senior classes come at half past seven. And then a bus brings children from the countryside from nearby villages. Then there are the middle classes, 6^{th} and -7th grades. Before being admitted to school, everyone needs to have their temperature taken and to sanitize their hands. And all go out directly to the left. Other streams of people, who need to enter, go to the right. Each class is regulated. And the canteen also works in the same way."
Source: Interview with a teacher of physics, Yaroslavl region, rural school

Overall, the results of the interviews revealed that:

- Team teaching is used in some schools but usually only once or twice a year and mostly during extracurricular activity weeks.
- Usually, the team consists of teachers of two different subjects such as science and math or science and a foreign language (English or French).
- The introduction of team teaching into a school's daily practice requires advance planning and good cooperation between teachers and the school administrators.
- Group work is often used in daily teaching but in order to easily reorganize the learning space to accommodate this kind of work, light and movable furniture is needed.
- The current COVID-19 prevention regime limits the ability of teachers to conduct practical exercises and use modern teaching methods, thus potentially generating learning losses even after schools have reopened and are back to face-to-face learning.

6. Recommendations for Policymakers

High-quality teaching can be delivered using both traditional and modern styles. The effectiveness of each will depend on the specific school context. Our data suggest that high-quality teaching, whether traditional or modern, results in high TIMSS scores. Teachers are the main contributors to the quality of learning and in the academic performance of their students. With that in mind, our data also confirms that student's positive attitudes improve their learning outcomes. Therefore, education policies related to teachers should encourage

[28] https://projects.worldbank.org/en/projects-operations/project-detail/P075387

the development not only of their technical knowledge of the subject that they teach but also ways to encourage students and foster a positive attitude towards learning.

The use of modern teaching practices can be supported by expanding the availability and use of technology in learning and by enhancing the quality of furniture in classrooms. The data show that these two factors – technology and comfortable furniture – play a significant role in enabling modern teaching practices such as group work and team teaching and enhance both students' performance and their well-being. The interviews that we conducted with teachers confirmed this finding and showed that most teachers who practice modern teaching would like more flexibility in their school environment, including mobile laboratories, transformable spaces, and movable furniture.

The Russian education system has strong theoretical and empirical foundations to expand modern teaching. For example, team teaching is similar to the well-defined collective method of education propounded by Vitaly Dyachenko, Manuk Mkrtchyan, and other Russian and international scholars who have promoted modern teaching and learning methods. This report finds that implementing these modern practices in schools nationwide would develop students' 21st-century skills and thus improve their learning outcomes.

Modern teaching practices that support the development of students' 21st-century skills can be realized at each level of education, and Russia can learn from many examples of international best practices such as:

- *A child-centered approach and play-based learning in early childhood education*: A number of Southeast and East Asian education systems are using child-centered pedagogic practices to foster holistic learning. They are expanding the definition of learning outcomes to include social, emotional, physical, and higher-order thinking skills and are recognizing that holistic learning requires new format of teaching to fully accumulate child potential.[29] Another example is the Montessori model, characterized by multi-age classrooms, student-chosen learning activities, and minimal instruction. It has been shown to be more effective than conventional education in improving children's executive functions. With successful local adaptations, Montessori and other child-centered approaches – including Steiner, Reggio Emilia, and Tools of the Mind – can be found in diverse settings from Haiti to Kenya.
- *Social and emotional learning (SEL) programs in general education:* SEL teaches students 21st-century skills, while improving their academic outcomes. The most successful SEL programs are those that follow a whole school approach by: (i) integrating SEL into the regular curriculum; (ii) introducing dedicated SEL curricular activities as necessary; and (iii) ensuring a safe and supportive school climate. Teachers can deliver their regular curricular activities while integrating SEL strategies such as interactive learning, the establishment of goals and rules, and use of greetings and closings that have been shown to improve students' academic skills as well as their socio-emotional skills. For example, the US Responsive Classrooms program takes a student-centered social and emotional learning approach to teaching and discipline. The program includes a set of practices designed to create safe, joyful, and engaging classrooms and school communities for both students and teachers.
- *Twenty-first century skills modules and practice-based teaching in tertiary education:* TVET and higher education programs across the world use practice-based teaching. In Japan, KOSEN, a renowned TVET and five-year engineering education program KOSEN for students from 15 years old (with an additional two-year further study option), includes scientific experiments, workshop-based training, and training in practical manufacturing skills. KOSEN makes extensive use of project-based learning to nurture critical thinking and problem-solving skills where multi-disciplinary thinking and entrepreneurship are strongly encouraged. Internships and cooperative education provided in partnership with local industries are also part of KOSEN's teaching and learning. There are a number

