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Drivers of Student Performance: Insights from Asia

Education 2017

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acknowledgements

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foreword

The PISA database is open to the world – a powerful resource for everyone who wants to understand education and help improve it, from policy-makers and researchers to school leaders, teachers and parents. Over recent years, McKinsey have done just this, drawing on PISA to identify the policies and practices that make a real difference. Their work began with ground-breaking reports on The World's Best School Systems And How To Build Them. And these new regional analyses of student-level performance represent another significant milestone.

The reports suggest that students' attitudes and motivation are critical drivers of achievement. So too are their experience in the classroom, of both teaching strategies and digital technology, as well as the time they spend in education. McKinsey's perceptive insights will encourage schools around the world to discover new ways to nurture and inspire their students.

What sets these reports apart is their regional focus. I often hear countries say that learning from the world's outstanding systems is vital, but that just as powerful is the chance to learn from their own neighbours, with similar cultural backgrounds and with shared problems and opportunities.

In every country, the search is on for ways to take education to the next level, to prepare young people for a dramatic and challenging century. This is complex work. What is the right mix of policies, implementation strategies and enabling conditions – in each country and region? How should they be prioritised, sequenced and linked? If we are really to secure achievement, well being and equity, on a global basis, then these will be the issues that educators need to work on. The new reports from McKinsey offer us a fresh and welcome perspective.

Andreas Schleicher
Director for the Directorate of Education and Skills | OECD

executive summary

A well-educated citizenry is an economic and social necessity. But there is little consensus about what it takes to deliver a quality education.

In two previous reports, one on the world's best-performing school systems (2007) and the other on the most improved ones (2010), we examined what great school systems look like and how they can sustain significant improvements from any starting point. In this report, we switch our focus from systems to student-level performance, by applying advanced analytics and machine learning to the results of the Organisation for Economic Co-operation and Development's (OECD) Program for International Student Assessment (PISA). Beginning in 2000, and every three years since, the OECD has tested 15-year-olds around the world on math, reading, and science; it also surveys students, principals, teachers, and parents on their social, economic, and attitudinal attributes.

Using this rich data set, we have created five regional (Asia, Europe, Latin America, Middle East and North Africa, and North America) reports that consider the drivers of student performance. In Asia, 13 countries and autonomous territories participated in the 2015 PISA. For our analysis, we divided these into three categories based on performance. High-performing Asia is composed of China (specifically the cities of Beijing, Guangdong, Jiangsu, and Shanghai), Hong Kong, Japan, Macao, Singapore, South Korea, Taiwan, and Vietnam. Oceania refers to Australia and New Zealand. Developing Asia is composed of Indonesia, Malaysia, and Thailand. High-performing Asia has high yet flat achievement; Oceania performs generally well, but scores appear to be declining; and Developing Asia is improving, but slowly and from a low base.

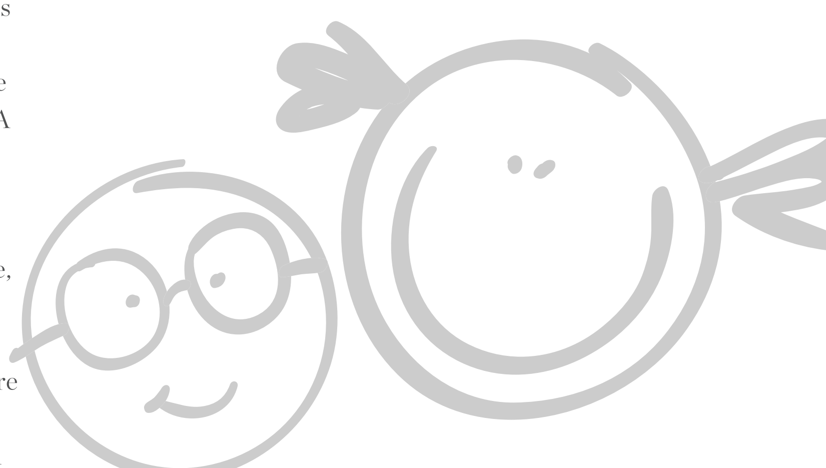
Our research is not intended as a road map to system improvement; that was the theme of our 2010 report, which set out the interventions school systems need to undertake to move from poor to fair to good to great to excellent performance. Instead, this report examines four specific factors that we found to be particularly important to student outcomes: mindsets, teaching practices, information technology, and early childhood education.

The report's findings include the following four highlights.

Student mindsets have double the effect of socioeconomic background on outcomes.

It is hardly news that students' attitudes and beliefs influence their academic performance. The magnitude of this effect, and which mindsets matter most, is still under debate; we focused our research on these areas. While there is likely overlap between socioeconomics and student mindsets, we measured the effect of mindsets that is not explained by socioeconomics alone. By analyzing the PISA data, we found that mindset factors have double the predictive power (31 percent) of home environment and demographics (15 percent) on student PISA scores in Asia. This relationship also holds true in all other regions, reinforcing the importance of this finding.

Some mindsets are more important than others. For example, we compared motivation calibration (being able to identify what motivation looks like in day-to-day life, including "working on tasks until everything is perfect" and "doing more than expected") to self-identified motivation ("wanting to be the best" or "wanting to get top grades"). In the 2015 PISA



Across Asia, students with a strong growth mindset—those who believe they can succeed if they work hard—outperform students with a fixed mindset—those who believe that their capabilities are static.

assessment, motivation calibration has over double the impact of self-identified motivation. Across Asia, students who have good motivation calibration score 8 to 14 percent higher on the science test than poorly calibrated ones. By contrast, students with high self-identified motivation score only 6 to 8 percent higher.

The impact of motivation calibration varies by geography and type of student. For students in Oceania and Developing Asia, it accounts for a 14 percent lift and for those in High-performing Asia, it is 8 percent.

In Developing Asia, the relationship is particularly strong for the three-quarters of students who attend poorly performing schools, where having a well-calibrated motivation mindset is equivalent to vaulting into a higher socioeconomic status. In these schools, students in the lowest socioeconomic quartile who are well calibrated perform better than those in the highest socioeconomic quartile who are poorly calibrated. In High-performing Asia and Oceania, the relationship is particularly strong for lower socioeconomic status students—double the effect experienced by students from wealthier households.

Having a growth mindset is also strongly linked to student outcomes. Across Asia, students with a strong growth mindset—those who believe they can succeed if they work hard—outperform students with a fixed mindset—those who believe that their capabilities are static. The difference in score between having a growth versus fixed mindset is 12 percent in Developing Asia, 14 percent in High-performing Asia, and 20 percent in Oceania.

To be clear, mindsets alone cannot overcome economic and social barriers, and researchers still debate the extent to which school-system-level interventions can shift student mindsets. Our research does, however, suggest that they matter—a lot, and particularly for those living in the most challenging circumstances. The research on this subject is both nascent and predominantly US-based. Considering its importance, local experimentation should be a priority.

Students who receive a blend of inquiry-based and teacher-directed instruction have the best outcomes.

High-performing and fast-improving school systems require high-quality instruction. It's that simple—and that difficult. We evaluated two types of science instruction to understand how different teaching styles affect student outcomes. The first type is "teacher-directed instruction," where the teacher explains and demonstrates scientific ideas, discusses questions, and leads classroom discussions. The second is "inquiry-based learning," where students play a more active role, creating their own questions and engaging in experiments.

Our research found that student outcomes are highest with a combination of teacher-directed instruction in most or almost all classes, with inquiry-based learning in some. If all students experienced this blend, average PISA scores would rise by 3.8 percent in High-performing Asia, 3.4 percent in Oceania, and 1.2 percent in Developing Asia. For High-performing Asia and Oceania, this is equivalent to approximately half a year of schooling.

Given the strong support for inquiry-based pedagogy, these results may seem counterintuitive. We offer two hypotheses. First, students cannot progress to inquiry-based methods without a strong foundation of knowledge, gained through teacher-directed instruction. Second, inquiry-based teaching is inherently more challenging to deliver, and teachers who attempt it without sufficient training and support tend to struggle. Better teacher training, high-quality lesson plans, and school-based support can help. It's also important to note that some kinds of inquiry-based teaching are better than others. For example, explaining how a science concept can be applied to a real-world situation appears to boost outcomes; having students design their own experiments seems to do the opposite.

School-based technology yields the best results when placed in the hands of teachers.

Screens are not the problem when it comes to student outcomes—but neither are they the answer. Our research examined the impact of first exposure to information and communications technologies (ICT), the impact of ICT use at home, and also the impact during school. Across Asia, students with their first digital exposure before the age of six score 12 percent higher than those exposed at age 13 or later (controlling for socioeconomic status, school type, and location). Students of higher socioeconomic status are more likely to start using devices at an early age, which has worrying implications for the equity gap.

When 15-year-olds were asked how much time they spend using the Internet at home, interesting differences emerged. In Developing Asia and Oceania, moderate use of the Internet (defined as two to four hours per day) correlated with higher PISA scores. Beyond four hours, the positive effects tended to decline, with negative implications when students spend more than six hours per day on screens outside of school. However, in most High-performing Asian countries, students who spend more than about an hour per day saw declining benefits. Across High-performing Asia, only 65 percent of students report spending more than 30 minutes online a day, versus 95 percent of students in Oceania, suggesting very different cultural norms.

The impact of ICT use during the school day is much more mixed: from minus 17 percent to plus 8 percent, depending on the type of hardware. Most important, we found that deploying ICT to teachers works best. For example, students who report teacher usage of data projectors in their classrooms score 8 percent higher than those who do not. The lift for desktop and Internet-connected student computers, by contrast, is only three and five percent respectively. These results all hold controlling for socioeconomic status, school type, and location. Some student-based classroom technologies, such as laptops in High-performing Asia, and tablets and e-book readers across all of Asia, actually appear to hurt performance.

It is important to note that these results describe the impact of education technology now, not its eventual potential. Nor do these findings consider software or how teachers are using the technology in the classroom. Even so, Asian leaders should not assume the impact of ICT will always be positive or even neutral. Systems should ensure that ICT programs are fully integrated with the curriculum and instruction and are supported by teacher professional development and coaching.

Early childhood education has a positive impact on student scores, but the quality and type of care is important.

Many studies have shown that quality early childhood education (ECE) improves social and academic outcomes, although there are some concerns about fade-out in later years. Our findings, like other research, validate the overall positive impact of ECE. Across Asia, students who report some ECE perform 21 PISA points (over half a school year) better on the PISA science test a decade later than students who attended no ECE, (controlling for socioeconomic status, school type, and location).

There are meaningful differences across the categories. First, the lift for High-performing Asia is six PISA points, versus 11 for Oceania (there was not enough data for Developing Asia to draw statistically significant conclusions). Second, students in High-performing Asia and Oceania do best at age 15 when they start ECE at age three; for Developing Asia, the best performers start at age four. This may reflect variation in the quality of care available for younger children.

Type of care matters also. The parent survey data from three high-performing school systems (Hong Kong, Macao, and South Korea) indicates that children who went to more formal, structured pre-primary programs significantly outscored those who went to less formal programs or had no ECE at all.

The data suggests that Asian governments should continue to prioritize providing early childhood education and should carefully monitor the quality of provision.

We are mindful of the limits of these findings. One cannot hope to gain definitive answers from a single source, no matter how broad or well designed. The direction of causality, sample sizes, missing variables, and nonlinear relationships are important issues. There are still many questions that need to be resolved through a thoughtful research agenda and longitudinal experimentation. That said, we believe that these findings provide important insights into how students succeed. Asian educators should incorporate them into their school-improvement programs to deliver the progress that their students deserve □

introduction

Effective education is essential to forge economic productivity, address inequality, and prepare children for constructive citizenship. No wonder, then, that there is broad interest in understanding how to build school systems that serve everyone well, regardless of background, and how to improve systems that are not making the grade.

For the past decade, McKinsey has studied these issues. In 2007, we published *How the world's best-performing school systems come out on top*, which examined why some school systems consistently perform better than others. This report highlighted the importance of getting the right people to become teachers, developing their skills, and ensuring that the system is able to offer the best possible instruction to every child. In 2010, *How the world's most improved school systems keep getting better,* explored what it takes to achieve significant and sustained performance improvement. This report defined poor, fair, good, great, and excellent systems (see the analytical appendix for more detail) and outlined what school systems need to do to progress from one performance level to the next[1] (Exhibit 1).

These two reports focused on interventions at the system level. In this report, we undertake a quantitative analysis at the student level. To do so, we applied advanced analytics and machine learning to develop insights from the world's deepest and broadest education data set, the Program for International Student Assessment (PISA), run by the Organisation for Economic Co-operation and Development (OECD).

