Nevertheless, the strength of association between problem-solving skills and domain-specific skills that are explicitly taught in school subjects is weaker than the association between, say, mathematics and reading skills. And while better results in problem solving are associated with better results in mathematics, reading and science, the pattern is not without exceptions. Performance in problem solving, among both students and school systems, is not identical to that in other assessed subjects. In nine countries and economies (Australia, Brazil, Italy, Japan, Korea, Macao-China, Serbia, England [United Kingdom] and the United States), students perform significantly better in problem solving than students in other countries/economies who show similar performance in mathematics, reading and science. Countries where students perform worse in problem-solving than students with similar proficiency in curricular domains in other countries may look more closely at the features of the curricula and instructional styles in the more successful countries to determine how to equip students better for tackling complex, real-life problems in contexts that they do not usually encounter at school.

A closer analysis reveals interesting differences within this set of nine countries. In some, such as the United States, England (United Kingdom) and Australia, the good performance in problem solving at the system level stems mainly from the students with the strongest performance in mathematics. This alignment suggests that, in these countries, high performers in mathematics have greater access to the kinds of learning opportunities that build problem-solving skills. In others, such as Japan, Korea and Italy, the good performance in problem solving at the system level can be attributed to the resilience of many low achievers in mathematics. These countries, more than others, seem to offer students who struggle to master the basic curriculum second chances to develop the problem-solving skills that are required to fully participate in today's societies (Box V.5.7).

### Box V.5.7. Developing and assessing problem-solving skills in Japan: Cross-curricular project-based learning

Japan ranks at or near the top in all subjects assessed in PISA 2012, and performance in problem solving is no exception. What's more, Japanese students, who score 552 points, on average, show better performance in problem solving than students with similar performance in mathematics, reading and science in other countries and economies, particularly among moderate and low performers in core subjects. On the problem-solving scale, at least 20 points separate Japanese students who perform below Level 4 in mathematics, reading or science from similarly proficient students in other countries (Table V.2.6). One plausible explanation for this is Japan's focus on developing every student's problem-solving skills through his or her participation in cross-curricular, student-led projects, both within the subjects and through integrated learning activities.

In the late 1990's, the "zest for living" approach was introduced by the Japanese government through a reform to the Course of Study, Japan's national curriculum standards. The aim of the approach was to strengthen students' ability to think critically and creatively, and to identify and solve problems independently. This reform prompted substantial changes towards an inquiry-based, student-centred model of learning. The need for improving students' engagement and motivation was at the heart of these transformations.

The new approach led to a revision of subject-matter curricula. The new curricula reduced the content load by about 30%. For example, the number of English words that students had to memorise in junior high school was reduced from 1 000 to 900. The intention was to create space, within each subject, for deepening learning through classroom activities that cultivate introspection, the desire to learn and think, independent decision-making, and problem-solving skills. In 2007, new national assessments that focus on the ability of students to apply their knowledge in real-world contexts were introduced in sixth and ninth grades.

The reform also allocated more time for elective offerings and introduced a new class period in all schools, called "Integrated Learning". In these classes, students engage in cross-curricular projects related to international understanding, social welfare and health, or environmental issues, that provide opportunities to practice observation and experimentation and to discover multiple solutions to problems and draw connections to their own lives (MEXT, 2002; Aranil and Fukaya, 2010). The homeroom teacher is responsible for this class period, and topics are often decided in collaboration with other teachers in the same school. The Ministry of Education, as well as local school boards, produce guidelines and scripted examples for the integrated study lesson, often in collaboration with other agencies and with private-sector employers (see *www.mext.go.jp/a_menu/shotou/sougou/syokatsu.htm*).

...

Students' work is recorded in portfolios and qualitative feedback is provided to students and families, but the work is not formally assessed.

The implementation of this reform sparked some controversy. In practice, the guidelines for teaching the "Integrated Learning" course gave a great deal of freedom to schools and teachers for deciding how to implement the programme, but not all teachers, particularly at the secondary level, felt that they were adequately prepared to do so. This resulted in changes to the curriculum standards, implemented in 2011 and 2012, involving a reduction of the time allocated to "Integrated Learning" in favour of teaching academic subjects (OECD, 2012). Nonetheless, the "zest for living" approach is still promoted throughout the curriculum and the national standards continue to recommend that schools increase the amount of learning activities, in all subjects, that involve the application of knowledge through observation and experimentation.

Japan's constant effort to improve the curriculum and instruction to promote more relevant learning has resulted not only in good results on the PISA test, but also in remarkable improvements, between 2003 and 2012, in students' sense of belonging at school and in their dispositions towards learning (see Volume III, *Ready to Learn: Students' Engagement, Drive and Self-Beliefs*) (OECD, 2013a).

**Sources:** Aranil and Fukaya (2010); MEXT (2002); OECD (2013a); OECD (2012).

It seems that problem solving is a distinct skill with similar attributes as proficiency in specific school subjects. While influenced by differences in individuals' cognitive abilities, its development depends on the opportunities offered by good teaching. Ensuring opportunities to develop problem-solving skills for all students and in all subjects, including those not assessed in PISA, in turn, depends on school- and system-level policies.

## LEARN FROM CURRICULAR DIVERSITY AND PERFORMANCE DIFFERENCES IN PROBLEM SOLVING

Improving the curriculum and instruction to promote learning for life is a huge challenge. It is, to some extent, reassuring to know that students with good results in mathematics, reading and science also have, by and large, good results in problem solving. At the very least, this is consistent with the idea that better instruction in the core subjects corresponds to a greater capacity of students to meet the challenges they will encounter in life beyond school.

Further indications about how to improve the curriculum and instruction may come from the strengths and weaknesses in problem solving that are observed within and across countries. The analysis in Chapter 3, for instance, identifies interesting differences in performance across different types of problem-solving tasks. These differences are likely a reflection of how well students learn, through the content of the various school subjects and the way in which it is taught, to handle unexpected obstacles and deal with novelty.

In some countries and economies, such as Finland, Shanghai-China and Sweden, students master the skills needed to solve static, analytical problems similar to those that textbooks and exam sheets typically contain as well or better than 15-year-olds, on average, across OECD countries. But the same 15-year-olds are less successful when not all information that is needed to solve the problem is disclosed, and the information provided must be completed by interacting with the problem situation. A specific difficulty with items that require students to be open to novelty, tolerate doubt and uncertainty, and dare to use intuitions ("hunches and feelings") to initiate a solution suggests that opportunities to develop and exercise these traits, which are related to curiosity, perseverance and creativity, need to be prioritised.

In yet other countries and economies, such as Portugal and Slovenia, students are better at using their knowledge to plan and execute a solution than they are at acquiring such useful knowledge themselves, questioning their own knowledge, and generating and experimenting with alternatives. While these students appear to be goal-driven, motivated and persistent, their relatively weak performance on problems that require abstract information processing suggests that opportunities to develop the reasoning skills and habits of self-directed learners and effective problem-solvers need to be prioritised.

The analysis in Chapter 4 also identifies, within many countries and economies, certain study programmes whose students perform significantly better in problem solving, on average, than students in the same country/economy with