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of local and global competitions for KOSEN students to demonstrate their engineering skills. (https://www.kosen-k.go.jp/english/). In China, Lenovo, an IT and computer manufacturer, is working with tertiary institutes to train vocational students in high-tech areas such as cloud computing using practice-based curricula, practitioner-led instruction, and professional certification. In Hong Kong SAR, China, an additional year of general education was added to undergraduate programs in 2012 that is focused on developing students' problem-solving, critical thinking, communication, leadership, and lifelong learning skills. This extra year seems to be producing graduates with the attributes and abilities prized by the labor market. In Singapore, Nanyang Polytechnic (NYP) established very close and active collaboration with partners in industry. The NYP's Teaching Factory concept integrates academic studies with real-life work experience on industry-based projects. Industry-based projects enable students to develop hands-on, real-world problem-solving skills and to be ready to work upon graduation (https://www.nyp.edu.sg/). In the Netherlands, the Dutch Vocational Colleges provide entrepreneurial courses with the objective of improving students' non-cognitive skills such as teamwork and self-confidence.

- *Making technology available in schools on an equitable basis to improve student learning and enhance teachers' professional development.* This would require equipping teachers with the skills needed to use technologies in teaching as well as providing them with ongoing support**.** The types of technology used in teaching include computers, the Internet, projectors, and any other learning tools that can help students with a diversity of learning needs and preferences. Portable devices as laptops and tablets are considered as the most suitable tools to support these learning needs. In addition, technological tools provide teachers with an enhanced array of strategies for their pedagogy. Our study revealed that students scored higher in all of TIMSS subject domains in those schools where teachers frequently used different kinds of technologies in their lessons. These higher scores for different subjects and different types of technology ranged from the equivalent of one-third to two-thirds of a year of schooling. Even after controlling for students' socioeconomic characteristics, the difference and statistical significance in these scores remained for all subjects, especially for schools that use the Internet (both wireless and wired), desktop computers, and projectors/large TVs with audio equipment. This is especially important given the hybrid learning formats that have been adopted as a result of the COVID-19 pandemic.
- *Helping teachers to adopt innovative teaching methods and exchange knowledge and experiences***.** Only a small share of teachers use modern teaching practices, but when asked if they would be prepared to use these practices, many teachers said that they would. However, most current learning spaces are not conducive to adopting these innovative methods. What is needed is more flexible spaces and movable furniture that can be rearranged to enable more group work and team teaching. It is important for education decision-makers to make it possible for team teaching to be used in daily practice instead of only during extracurricular time (which was identified as the common practice in Russian regional schools in our qualitative interviews with teachers). This would require changing the traditional way of planning the academic schedule, providing teachers with more time to design team teaching lessons, and supplying appropriate learning materials. Given the diversity of Russia's regions, it would be useful for policymakers to set up a knowledge exchange among regions and between schools in urban and rural areas to promote best practices across the country.
- *Preventing bullying and developing supporting measures to maintain a positive school climate:* Our findings showed that bullying can negatively affect students' learning outcomes, especially those of students from lower socioeconomic groups. The government and NGOs should unite to develop training for teachers in bullying prevention, psychological support services for students in and outside the school, and information campaigns and learning material for parents to help them to support their children if they suffer from bullying. Additionally, schools should explore how they can redesign existing learning environments to prevent bullying behavior (for example, by creating open and transparent spaces with physically comfortable furniture).

- *Adjusting schooling in response to COVID-19.* The pandemic required schools to adopt new and varied ways to ensure that education could continue safely. Students were required to interact with their teachers remotely or in classrooms adapted to minimize interactions and ensure safe distances between students. Returning to full-time face-to-face schooling is involving the continuation of many safety measures, which means that learning losses are still happening despite the return of students back to schools. If education policymakers were to invest in new school equipment and ICT and in modern ways of teaching, it might be possible to compensate for these learning losses.