Begun in 2000 and repeated every three years since, PISA examines 15-year-olds on applied mathematics, reading, and science. The most recent assessment, in 2015, covered nearly 540,000 students in 72 countries.[2] PISA test takers also

EXHIBIT 01: OUR 2010 REPORT OUTLINED INTERVENTIONS REQUIRED AT EACH STAGE OF THE SCHOOL-SYSTEM-IMPROVEMENT JOURNEY.

IMPROVEMENT JOURNEY	POOR TO FAIR	FAIR TO GOOD	GOOD TO GREAT	GREAT TO EXCELLENT
THEME	Achieving the basics of literacy and numeracy	Getting the foundations in place	Shaping the professional	Improving through peers and innovation
INTERVENTION CLUSTER	• **Providing motivation and fundamentals for low-skill teachers** – Scripted teaching materials – External coaches – Instructional time on task – School visits – Incentives for high performance • **Getting all schools to a minimum quality level** – Outcome targets – Additional support for low performing schools – School infrastructure improvement – Provision of textbooks • **Getting students in school** – Increase number of seats – Fulfill students' basic needs	• **Data and accountability** – Transparency school performance to schools and/or public – School inspections • **Financial and organizational** – Optimization of school and teacher volumes – Decentralizing financial and administrative rights – Increasing funding – Funding allocation model – Organizational redesign • **Teaching** – School model/ streaming – Language of instruction	• **Raising the caliber of new teachers and principals** – Recruiting programs – Pre-service training – Certification requirements • **Raising caliber of existing teachers and principals** – In-service training – Coaches – Career tracks – Teacher and community forums • **School-based decision making** – Self-evaluation – Independent and specialized schools	• **Cultivating peer-led learning for teachers and principals** – Collaborative practice – Decentralizing pedagogical rights to schools and teachers – Rotation and secondment programs • **Building support programs for professionals** – Release professionals from administrative burden by providing additional administrative staff • **System-sponsored experimentation/ innovation** – Providing additional funding for innovation – Sharing innovation from frontline to all schools
COMMON ACROSS ALL JOURNEYS	Six interventions: [1] Revising curriculum and standards; [2] Reviewing reward and remunerations structure; [3] Building technical skills; [4] Assessing students; [5] Utilizing student learning data, and [6] Establishing policy documents and education laws			

EXHIBIT 02: PISA IS A RICH SET OF ASSESSMENT AND SURVEY DATA.

OECD PISA test performance + survey data

72	18,000	140,000	110,000	540,000
countries[1]	schools	parents	teachers	students

3	~270	~150	~250	~770
subjects	school variables	parent variables	teacher variables	student variables

3 subjects
- Math
- Science
- Reading

~270 school variables
E.g.,
- Size
- Resources
- Governance and autonomy
- Extra-curriculars

~150 parent variables
E.g.,
- Education
- Income
- Employment
- Attitudes to school and education

~250 teacher variables
E.g.,
- Experience
- Certification
- Professional development
- Teaching strategies
- Assessment strategies

~770 student variables
E.g.,
- Attitude to study and learning
- Growth mindset
- Problem solving approach
- Repeated grade
- Economic and social status

Linked over time through mapping of variables across 2003-2006-2009-2012-2015

1 Report excludes Albania as it was not possible to match test and survey data, includes Argentina, Kazakhstan and Malaysia despite sampling concerns as our analysis examines drivers at the student level rather than country-level comparisons

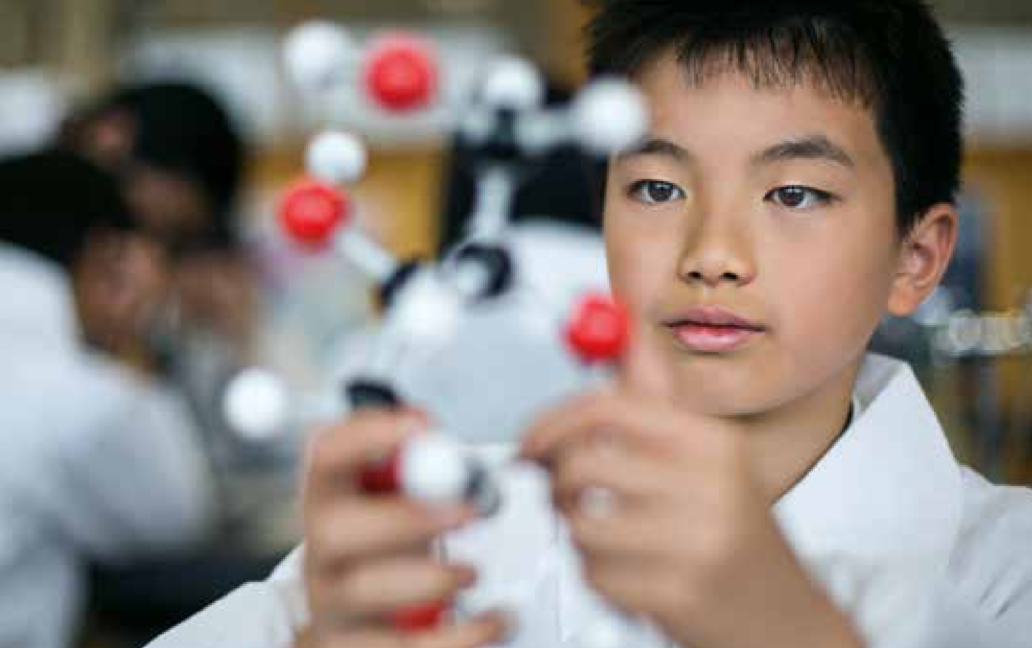
answer a rich set of attitudinal questions; students, teachers, parents, and principals completed surveys that provided information on home environment, economic status, student mindsets and behaviors, school resources and leadership, teaching practices, teacher background, and professional development (Exhibit 2). The 2015 PISA focused on scientific performance, with half of the student assessment related to science and the other half split between reading and math.[3] The survey questions therefore largely addressed science teaching and learning.

Standardized tests have their shortcomings. They cannot measure important soft skills or nonacademic outcomes, and they are subject to teaching to the test and gaming the system. Surveys rely on self-reporting, which may create inherent bias. Nonetheless, we believe that PISA provides powerful insights into global student performance, especially because it aims to test the understanding and application of ideas, rather than facts derived from rote memorization.

In this report, we examine educational performance in the Asia–Pacific region. We divide the countries in the region into the following three categories, based on their performance (Exhibit 3).

EXHIBIT 03: WE DIVIDED THE ASIA–PACIFIC REGION INTO THREE CATEGORIES.

1 Included in all analyses despite weighted response rate for Malaysian schools (51%) falling short of standard PISA response rate of 85%.
Source: OECD PISA 2015




High-performing Asia: This group is composed of China (specifically, the cities of Beijing, Guangdong, Jiangsu, and Shanghai, or B-S-J-G), Hong Kong, Japan, Macao, Singapore, South Korea, Taiwan, and Vietnam. These places generally outscore the rest of the region.

Developing Asia: Indonesia, Malaysia,[4] and Thailand lag the rest of the region in all subjects.

Oceania: Australia and New Zealand generally trail High-performing Asia but always outscore developing Asia.

First, we used a supervised machine-learning and feature discovery tool that identified variables and groups of variables most predictive of student performance. We then applied more traditional descriptive and statistical analyses to the factors that were shown to be the most important in contributing to students' PISA performance. (For more, see the analytical appendix at the end of the report.)

We looked not only at macroperformance but also at how patterns differed by the system performance levels outlined in our 2010 report and by students' economic, social, and cultural status (or ESCS; see the analytical appendix for an explanation). Our research resulted in four key findings, regarding mindsets, teaching practices, information

technology, and early childhood education. These four findings emerged as both highly predictive of student performance in Asia and potentially responsive to school system interventions.

In what follows, we describe the region's educational performance in historical terms. Then we discuss each of the findings and suggest their possible implications. Our intention is to offer insights that policy makers and practitioners can use to make improvements. □

setting the context:

Educational performance in the Asia-Pacific region.

Educational performance can be measured in terms of overall quality (absolute scores), cost-effectiveness (performance per dollar spent) and equity (differences in performance between boys and girls, and among different economic and ethnic groups).

In our previous work, we divided education systems into five bands—poor, fair, good, great, and excellent. In terms of quality, the Asia–Pacific region spans the gamut. High-performing Asia performs well on most subjects; Oceania performs above the OECD average; and Developing Asia scores far below (Exhibit 4)

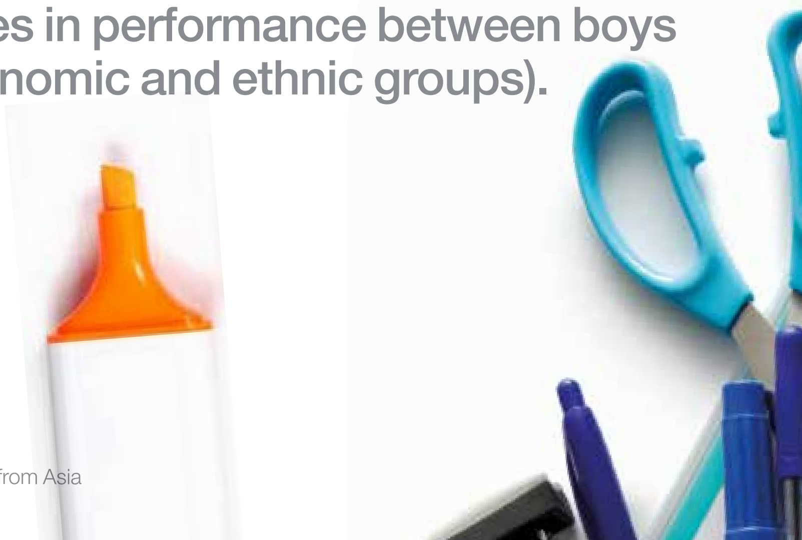


EXHIBIT 04: ASIA'S PISA SCORES VARY WIDELY.

Science 2015

Rank	Country	Mean
1	Singapore	556
2	Japan	538
3	Estonia	534
4	Taiwan	532
5	Finland	531
6	Macao (China)	529
7	Canada	528
8	Vietnam	525
9	Hong Kong (China)	523
10	B-S-J-G (China)	518
11	Korea	516
12	New Zealand	513
14	Australia	510
	OECD average	493
47	Malaysia	443
54	Thailand	421
62	Indonesia	403
70	Dominican Rep.[1]	332

Reading 2015

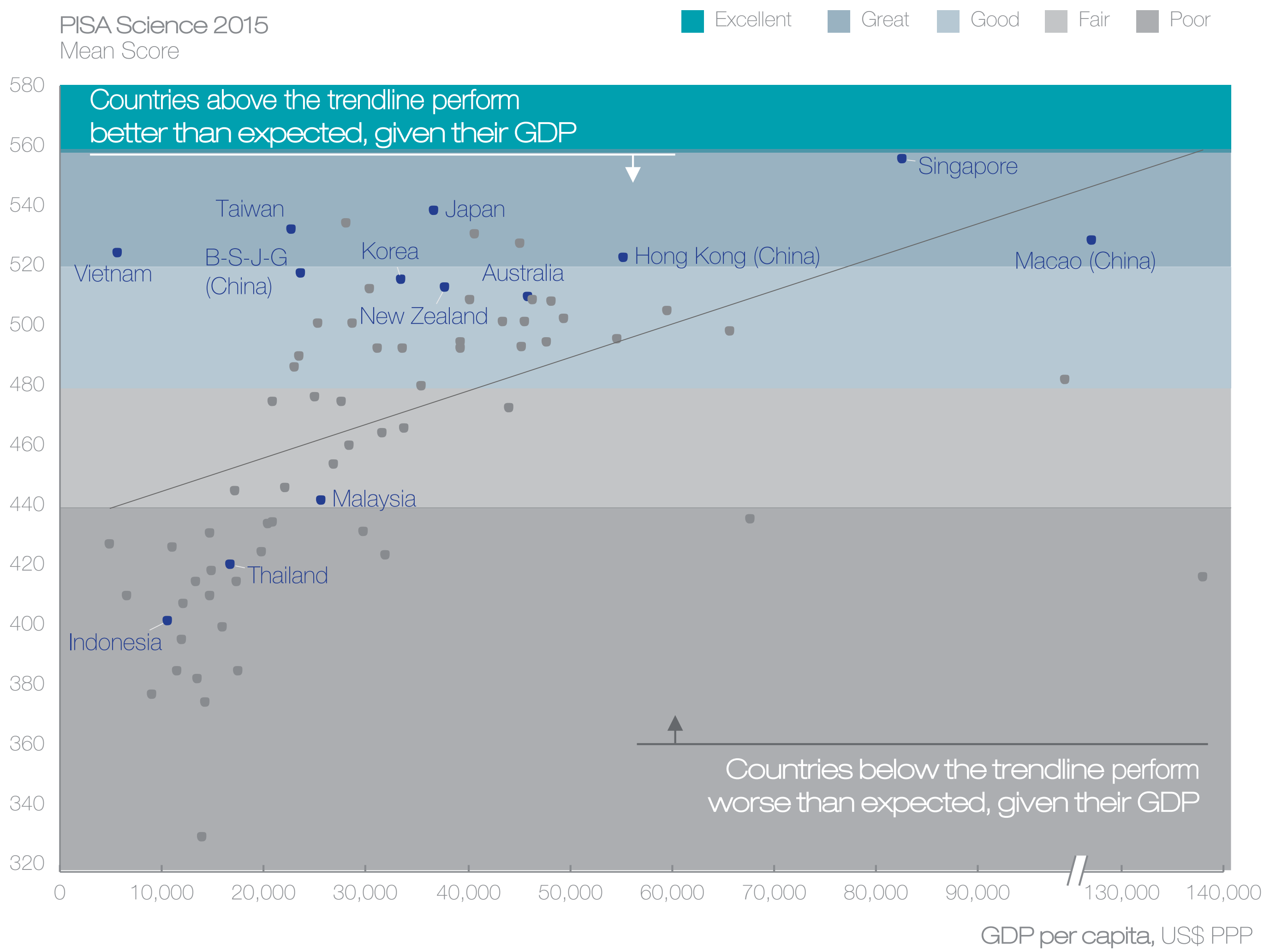
Rank	Country	Mean
1	Singapore	535
2	Hong Kong (China)	527
3	Canada	527
4	Finland	526
5	Ireland	521
6	Estonia	519
7	Korea	517
8	Japan	516
9	Norway	513
10	New Zealand	509
12	Macao (China)	509
16	Australia	503
23	Taiwan	497
27	B-S-J-G (China)	494
	OECD average	493
32	Vietnam	487
49	Malaysia	431
57	Thailand	409
64	Indonesia	397
70	Lebanon	347

