Executive Summary

This report looks at top-performing students in the PISA 2006 science assessment, their attitudes and motivations, and the schools in which they are enrolled. Top-performers are defined as those 15-year-old students who are proficient at Levels 5 and 6 on the PISA 2006 science scale as compared with strong performers (proficient at Level 4), moderate performers (proficient at Levels 2 and 3), and those who are at risk of being left behind (proficient at Level 1 or below).

Who are top performers in science in PISA 2006?

Top performers on the PISA 2006 science assessment form a diverse group, and the evidence suggests that excellence in science can develop in very different educational settings and circumstances.

- Achieving excellence is not just a question of inherent student ability and it can also relate to specific subject areas. The proportion of top performers varies widely from country to country. While, on average, 9% of OECD students are top performers in science, 20% of all students in Finland and 18% in New Zealand are top performers in science. On average across the OECD, 18% of students are top performers in at least one of the subject areas of science, mathematics or reading. However, only 4% are top performers in all three areas.
- A socio-economically disadvantaged background is not an insurmountable barrier to excellence. In the typical OECD country about a quarter of top performers in science come from a socio-economic background below the country's average. Some systems, however, are even more conducive for students from a relatively disadvantaged background to become top performers in science. For instance, in Japan, Finland and Austria and the partner economies Macao-China and Hong Kong-China, a third or more of the top performers in science come from a socio-economic background below the average of the country.
- Across subject areas and countries, female students are as likely to be top performers as male students. On average across OECD countries, the proportion of top performers across subject areas is practically equal between males and females: 4.1% of females and 3.9% of males are top performers in all three subject areas and 17.3% of females and 18.6% of males are top performers in at least one subject area. These averages, however, hide significant cross country variation and some significant gender gaps across subject areas. While the gender gap among students who are top performers only in science is small (1.1% of females and 1.5% of males), the gender gap is significant among top performers in reading only (3.7% of females and 0.8% of males) and in mathematics (3.7% of females and 6.8% of males).
- Top performers in science tend to be non-immigrant students who speak the test language at home, but in some countries immigrant or linguistic minority students excel as well. Germany, the Netherlands and the partner country Slovenia are the countries where the largest differences, in favour of non-immigrant students and students who speak the test language at home, are found.

Which schools do top performers in science attend?

The evidence from PISA suggests that some school characteristics, policies and practices matter for excellence, and often in ways that interact with the socio-economic context of the schools.

- Top performers in science generally attend schools with student populations characterised by high performance and a relatively advantaged socio-economic background. Many of these schools are private. However, once student and school socio-economic background are accounted for the advantage of private schools disappears in most OECD countries and in some countries it turns in favour of public schools.
- Top performers in science generally attend schools characterised by certain school policies, such as selecting in students according to their academic record, no ability grouping for all subjects or publishing performance data publicly. Yet, perhaps due to specific system characteristics, such as tracking and streaming, there is no consistent pattern across countries.

How do top performers in science experience science teaching and learning?

Learning experiences differ from one student to another. The analysis presented in this report shows that top performers in science are engaged learners who put a significant amount of effort into the study of science, particularly at school. They also actively engage in science-related activities outside school.

- In terms of effort, top performers in science spend more time studying science at school and less time on out-of-school lessons. On average, top performers receive 4 hours of instruction in science at school, half an hour more than strong performers and two hours more than lowest performers. By contrast top performers receive on average 30 minutes of out-of-school lessons a week, whereas the lowest performers receive 45 minutes, which may be attributable to the fact that these out-of-school lessons are largely remedial in nature, rather than fostering scientific talent. Understanding the nature of out-of-school lessons is important, as they are likely to differ across countries. Korea, a country with a large proportion of top performers, is an important exception. Korean top performers take an hour more of out-of-school lessons than lowest performers.
- Top performers in science are engaged science learners: they report that they enjoy learning science, that they want to learn more, that their science lessons are fun and that they are motivated to do well in science. On average 68% of top performers report being happy doing science problems (only 53% of strong performers did so). Over 80% of top performers report that they enjoy acquiring new knowledge in science, are interested in learning about science and generally have fun when learning science (only 50% of lowest performers did so).
- On top of what they do at school, top performers in science get involved in science-related activities outside school. More than a third of top performers regularly or very often watch science programs on TV and read science magazines or science articles in newspapers (only about 15% of lowest performers report the same kind of behaviour). A somewhat smaller proportion of top performers regularly or very often visit science-related websites (21%) or borrow or buy science books (14%). A few top performers attend science clubs (7%) or listen to radio programs on science (5%). Even after accounting for socio-economic background, top performers are significantly more involved in science-related activities than strong performers (in all systems except the partner economy Chinese Taipei).