Implementing a program to improve teaching and learning based on these recommendations could yield significant improvements in learning outcomes, potentially equivalent to a half to a full year of learning. This would go a long way towards compensating for the learning losses resulting from COVID-19 and bring Russia back on track in terms of improving its learning outcomes. The post-pandemic period may be a chance to rethink the Russian education sector and to introduce innovations in the teaching of traditional subjects such as reading, mathematics, and science as well of 21st-century skills. This will require policymakers to focus heavily on teachers and finding ways to support them in the process of changing their pedagogical practices.

7. Conclusion

As this study has shown, Russia's education system has done well in terms of creating equitable access to different education levels and achieving good learning outcomes but has the potential to do better. One way to improve the academic performance of Russia's students would be for schools to focus on developing students' socio-emotional and higher-order cognitive skills in addition to teaching academic knowledge and skills. Global evidence suggests that the development of 21st-century skills such as complex problem-solving and teamwork is a sound and necessary investment to equip students with the ability to apply their academic skills effectively in the workplace and in life. While there is already demand on the labor market in Russia for such skills, education policies are not yet sufficiently focused on their development.

In this study, we analyzed several datasets and conducted a qualitative review of innovative teaching practices in Russian schools in order to explore the relationship among teaching practices, learning environments, the school environment, and students' learning outcomes.

This study expands on the earlier findings of TIMSS pilot study that suggested a connection between learning environments and learning outcomes as measured by TIMSS 2019 and also the importance of modern teaching approaches in developing 21st-century skills. How students perceive their schools, how secure they feel, and the frequency of bullying are all directly connected with learning outcomes, as the more positive students' experiences of school, the more likely they will perform well. The findings of our study show that solving some problems (such as severe bullying) could help to raise students' scores on learning achievement tests. Teacher training, group work, team teaching, related spaces that enable such activities, and fostering the development of 21st-century skills in students may also make the education system more equitable and efficient. Using ICT in teaching and learning can also add to these performance gains, and the increased use of technology during the COVID-19 pandemic has created an opportunity to consolidate and extend this trend nationwide, thus unlocking the potential of the Russian education system.

Russia has already allocated a significant part of education public funding within the national projects up to 2030. The focus of those projects includes strengthening education infrastructure, fostering the professional development of teachers, digitizing education, and helping all students to excel. Adding the development of 21st-century skills agenda to the goals of the national projects would encourage the use of modern teaching practices and improve learning environments, at the same time creating better and more welcoming space in schools. In turn, this would yield better academic outcomes, thus helping to overcome the learning losses associated with COVID-19 and providing Russia with a skilled and productive workforce for the future.

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- Project Teacher of the Future («Учитель будущего»)
- Project Young Professionals («Молодые профессионалы (Повышение конкурентоспособности профессионального образования»)
- Project New Opportunities for Everyone («Новые возможности для каждого»)
- Project Social Activity («Социальная активность»)
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Annex 1: Tables and Figures