Math 2015

Rank	Country	Mean
1	Singapore	564
2	Hong Kong (China)	548
3	Macao (China)	544
4	Taiwan	542
5	Japan	532
6	B-S-J-G (China)	531
7	Korea	524
8	Switzerland	521
9	Estonia	520
10	Canada	516
21	New Zealand	495
22	Vietnam	495
25	Austrailia	494
	OECD average	490
45	Malaysia	446
54	Thailand	415
63	Indonesia	386
70	Dominican Rep.	328

1 Ranking contains only 70 countries not the full 72 countries we analyze in our student-level analysis - due to sampling issues in some countries that prevent accurate comparison of country-level results
Source: PISA 2015

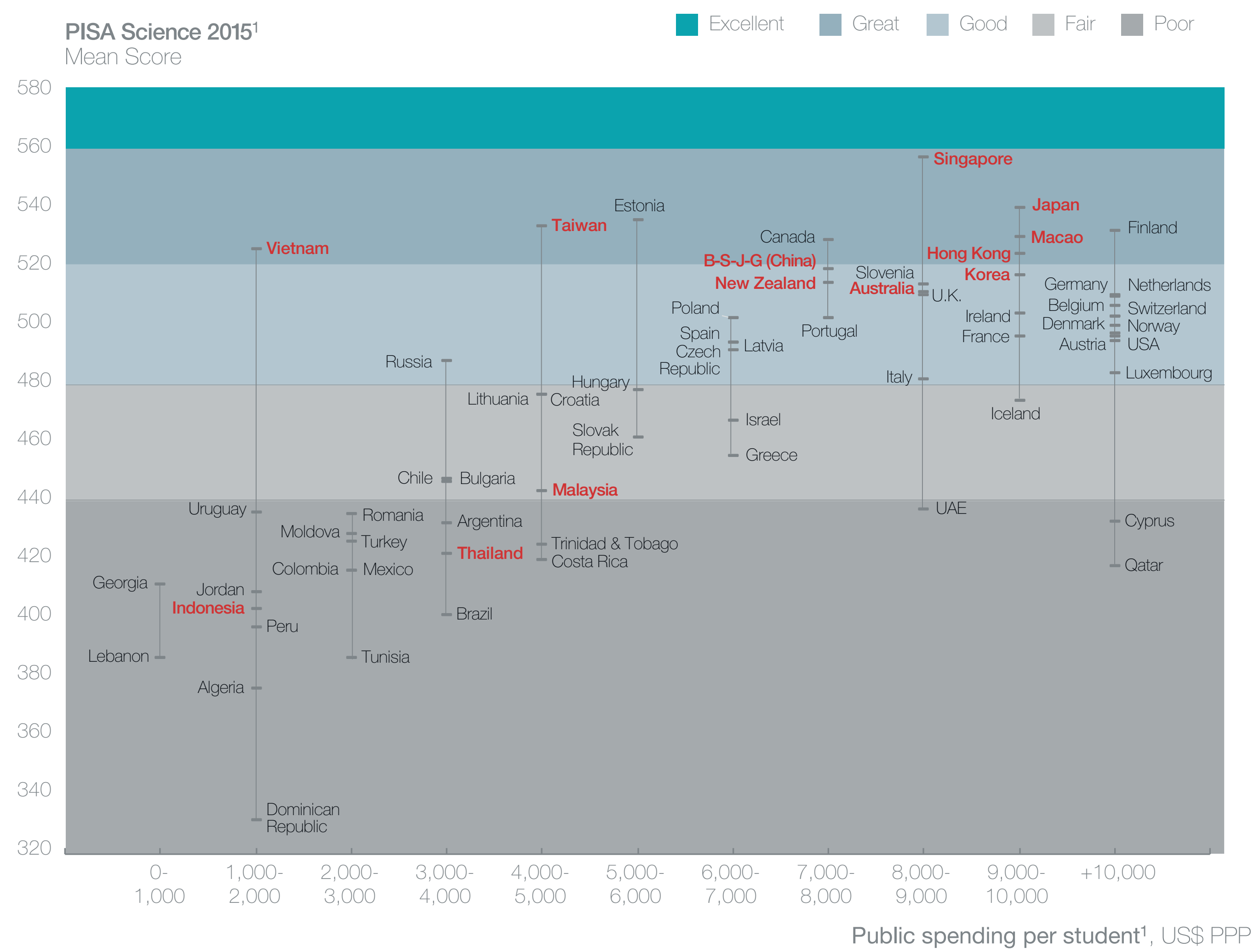
EXHIBIT 05: HIGH-PERFORMING ASIA AND OCEANIA PERFORM BETTER THAN EXPECTED GIVEN GDP; DEVELOPING ASIA PERFORMS WORSE.



Source: OECD PISA 2015, World Bank local statistical yearbooks

When compared to peers with a similar level of GDP and education spending, the performance of Developing Asia also lags, suggesting low cost-effectiveness (Exhibits 5 and 6). Most systems in High-performing Asia and Oceania, on the other hand, perform better than expected on that basis. Taiwan, for example, spends about as much per capita as Malaysia, but its students score two levels higher. Vietnam is an even more striking example. Although it is a low-income country, with a GDP per capita less than that of Malaysia or Thailand, it outperforms them in every subject and generally performs at a high level. In science, it ranks eighth in the world.

EXHIBIT 06: DEVELOPING ASIA LAGS ON COST-EFFECTIVENESS.



1 If 2015 data is not available, the most recent year's data is used.
Source: World Bank EdStats; IMF; UNESCO; PISA; TIMSS; PIRLS; Global Insight; McKinsey & Company

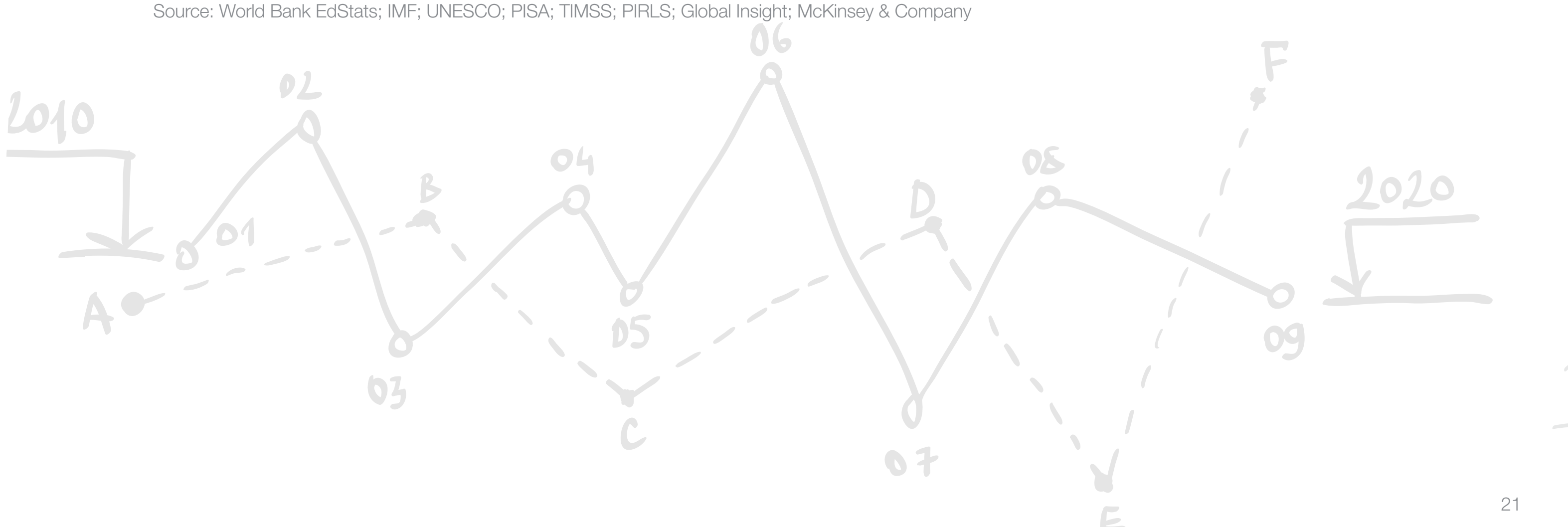
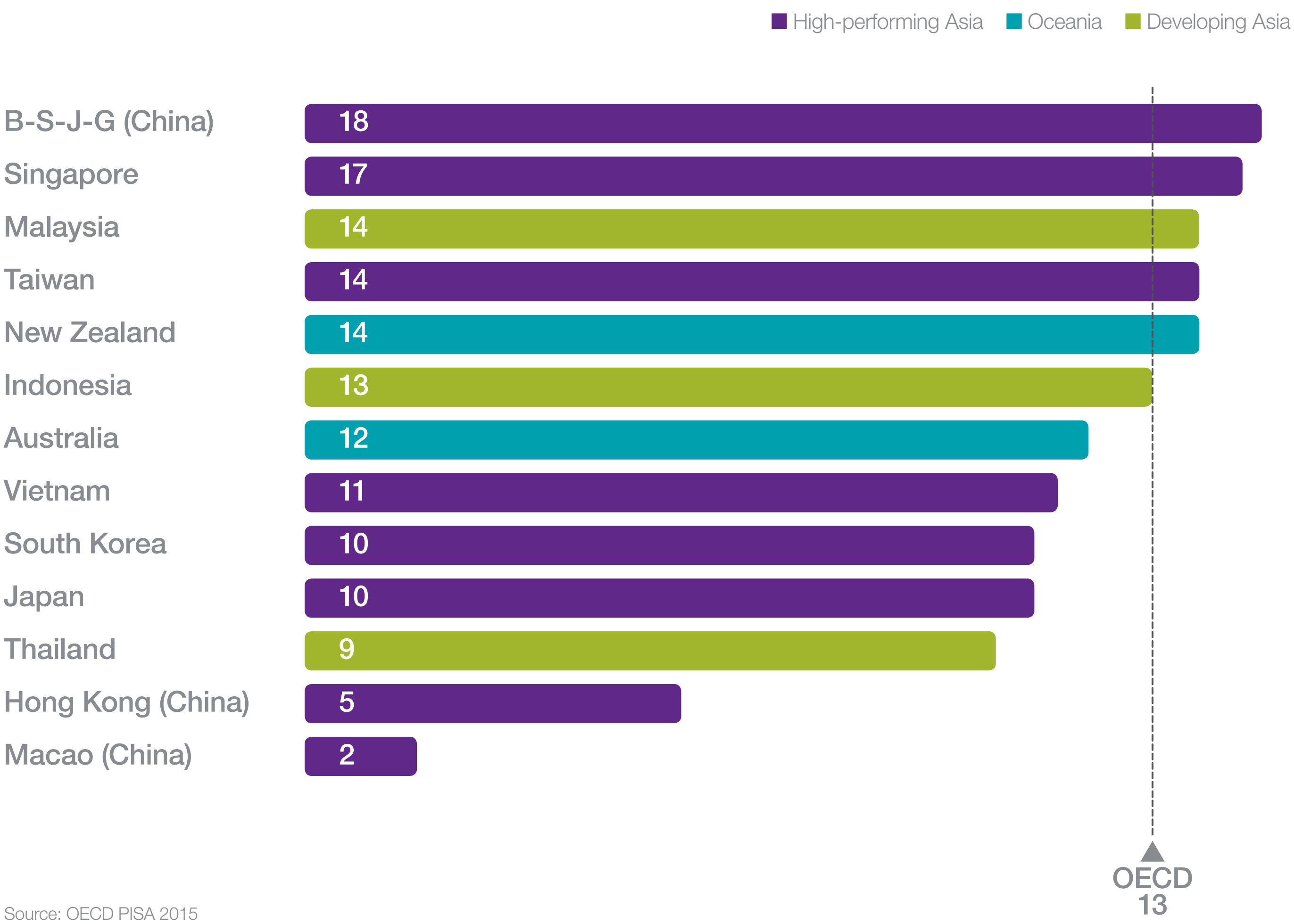


EXHIBIT 07: THE INFLUENCE OF SOCIOECONOMIC BACKGROUND VARIES SIGNIFICANTLY BY COUNTRY.