What attitudes and motivations towards science characterise top performers in science?

Student attitudes and motivations tend to be closely related with student performance.

- Top performers in science care about doing well, in part because they believe that it will pay off in their future academic and professional careers. 81% of top performers report they study science because it is useful for them, 76% because it will improve their career prospects and 70% because they will need it for what they want to study later on.

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- In terms of their motivations, top performers in science report that they value their science learning. More than three quarters of top performers (significantly more than any other group) believe they will use science as adults, find it very relevant to themselves and expect to have many opportunities to use it when they leave school.
- Top performers in science are confident learners. The average *index of self-efficacy* – a measure of the student's level of confidence in their own ability to handle specific scientific tasks effectively and overcome difficulties – of top performers is 40% higher than that of strong performers. More than three quarters of top performers (significantly more than strong performers) reported they can usually give good answers to test questions on science topics, that they understand very well the science concepts they are taught and that they learn science topics quickly. 70% of top performers and 55% of strong performers reported science topics are easy for them.

Do top performers in science aspire to a career in science?

Top performers in science want to continue learning science but often do not feel well informed about science-related careers.

- On average across the OECD, 56% of top performers report that they would like to study science after secondary school. 61% of top performers report they would like to work in a career involving science.
- With respect to their aspirations, top performers in science report feeling well prepared for science-related careers (more so than any other group). Across the OECD countries, for instance, top performers agreed that the subjects they study (82%) and their teachers (81%) provide them with the basic skills and knowledge for a science-related career.
- However, only around than half of top performers in science report being well informed about science-related careers, or about where to find information on science related careers. Only a third of top performers feel well informed about employers or companies that hire people to work in science-related careers.

What do the findings tell us?

Countries vary significantly in the proportion of students who demonstrate excellence in science performance. Interestingly, scientific excellence is only weakly related to average performance in countries, that is, while some countries show large proportions of both high and poor performers, other countries combine large proportions of 15-year-olds reaching high levels of scientific excellence with few students falling behind.

The talent pool of countries differs not just in its relative and absolute size, but also in its composition. Student characteristics such as gender, origin, language, or socio-economic status are related to top performance in science but none of these student characteristics impose an insurmountable barrier to excellence. It is particularly encouraging that in some education systems significant proportions of students with disadvantaged backgrounds achieve high levels of excellence, which suggests that there is no inevitable trade-off between excellence and equity in education.

As the individual socio-economic background of students relates to the prevalence of scientific excellence, so does the socio-economic context in which schools operate. The interaction of this context with specific school policies and practices also needs to be taken into consideration. For example, there are in general higher proportions of top performers in private than in public schools. However, once the socio-economic context of schools is accounted for, the edge for private schools disappears.

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In terms of their experiences, attitudes, motivations and aspirations, top performers in science are dedicated and engaged learners who aspire to a career in science. Top performers in science also tend to spend more time in regular science lessons at school and more frequently engage in science related activities. They are confident learners interested in a broad range of science topics, they enjoy learning science even when the content is challenging and they believe they are good at science. They think that learning science will prove useful for them in their further studies and professional activities and more often aspire to a career in science, whether this is a cause or consequence of their performance and engagement with science. However, top performers often do not feel well informed about potential career opportunities in science, which is an area school policy and practice can act upon. The link between attitudes and motivations is strengthened by evidence suggesting that motivation among top performers is unrelated to socio-economic factors but rather a reflection of their enjoyment and active engagement in science learning inside and outside school.

At the same time, in a number of countries there are significant proportions of top performers who show comparatively low levels of interest in science. While these education systems have succeeded in conveying scientific knowledge and competencies to students, they have been less successful in engaging them in science-related issues and fostering their career aspirations in science. These countries may thus not fully realise the potential of these students. Fostering interest and motivation in science thus seems an important policy goal in its own right. Efforts to this end may relate to improved instructional techniques and a more engaging learning environment at school but they can also extend to students' lives outside school, such as through establishing and making available more and better content on the internet or in video games that applies scientific principles; establishing contests on the Internet with prizes for students who achieve particular levels of performance or stages of accomplishment; more and better television programming using children's cartoons to enlist interests in science and scientific curiosity for younger children; or science fiction novels and series of books on adventures or mysteries based upon scientific and technical knowledge, ingenuity and solutions with characters.

In sum, educational excellence goes hand in hand with promoting student engagement and enjoyment of science learning both inside and outside school. The payoff is quite significant: A large and diverse talent pool ready to take up the challenge of a career in science. In today's global economy, it is the opportunity to compete on innovation and technology.

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