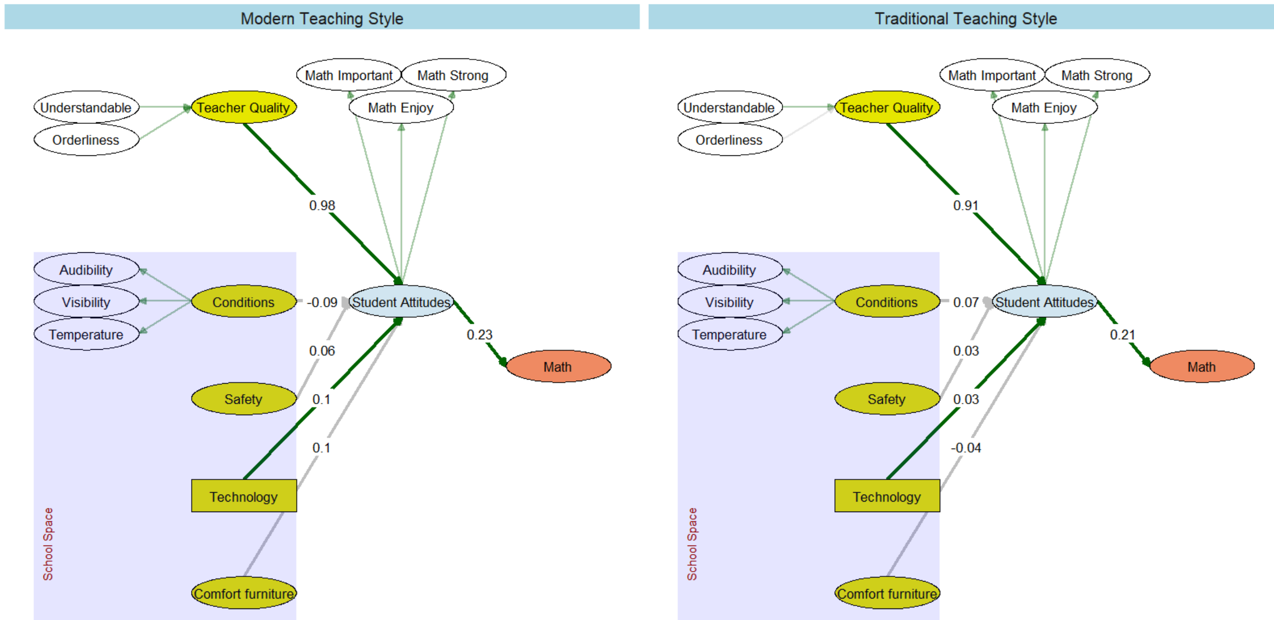
Annex Table 1.1: Descriptive Statistics for Main Variables, weighted

	Variable	Mean	SD	Min	Max
Math teacher quality	BSBM17A	3.07	0.78	1	4
	BSBM17B	3.04	0.79	1	4
	BSBM17C	3.27	0.77	1	4
	BSBM17D	3.45	0.71	1	4
	BSBM17E	3.48	0.68	1	4
	BSBM17F	3.22	0.76	1	4
	BSBM17G	3.45	0.72	1	4
Teacher’s orderliness in math	BSBM18A	2.66	0.94	1	4
	BSBM18B	2.82	0.95	1	4
	BSBM18C	3.12	0.93	1	4
	BSBM18D	3.04	0.96	1	4
	BSBM18E	3.17	0.92	1	4
	BSBM18F	2.76	1.02	1	4
Students' beliefs	BSBM16A	2.93	0.83	1	4
	BSBM16B	2.90	0.95	1	4
	BSBM16C	3.01	0.85	1	4
	BSBM16D	3.02	0.80	1	4
	BSBM16E	2.91	0.89	1	4
	BSBM16F	2.62	0.88	1	4
	BSBM16G	2.62	0.90	1	4
	BSBM16H	2.30	0.84	1	4
	BSBM16I	2.43	1.01	1	4
	BSBM19A	2.83	0.84	1	4
	BSBM19B	2.63	0.92	1	4
	BSBM19C	2.60	0.99	1	4
	BSBM19D	2.50	0.86	1	4
	BSBM19E	2.73	0.92	1	4
	BSBM19F	2.34	0.81	1	4
	BSBM19G	2.46	0.88	1	4
	BSBM19H	2.68	0.98	1	4
	BSBM19I	2.78	0.95	1	4
	BSBM20A	3.17	0.84	1	4
	BSBM20B	3.24	0.75	1	4
	BSBM20C	3.04	0.93	1	4
	BSBM20D	2.97	0.94	1	4
	BSBM20E	2.26	0.94	1	4
	BSBM20F	2.94	0.89	1	4
	BSBM20G	3.06	0.84	1	4
	BSBM20H	3.23	0.78	1	4
	BSBM20I	3.11	0.82	1	4
Math	BSMMAT01	546.54	80.83	227	841
	BSMMAT02	546.79	80.33	255	819