% of score variance explained by PISA's index of economic, social, and cultural status (ESCS)



Source: OECD PISA 2015

Equity in education—defined as the extent to which economic, social, and cultural status (ESCS) influences student outcomes—also varies significantly across the Asia–Pacific region. Hong Kong and Macao, in particular, achieved high performance with a high degree of equity, with only 5 percent and 2 percent of student scores, respectively, explained by ESCS factors (Exhibit 7). For Singapore and China, the figures were 17 and 18 percent. The OECD average is 13 percent.

Access to schooling also varies. Oceania and High-performing Asia have almost universal primary-school enrollment and high enrollment rates at upper levels. In Developing Asia, enrollment and completion remain a challenge (Exhibit 8).[5]

EXHIBIT 08: ENROLLMENT RATES VARY WIDELY, PARTICULARLY AT THE PRE-PRIMARY AND UPPER-SECONDARY LEVELS.

Net enrollment rate by level of education[1], 2015[2]
(%)

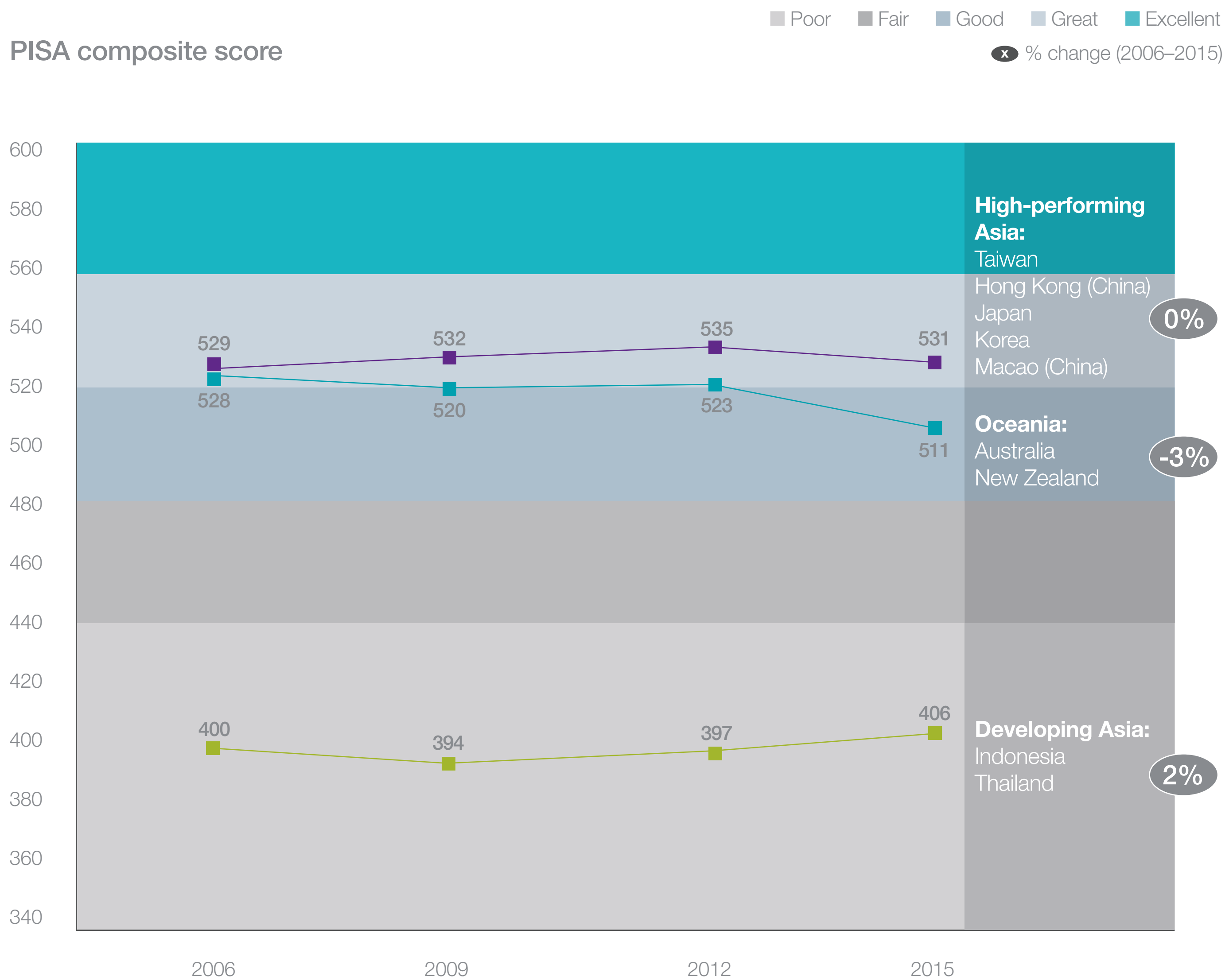
		Pre-Primary	Primary	Lower-Secondary	Upper Secondary
High-performing Asia	South Korea	91.5	96.3	95.2	90.8
	Macao	90.4	95.0	77.3	61.2
	Japan	89.8	100.0	99.9	95.9
	Hong Kong	88.9	n/a	86.7	75.5
	Vietnam	77.9	98.0	94.0	n/a
Oceania	New Zealand	90.2	98.4	98.0	87.9
	Australia	81.3	97.0	84.0	74.5
Developing Asia	Malaysia	80.7	98.1	87.3	55.0
	Thailand	57.8	90.8	79.1	68.5
	Indonesia	40.4	89.7	72.8	58.8

1 As defined according to the International Standard Classification of Education (ISCED): Pre-primary: ISCED level 0 includes preschool and kindergarten programs; Primary: ISCED level 1 typically begins between ages 5 and 7 and lasts for 4–6 years; Lower secondary: ISCED level 2 begins around the age of 11—equivalent of intermediate school, middle school, or junior high school; Upper secondary: ISCED level 3 immediately follows lower-secondary education and includes general (academic), technical, and vocational education—equivalent of senior high school.

2 If 2015 data is not available, the latest data is used; data unavailable for B-S-J-G (China), Taiwan, and Singapore.

Source: UNESCO

EXHIBIT 09: SCORES HAVE CHANGED LITTLE SINCE 2006.

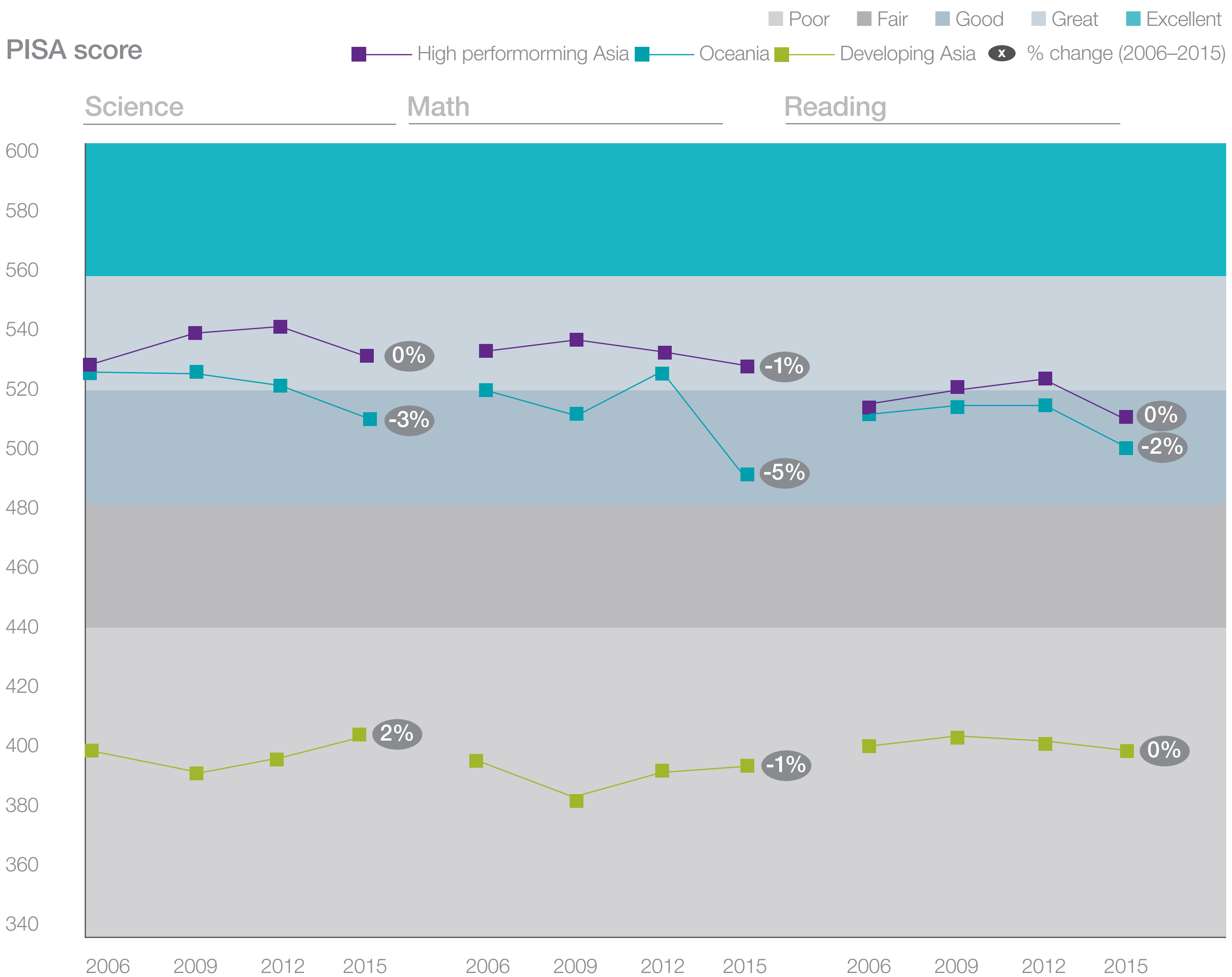


1 Includes only countries that participated in all PISA cycles from 2006 to 2015. B-S-J-G (China), Malaysia, Singapore, and Vietnam are therefore not included.
Source: OECD PISA 2006-2015

In the past decade, a number of Asia–Pacific systems have undertaken education reforms. For example, China has expanded early childhood education;[6] Indonesia has implemented teacher reforms;[7] and New Zealand has established national standards in mathematics, reading, and writing.[8]

The results have been uneven. Data from 2006 to 2015 found that PISA scores for High-performing Asia and Developing Asia barely changed. High-performing Asia stayed in the "great" performance level, while developing Asia remained in the "poor" performance level. Oceania dropped from "great" to "good," with a decline of 17 PISA points in 2015 (Exhibit 9). Across subjects, only the science score in Developing Asia improved. The worst result was math in Oceania, where scores declined 5 percent (Exhibit 10).[9]

EXHIBIT 10: SUBJECT SCORES HAVE ALSO CHANGED LITTLE SINCE 2006.



1 Includes only countries that participated in all PISA cycles from 2006 to 2015; countries not included are B-S-J-G (China), Malaysia, Singapore, and Vietnam.
Source: OECD PISA 2006-2015

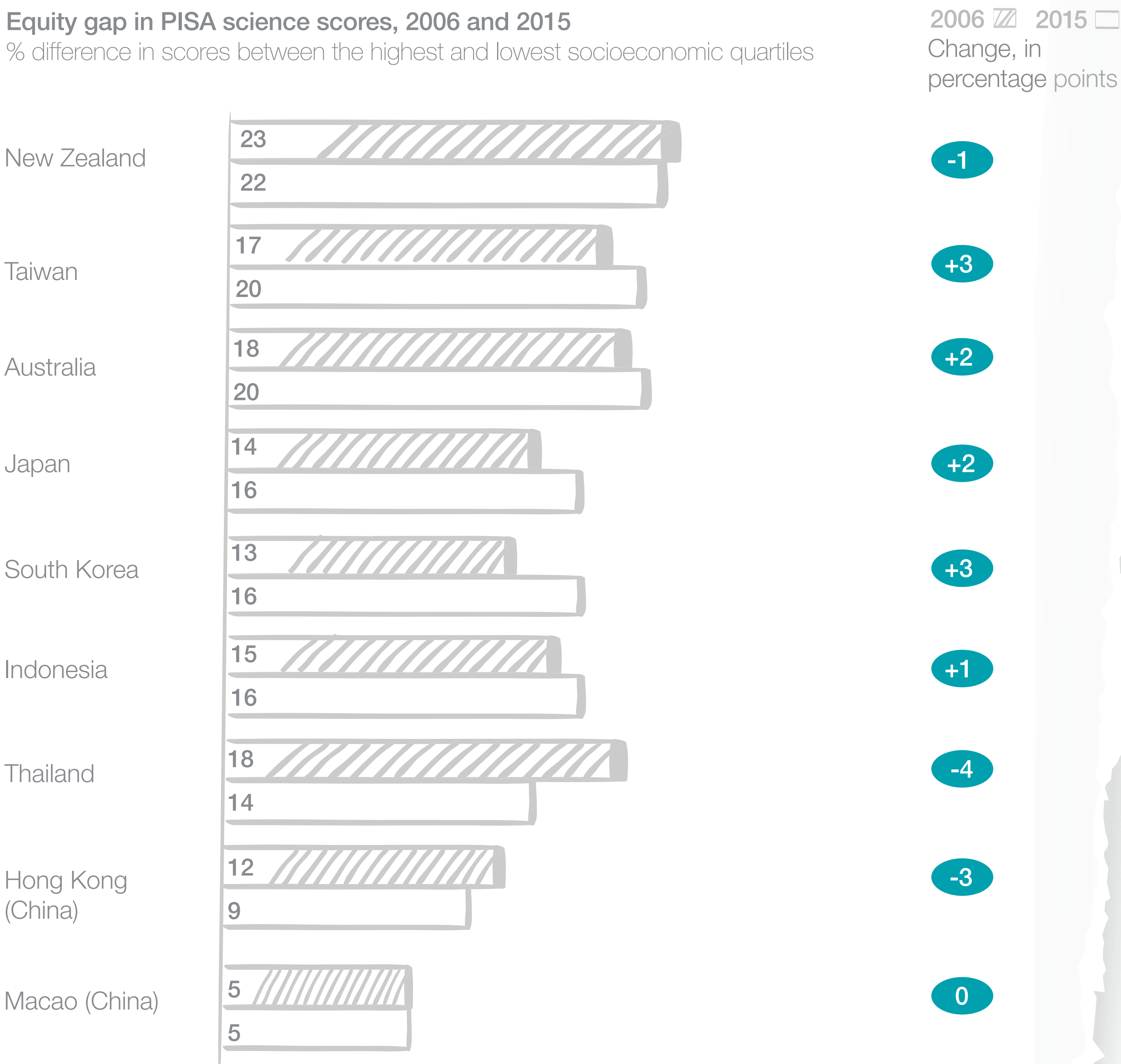
EXHIBIT 11: EQUITY GAP NARROWED IN ALL REGIONS, INCLUDING ASIA

Source: OECD PISA 2006; OECD PISA 2015

In terms of equity, the gap between students in the top and bottom socioeconomic quartiles has narrowed slightly since 2006, but it is still the widest (38 percent) of any region. This reflects the diversity of the region, rather than higher levels of inequity within any Asian country. (Exhibit 11).

Some systems have made progress. Since 2006, Hong Kong and Thailand have narrowed the achievement gap between the students in the poorest and richest quartiles by three and four percentage points, respectively. Most Asian systems, however, have seen the achievement gap widen—in both South Korea and Taiwan, the gap widened by three percentage points[10] (Exhibit 12).

EXHIBIT 12: PROGRESS IN NARROWING THE EQUITY GAP HAS BEEN UNEVEN.



Looked at broadly, the Asia–Pacific's PISA results are a mix of promise, challenges, and lost opportunities. High-performing Asia has high yet flat achievement; Oceania performs generally well, but scores appear to be declining; and Developing Asia is improving, but slowly and from a low base.

We believe the following four findings, which complement the interventions we outlined in our 2010 report, can help Asia–Pacific school systems to do better □

Finding 1:
Student mindsets have double the effect of socioeconomic background on outcomes

The role of mindsets in educational achievement is a nascent but intriguing field of study. In her 2006 book, Mindset: The New Psychology of Success, Carol Dweck argued that individuals with "growth mindsets"—that is, those who believed that their success was due to hard work and learning—were more resilient and likely to be motivated to succeed than those with "fixed mindsets"—those who believed that their innate abilities were static and could not be developed. Dweck also argued that growth mindsets could be taught.

In 2016, Angela Duckworth highlighted the importance of "grit" as a predictor of performance in Grit: The Power of Passion and Perseverance. Others have explored the role of broader character traits such as perseverance, curiosity, conscientiousness, optimism, and self-control in children's success. A large-scale 2016 Stanford study of all tenth graders in Chile—the largest study to date on the influence of mindsets on educational outcomes—found that having a strong growth mindset rivals socioeconomic status in predicting achievement and that low-income students with strong growth mindsets were able to achieve at the same level as high-income students with fixed mindsets.[11] Other researchers, however, have questioned both the magnitude of the effect and the usefulness of interventions in this area.[12]

We had three objectives in reviewing the role of mindsets: to quantify the impact of mindsets on student performance; to assess which mindsets matter most; and to understand which types of schools and students benefit the most from certain mindsets.

To quantify the impact of mindsets, we sorted the 100 most predictive variables (see the analytical appendix for more detail) emerging from the PISA surveys into a number of specific categories: mindset factors, home environment (including socioeconomic status), school factors, teacher factors, student behaviors, and others.[13] We separated mindsets into two types: "subject orientation" and "general mindsets." Subject orientation

refers to a student's attitudes about science as a discipline (science, specifically, because that was the focus of the 2015 PISA). General mindsets refer to a student's broader sense of belonging, motivation, and expectations.

To be conservative, we excluded from the analysis variables where we believed the direction of causality was largely from score-to-mindset rather than from mindset-to-score. For example, we judged that students' academic performance is more likely to influence their future educational expectations (e.g., whether they will complete college), rather than the other way around, and thus excluded this variable from our model.

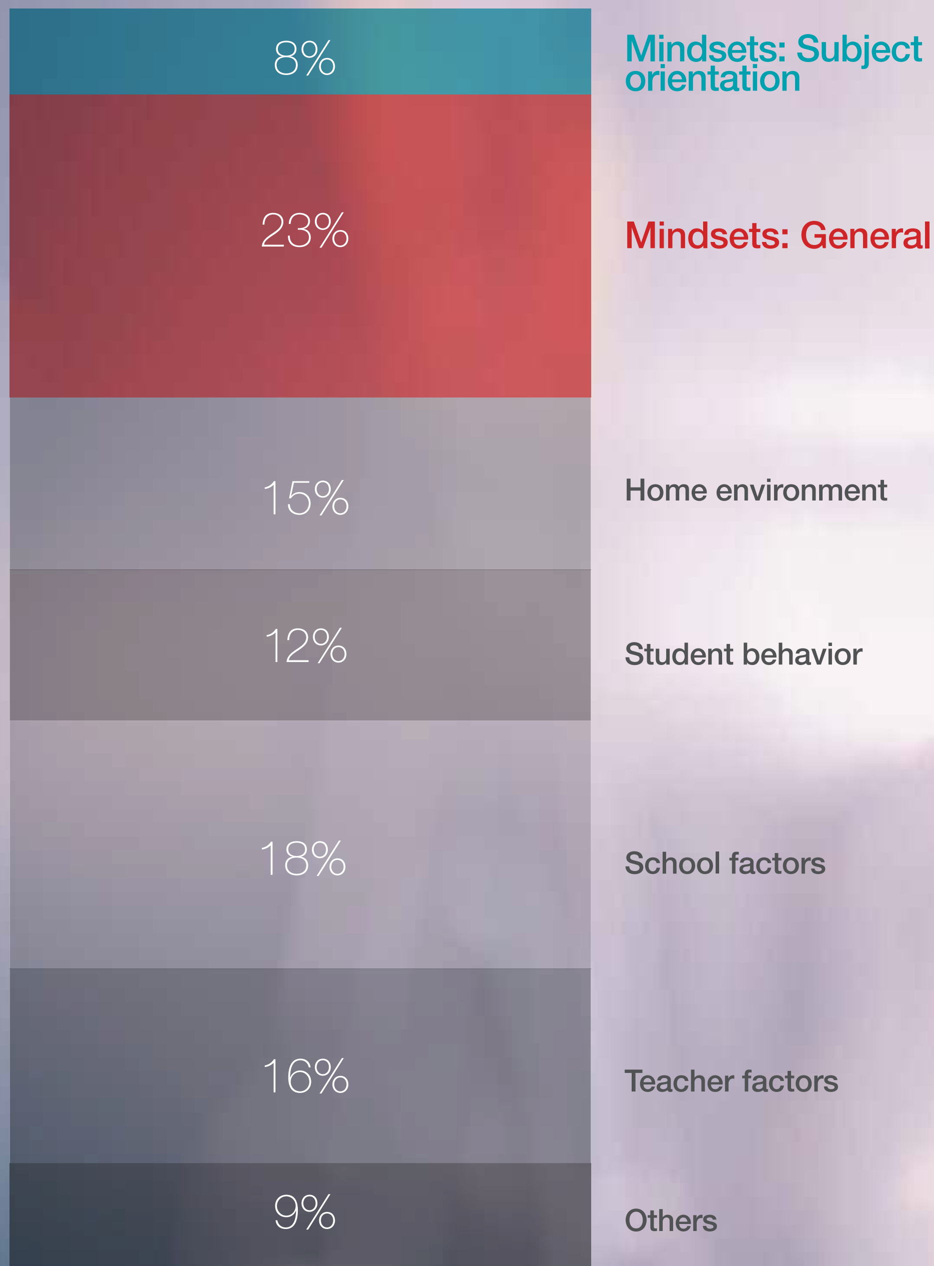
We then determined how influential each category was in terms of predicting student performance. Our conclusion was that, controlling for all other factors, student mindsets are twice as powerful (at 31 percent of total predictive power) as home and demographic factors[14] (Exhibit 13). Furthermore, general mindsets accounted for two-thirds of the effect found. The same pattern held true in all five regions (Asia, Europe, Latin America, Middle East and North Africa, and North America), reinforcing the importance of this finding.

EXHIBIT 13:
MINDSETS ARE THE SINGLE MOST IMPORTANT FACTOR IN PREDICTING STUDENT ACHIEVEMENT.

FACTORS DRIVING ASIAN STUDENT OECD PISA SCIENCE PERFORMANCE 2015

% of predictive power by category of variable

Source: OECD PISA 2015, McKinsey analysis



Examples of subject orientation mindsets:

"I have fun learning science"

"I am interested in the universe and its history"

"Air pollution will get worse over the next 20 years"

Examples of general mindsets:

"I see myself as an ambitious person"

"What I learn in school will help get me a job"

"I feel like I belong at school"

"If I put in enough effort, I can succeed"

EXHIBIT 14: WHAT MINDSETS MATTER MOST?

Score improvement for top general mindset measures in Asia[1]
Percent increase in PISA score

1 Percent increase in PISA science score
2 Growth mindset not asked in 2015 thus using 2012 data
Source: OECD PISA 2015, McKinsey analysis

Delving deeper into general mindsets, we found that several specific attributes emerged as particularly predictive of student performance (Exhibit 14).

"Motivation calibration" is the most important factor in 2015. This refers to the ability of students to correctly assess what motivation looks like in day-to-day life, such as "working on tasks until everything is perfect" and "doing more than expected." To measure this, PISA asked test takers to assess the motivation of three hypothetical students (Exhibit 15).