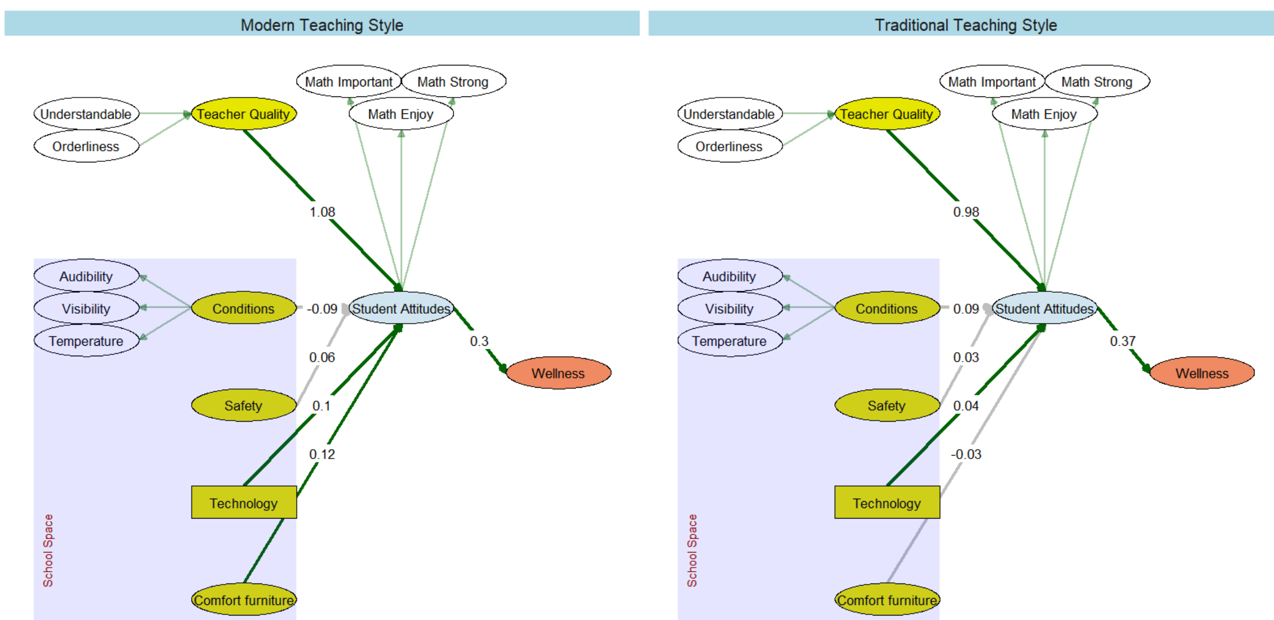
	Variable	Mean	SD	Min	Max
	BSMMAT03	547.61	80.59	242	805
	BSMMAT04	546.57	82.36	305	827
	BSMMAT05	546.92	81.07	274	810
Science	BSSSCI01	546.04	74.19	230	793
	BSSSCI02	545.93	74.40	273	823
	BSSSCI03	546.20	74.80	223	793
	BSSSCI04	545.19	75.63	267	774
	BSSSCI05	544.58	75.75	252	772
Math applying	BSMAPP01	545.98	81.49	250	809
	BSMAPP02	547.02	81.68	253	805
	BSMAPP03	545.94	81.10	278	810
	BSMAPP04	546.33	81.28	268	795
	BSMAPP05	547.01	81.84	261	805
Math reasoning	BSMREA01	537.35	84.12	245	797
	BSMREA02	538.52	84.27	257	807
	BSMREA03	540.48	84.98	270	827
	BSMREA04	539.12	84.33	265	804
	BSMREA05	541.69	82.98	257	809
Science applying	BSSAPP01	544.75	84.43	253	808
	BSSAPP02	546.89	84.12	175	813
	BSSAPP03	546.23	83.27	209	829
	BSSAPP04	544.64	82.45	177	819
	BSSAPP05	545.26	85.87	228	838
Science reasoning	BSSREA01	546.31	74.43	288	787
	BSSREA02	543.31	72.74	234	763
	BSSREA03	549.23	71.95	265	797
	BSSREA04	544.69	74.29	243	781
	BSSREA05	546.94	72.77	281	784
Safety	n24_0	3.00	1.07	1	4
	n24_1	3.36	0.86	1	4
	n24_2	3.34	0.87	1	4
	n24_3	2.88	1.18	1	4
	n24_4	3.29	0.92	1	4
Technology	n_tech	6.82	2.44	0	10
Temperature	n11_2	2.98	0.87	1	4
	n12_2	2.85	0.94	1	4
Audibility	n15_0	3.56	0.72	1	4
	n15_1	3.38	0.84	1	4
	n15_2	3.26	0.92	1	4
Visibility	n16_0	3.42	0.78	1	4
	n16_1	3.24	0.93	1	4
	n16_2	3.25	0.91	1	4
Comfortable furniture	n17_0	3.11	0.92	1	4
	n17_1	1.92	1.04	1	4

	Variable	Mean	SD	Min	Max
	n17_2	1.77	1.03	1	4
Traditional teaching style		0.69	0.46	0	1

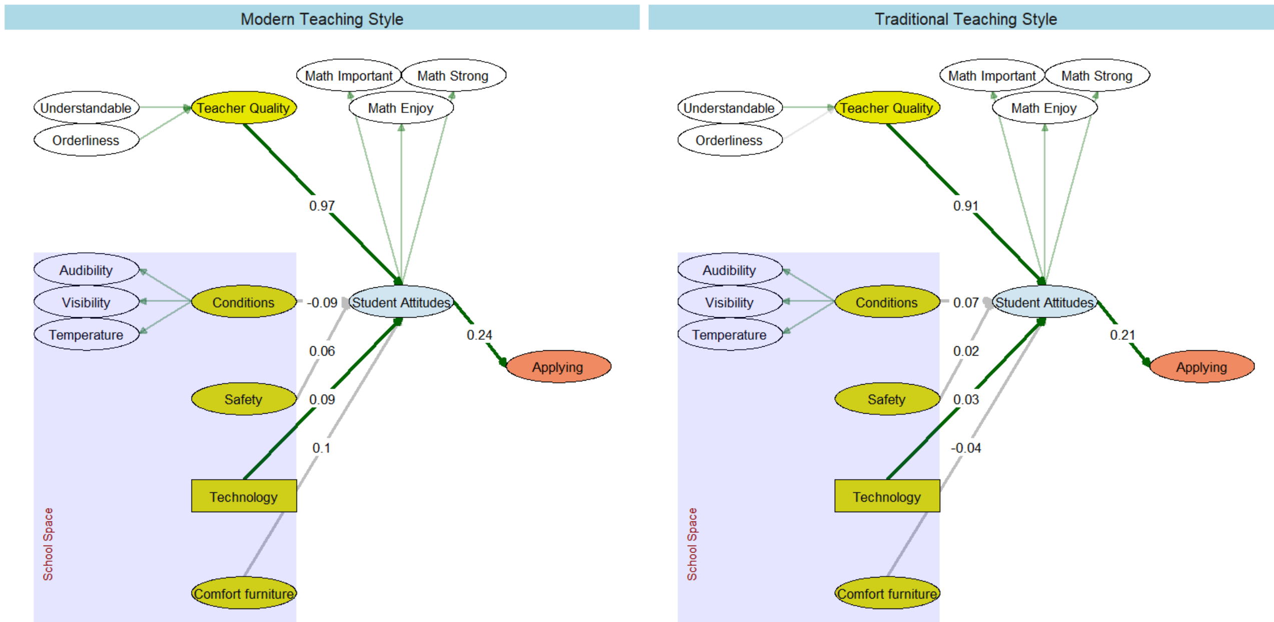
Annex Figure 1.1: Path Diagram for Math Scores as an Outcome