EXHIBIT 15: WHAT IS MOTIVATION CALIBRATION?

Edward gives up easily when confronted with a problem and is often unprepared for class.

Jane mostly remains interested in the tasks she starts and sometimes does more than what is expected of her.

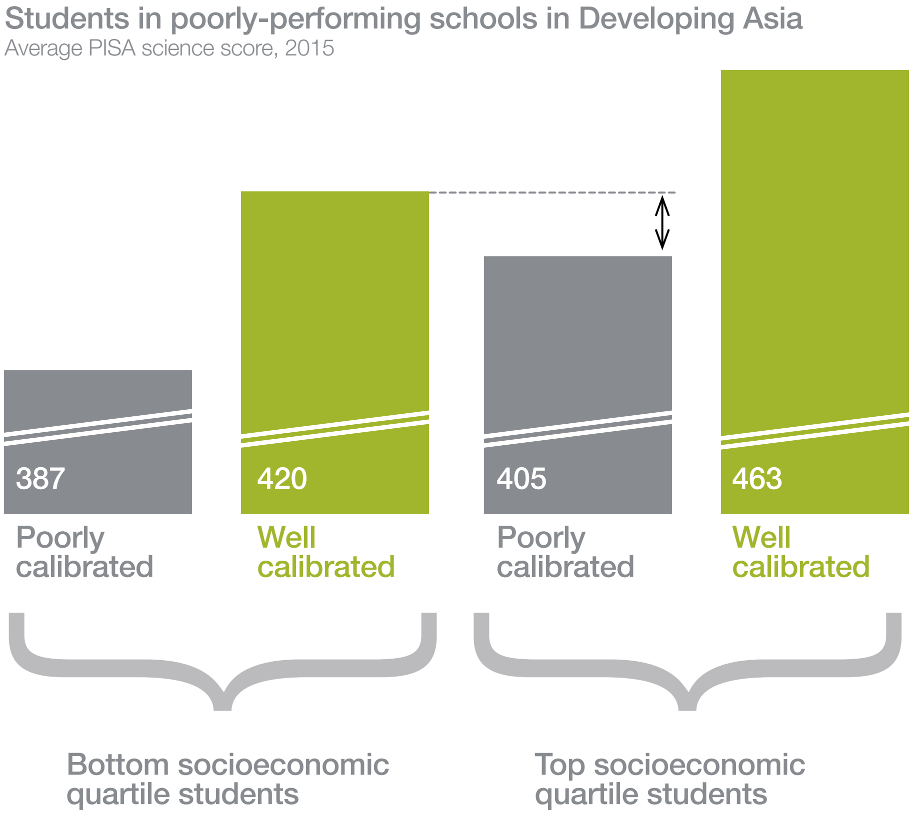
Ian wants to get top grades at school and continues working on tasks until everything is perfect.

Source: OECD PISA 2015, McKinsey analysis

Based on the responses to these questions, we created an index of "motivation calibration." We found that simply understanding the meaning of motivation was a powerful performance indicator—even more powerful than students directly characterizing themselves as motivated.[15] Across the Asia–Pacific region, students who were well calibrated scored 8 to 14 percent higher than those who were poorly calibrated. This pattern held even after controlling for socioeconomic background, location, and type of school.

Students in Oceania and Developing Asia see a larger lift of 14 percent (56 PISA points in Developing Asia, 66 PISA points in Oceania) with a well-calibrated mindset. For High-performing Asia, the lift is 8 percent (42 PISA points). These increases correspond to at least a grade-level equivalent of growth in achievement; in Oceania, it corresponds to nearly two grade levels. By contrast, students who self-identified as "wanting to be the best and wanting top grades" scored just 6 to 8 percent higher.

EXHIBIT 16: HAVING HIGH MOTIVATION CALIBRATION IS EQUIVALENT TO LEAPFROGGING INTO A HIGHER SOCIOECONOMIC QUARTILE.



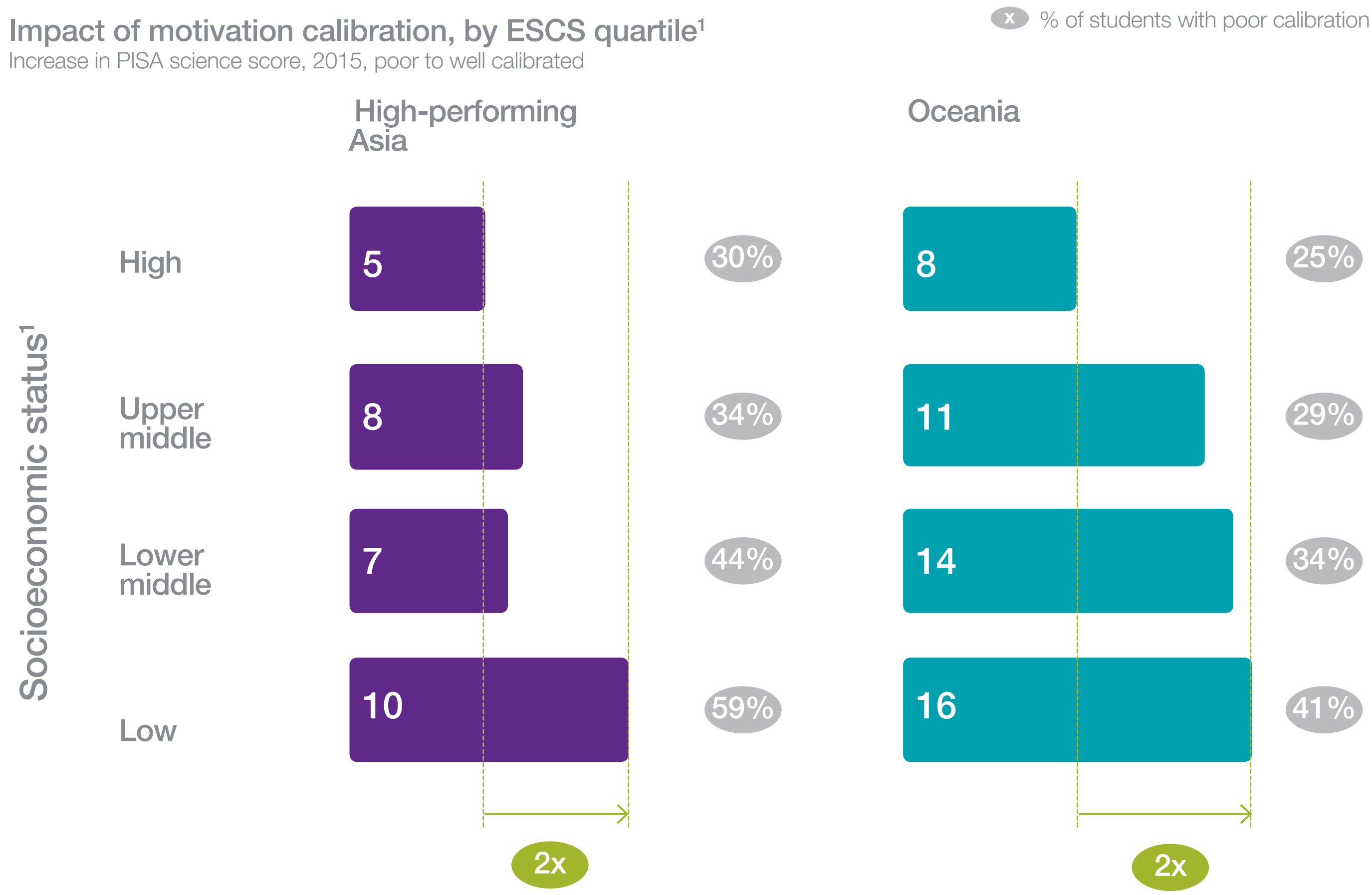
Almost 80% of schools in Developing Asia are in the poor-performing level

1 Using PISA's index of economic, social, and cultural status (ESCS) as a proxy for socioeconomic status; statistically significant in a regression controlling for school type and location
Source: OECD PISA 2015, McKinsey analysis

Why is this the case? Our hypothesis is that students are more likely to be honest when talking about a third person versus directly assessing their own motivation and that calibration itself is actually important. Students cannot exhibit positive behaviors if they do not know what they look like. Calibrating to a norm, then, may help to improve study habits.

The relationship between motivation calibration and PISA scores varies by students' socioeconomic status and school performance level. In Developing Asia, the relationship is particularly strong for the three-quarters of students who are in poorly performing schools. Having strong motivation calibration translates into a 12 percent increase in scores for these students versus 8 percent for those in fair schools and just 4 percent for those in good ones. Within poorly performing schools, students in the lowest socioeconomic quartile with a well-calibrated motivation mindset significantly outperform peers in the highest quartile who are poorly calibrated (Exhibit 16).[16]

EXHIBIT 17: HIGH MOTIVATION CALIBRATION IS PARTICULARLY IMPORTANT FOR LOWER SOCIOECONOMIC STATUS STUDENTS IN OCEANIA AND HIGH-PERFORMING ASIA



1 Using ESCS as a proxy for socioeconomic status; statistically significant in a regression controlling for school type and location. High motivation calibration improves outcomes for developing Asia as well, but effect is not more pronounced for students in low quartile of PISA's index for economic, social, and cultural status (ESCS).
Source: OECD PISA 2015, McKinsey analysis

For students in High-performing Asia and Oceania, the relationship is particularly strong for lower-socioeconomic-status students—double the effect seen for students from wealthier households (Exhibit 17).

These findings are consistent with those of previous PISA tests. In 2012, for example, PISA asked about growth versus fixed mindsets. Specifically, students answered questions about the extent to which they agreed that their academic results were fixed ("I do badly whether or not I study") or could be changed through personal effort ("If I put in enough effort, I can succeed" or "If I wanted to, I could do well"). Students with a strong growth mindset outperformed students with a fixed mindset by 20 percent in Oceania (more than two years of learning), 14 percent in High-performing Asia, and 12 percent in

Developing Asia (equivalent to about a year of learning), and this relationship held for all levels of school performance and socioeconomic status.

To determine the potential of a system-level intervention, we investigated how specific changes in mindsets could affect performance. In Oceania, if the 32 percent of students with low motivation calibration could be shifted to a well-calibrated mindset, and if the relationship between mindset and PISA performance held, this could result in a 4.1 percent overall score improvement, equivalent to more than half a school year. In High-performing Asia, this would impact 36 percent of students and improve scores by 2.9 percent, nearly half a school year. In Developing Asia, this would impact 63 percent of students and could improve regional scores by 8.2 percent, nearly a full school year.

To be clear, mindsets alone cannot overcome economic and social barriers. This research does suggest, however, that they are a powerful predictor of student outcomes, particularly for those living in the most challenging circumstances. The question is what, if anything, can be done to improve mindsets at a system-wide level. Research is being done to answer that question—albeit much of it focused on the United States—and there are promising indications that it may be possible for schools to make effective interventions.

For example, on growth mindsets, a 2015 study of 1,500 secondary-school students in 13 different schools, rich and poor, from all over the United States, found that growth-mindset and sense-of-purpose interventions delivered significant results. The researchers administered two 45-minute online modules to students over the course of a semester. The growth-mindset modules provided direct instruction on the physiological growth potential of the brain given hard work; they also guided students through writing exercises in which they summarized what they had learned and coached a theoretical student who was losing confidence in his intelligence. In the sense-of-purpose module, students did a writing exercise on how they wished the world could be a better place, provided examples of why other students work hard, and finished with another writing exercise in which they explained how working hard could help them achieve their own goals. The results were positive: Students at risk of dropping out of high school, constituting a third of the sample, increased their grade-point averages (GPAs) in core academic courses by 0.13 to 0.18 (on a 4.0 scale), and their core-course pass rates increased by 6.4 percent.

Similarly, on motivation calibration, recent research suggests that meta-cognition and self-regulation strategies can improve student outcomes. Interventions to help students plan, monitor, and evaluate their learning may be a promising way to improve student motivation and perseverance as they tackle a challenging academic content.[17]

Such research is a work in progress, but these and other experiments indicate that harnessing the power of mindsets may be a promising way to support achievement—in addition, of course, to teaching the fundamentals. Academics and policy makers across Asia should be encouraged to design, implement, and evaluate further interventions □

Isn't education about more than just academic results?

The role of education is not just about preparing students to take tests and be ready to join the workforce. The goal is also to develop well-rounded citizens with a positive sense of well-being. We looked at three non-academic outcomes—thinking like a scientist, having joy in science, and test anxiety—and found that High-performing Asia doesn't perform quite as well.

"Thinking like a scientist" is increasingly important in a world characterized by rapid technological and scientific evolution. If students cannot think like scientists, they are at risk of relying on today's science to solve tomorrow's problems. PISA evaluates this by asking students whether they agree with a series of statements including "A good way to know if something is true is to do an experiment", "Good answers are based on evidence from many different experiments", and "Sometimes scientists change their mind about what is true in science". High-performing Asia trails Oceania, North America, and Western Europe in this regard. For example, its best students (with scores of 520 and up) do less well on this metric than good students in North America (480 to 520 points). These high-performing students are the future leaders who will be starting companies, pioneering new research and leading global thought. This picture is reflected also at the country level. Excellent students in China and Macao land in the bottom 20 countries of the world in their ability to think like a scientist.

Having joy in science is also important, because students who enjoy the discipline are more likely to continue pursuing it as adults. PISA asked students whether they had fun learning about science, liked to read about it, and enjoyed acquiring new science knowledge. On this measure, High-performing Asia scores above the global average. However some countries did not fare as well. Students in Japan and Korea have very low joy in science at all levels of student performance.

PISA also asked students about anxiety related to schoolwork—specifically, the extent to which students are worried about getting poor grades, feel anxious when preparing for tests, and get nervous when they don't know how to solve a task. Having low test anxiety is an important factor in students choosing to continue their studies; it is also an indicator of general well-being. In most regions only students who are performing badly (under 480 points) show high levels of test-related anxiety. In High-Performing Asia even top-performers are anxious. Excellent students in High-performing Asia (with scores of 520 and above) are as anxious as good performers (480 to 520 points) in North America or Western Europe.

If the High-performing Asian countries are to sustain their reputation for being some of the best school systems in the world, they will need to work on creating more well-rounded students who can not only ace standardized tests, but can creatively apply that excellence. Educators also seriously need to address concerns about stress and burnout.

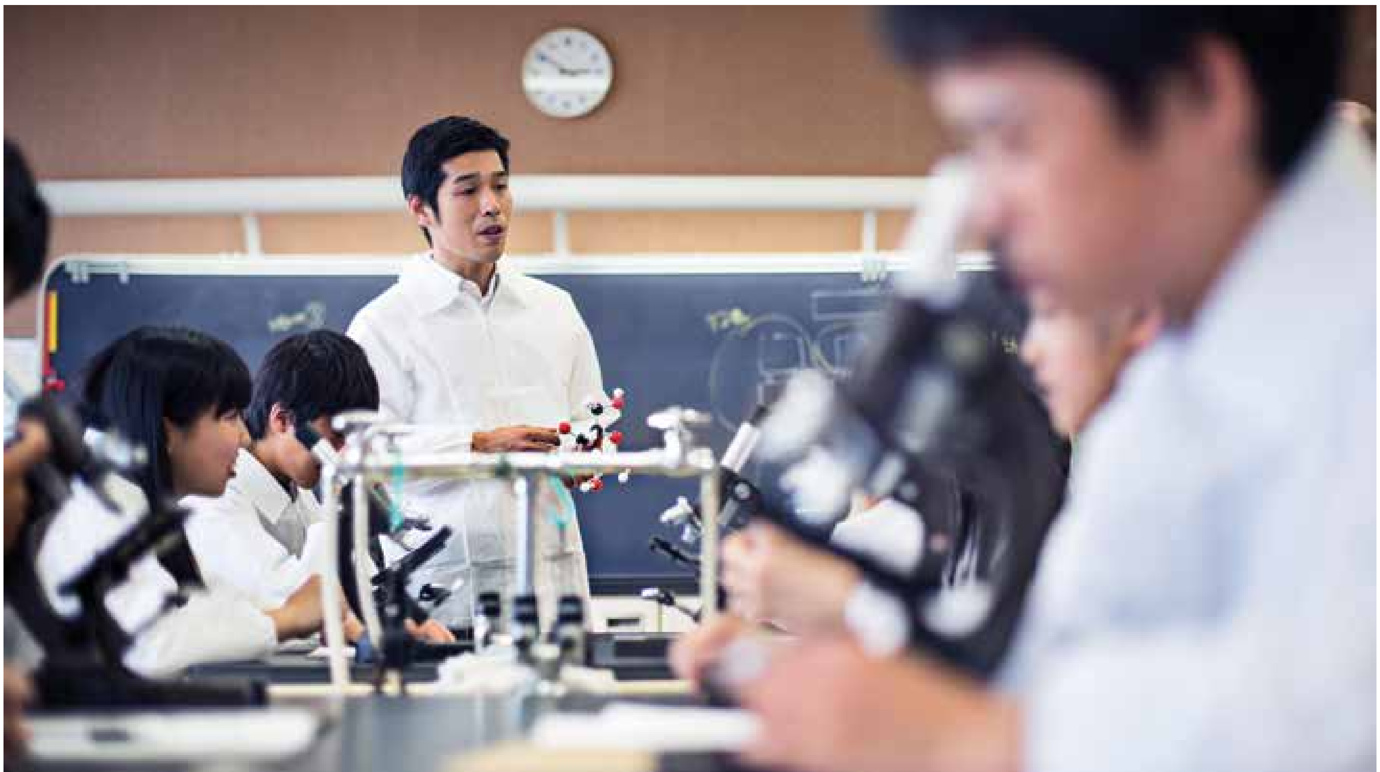
Finding 2:
Students who receive a blend of inquiry-based and teacher-directed instruction have the best outcomes

Teachers matter. Multiple research reports, including our own, have demonstrated that high-performing school systems require effective teachers and teaching. The challenge, then, is to determine what teaching practices work and how teachers can deliver high-quality instruction.

We evaluated two types of science instruction to understand the relationship between teaching styles and student outcomes. The first is "teacher-directed instruction," where the teacher explains and demonstrates scientific ideas, discusses student questions, and leads class discussions. The second is "inquiry-based teaching," where students play a more active role, creating their own questions, designing experiments to test their hypotheses, drawing conclusions, and relating learning to their experiences (Exhibit 18). There is active debate over which approach is preferable.

EXHIBIT 18: OECD PISA ASKED STUDENTS HOW OFTEN THEY EXPERIENCED CERTAIN TEACHING PRACTICES.

How often does this happen in your school science class…



Teacher-directed instruction

- The teacher explains scientific ideas.
- A whole class discussion takes place with the teacher.
- The teacher discusses our questions.
- The teacher demonstrates an idea.

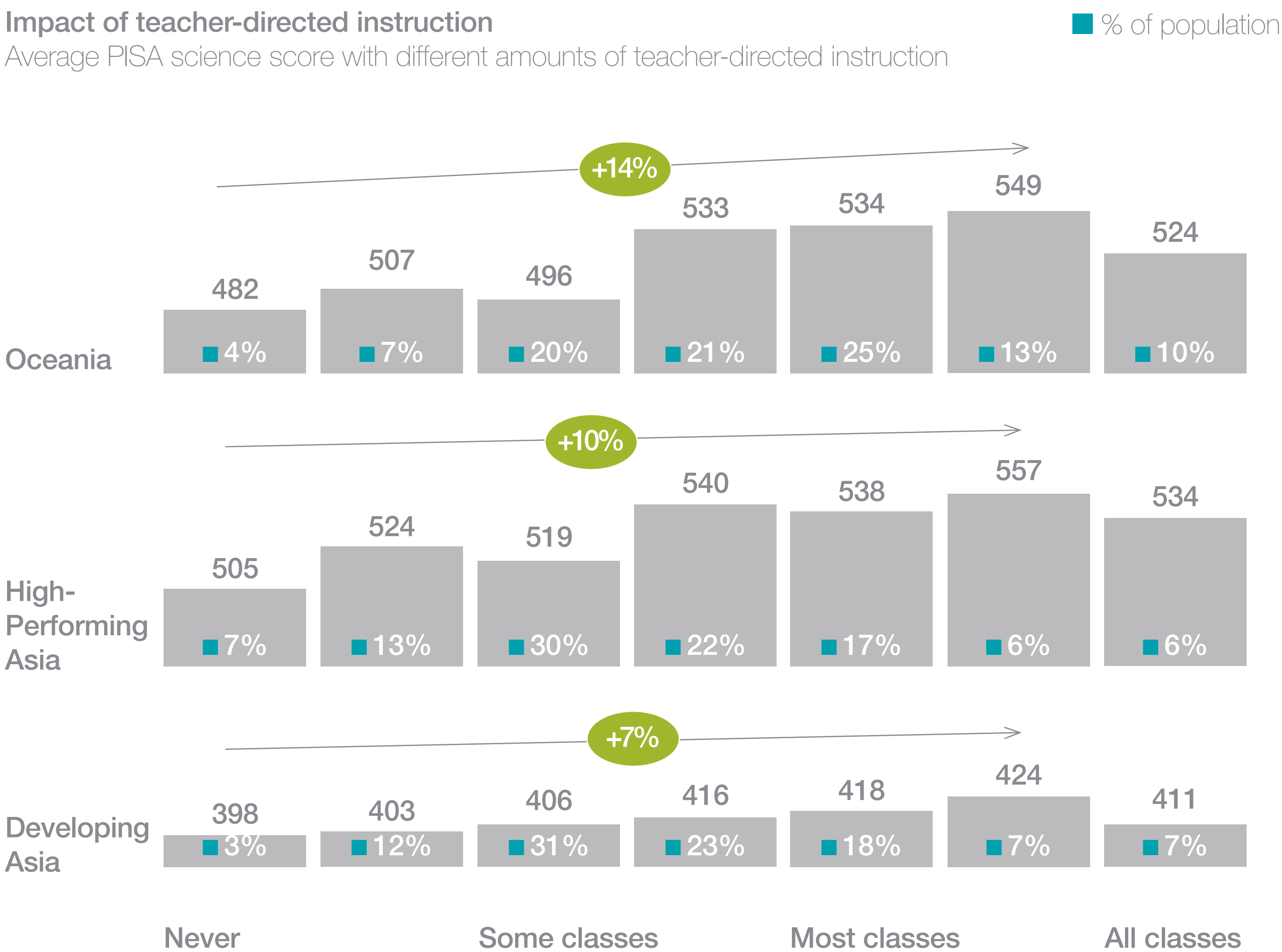
Inquiry-based teaching

- Students are given opportunities to explain their ideas.
- Students spend time in the laboratory doing practical experiments.
- Students are required to argue about science questions.
- Students are asked to draw conclusions from an experiment
- The teacher explains how science ideas can be applied
- Students are allowed to design their own experiments.
- There is a class debate about investigations.
- The teacher explains the relevance of concepts to our lives.
- Students are asked to do an investigation to test ideas.

Source: OECD PISA 2015

EXHIBIT 19: WHEN TEACHERS TAKE THE LEAD, PISA SCORES ARE HIGHER

Impact of teacher-directed instruction
Average PISA science score with different amounts of teacher-directed instruction