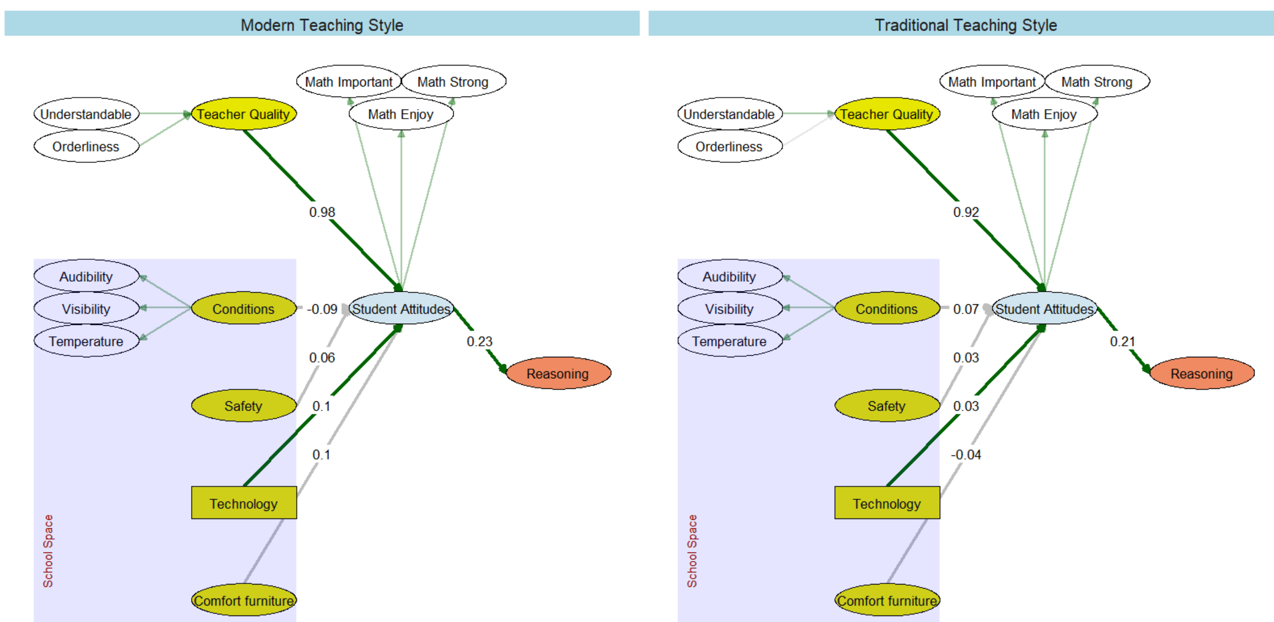
Annex Figure 1.2: Path Diagram with [Student?] Wellness as an Outcome



Annex Figure 1.3: Path Diagram with Math Applying as an Outcome



Annex Figure 1.4: Path Diagram with Math Reasoning as an Outcome



Annex 2: A guide for interviewing teachers

Respondents: Grade 8 teachers from general education schools, who took part in the TIMSS/School User Survey and specified in their questionnaires that they were using collaborative learning and group work techniques in their teaching activities.
Purpose of interview: To get an insight into how the teachers understand the essence of collaborative learning and group work techniques, understand when such techniques are employed in teaching practices, identify the barriers and opportunities for developing the educational environment of a school supporting the use of such methods.
Unit 1. Introduction
Objectives of the unit: To get an insight into the teacher's professional experience
Suggested questions: What is your length of employment? What subjects do you teach? Which other grades of students do you teach in addition to grade 8? What is the average number of students in the classroom who attend your lesson? What school classrooms do you use for teaching lessons?
Unit 2. Collaborative learning activities
Objectives of the unit: To get an insight into how the teachers understand the essence of collaborative learning techniques, and in what way they employ such techniques in their teaching practices.
Suggested questions:

1. Could you please tell me if you have experience in co-teaching with another teacher(s)?
2. What is the number of your teacher colleagues with whom you have collaborated in co-teaching?
3. What is the number of students that you have worked with using collaborative learning activities and co-teaching?
4. With what subject teachers have you conducted collaborative learning lessons?
5. How did you plan such lessons?
6. What school facilities and classrooms have you been using to provide for collaborative learning activities?
7. From your perspective, what classrooms do you need to provide for collaborative learning activities?
8. From your perspective, what school facilities do you need to provide for collaborative learning activities?

Unit 3. Group learning
Objectives of the unit: To get an insight into how the teachers understand the essence of the group work technique, and in what way they employ such method in their teaching practices.
Suggested questions:

1. Could you please give examples of how you or your colleagues separate students into small groups in your teaching practices?
2. For what purpose do you use this method in teaching your subject?
3. How many students have you worked with using group work?
4. What challenges have you noticed when your students were working in group?
5. What school facilities and classrooms have you been using to provide for group work?
6. What school facilities and classrooms have you been short of to provide for group work?
7. From your perspective, what classrooms are needed to provide for group work?
8. From your perspective, what school facilities are needed to provide for group work?

Conclusion of the interview, acknowledgement of participation