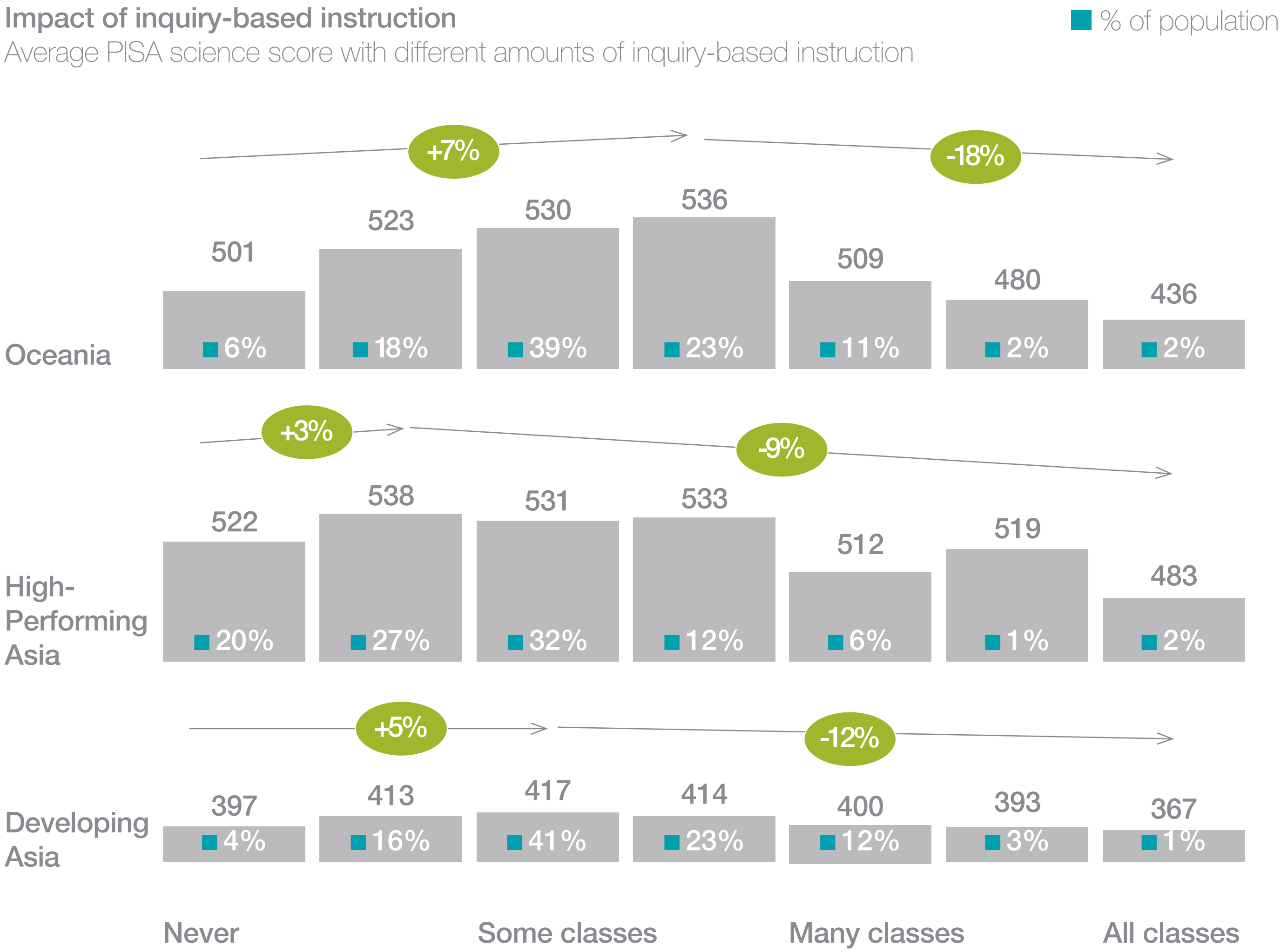
1 Statistically significant controlling for PISA's index of economic, social, and cultural status (ESCS), school type and location
2 Figures may not sum to 100%, because of rounding.
Source: OECD PISA 2015, McKinsey analysis

Analysis of the 2015 results found that the greater the frequency of teacher-directed learning in Asia region, the higher the PISA score - with the highest scores coming from teacher-direction in most-to-all classes. Oceania students experienced the largest lift (14 percent), which is equivalent to over one and a half school years (Exhibit 19).

The picture for inquiry-based learning is more complex. Scores initially rise with some inquiry-based learning but then fall sharply the more it is used (Exhibit 20). Oceania, again, shows the most dramatic results, with performance improving by 6 percent with increased exposure to inquiry-based methods in some lessons, but then falling by 18 percent with more extensive use.

EXHIBIT 20: INQUIRY-BASED INSTRUCTION DELIVERS MIXED RESULTS.

Impact of inquiry-based instruction
Average PISA science score with different amounts of inquiry-based instruction

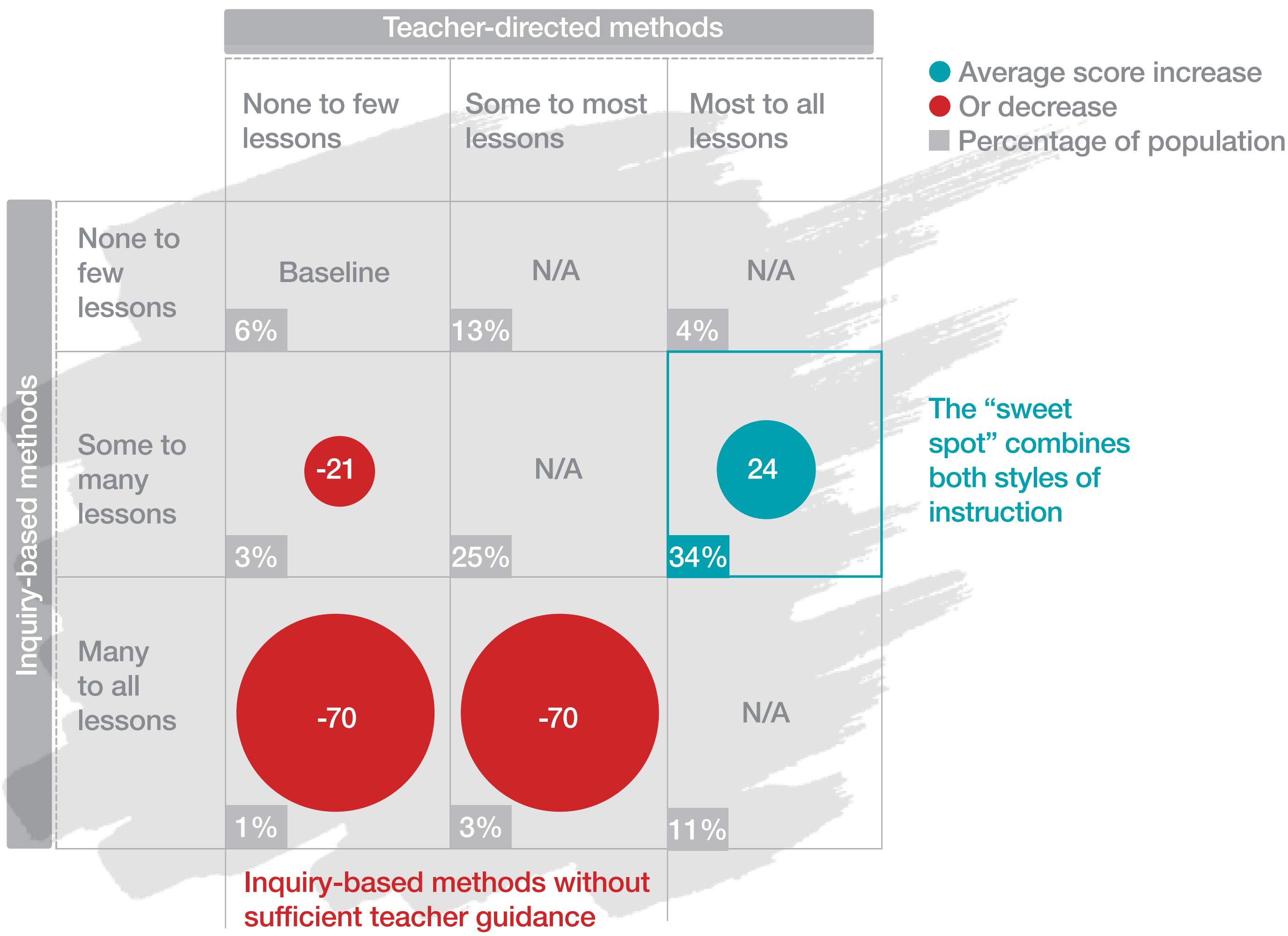


1 Statistically significant controlling for PISA's index of economic, social, and cultural status (ESCS), school type and location
2 Figures may not sum to 100%, because of rounding.
Source: OECD PISA 2015, McKinsey analysis

At first blush, then, inquiry-based learning looks like a less effective choice. But when we dug into the data, we found a more interesting story: what matters is the interplay between the two types of teaching. In an ideal world, there is a place for both. Inquiry-based learning can be effective—but only when strong teacher-directed teaching is in place. This suggests that teachers need to be able to clearly explain scientific concepts and students need to have content mastery to fully benefit from inquiry-based learning.

EXHIBIT 21: THE BEST OUTCOMES COMBINE BOTH TEACHING STYLES. (OCEANIA EXAMPLE)

Average point increase in PISA science score, relative to baseline[1]



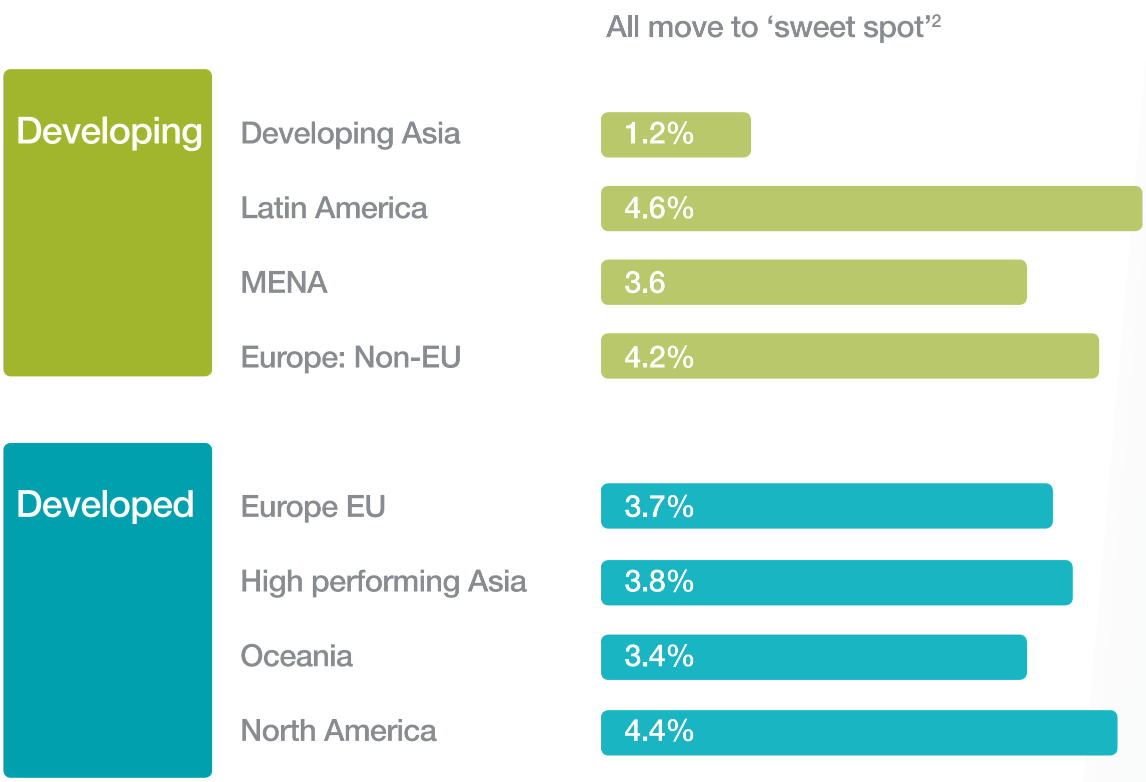
1 Statistically significant expected change in score controlling for ESCS, urban–rural location, and public–private school. Pattern similar in High Performing Asia, but not statistically significant in Developing Asia

Source: OECD PISA 2015, McKinsey analysis

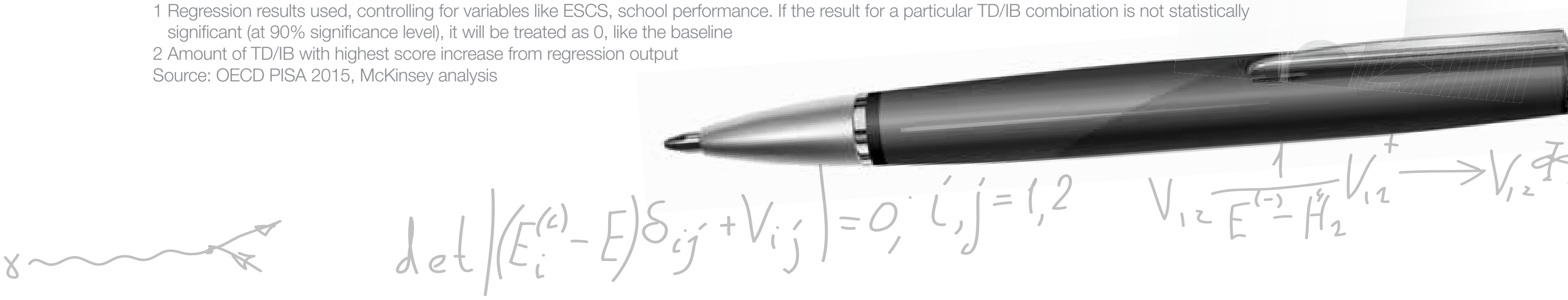
Based on the PISA results in High-performing Asia and Oceania, the sweet spot appears to be teacher-directed instruction in most or almost all classes, with inquiry-based learning in some of them. To put it another way, the more teacher-directed learning there is, the more that inquiry-based learning can be supported (Exhibit 21).

EXHIBIT 22: ALL REGIONS WOULD BENEFIT FROM MOVING TO THE 'SWEET SPOT'.

Percent expected score increase[1]



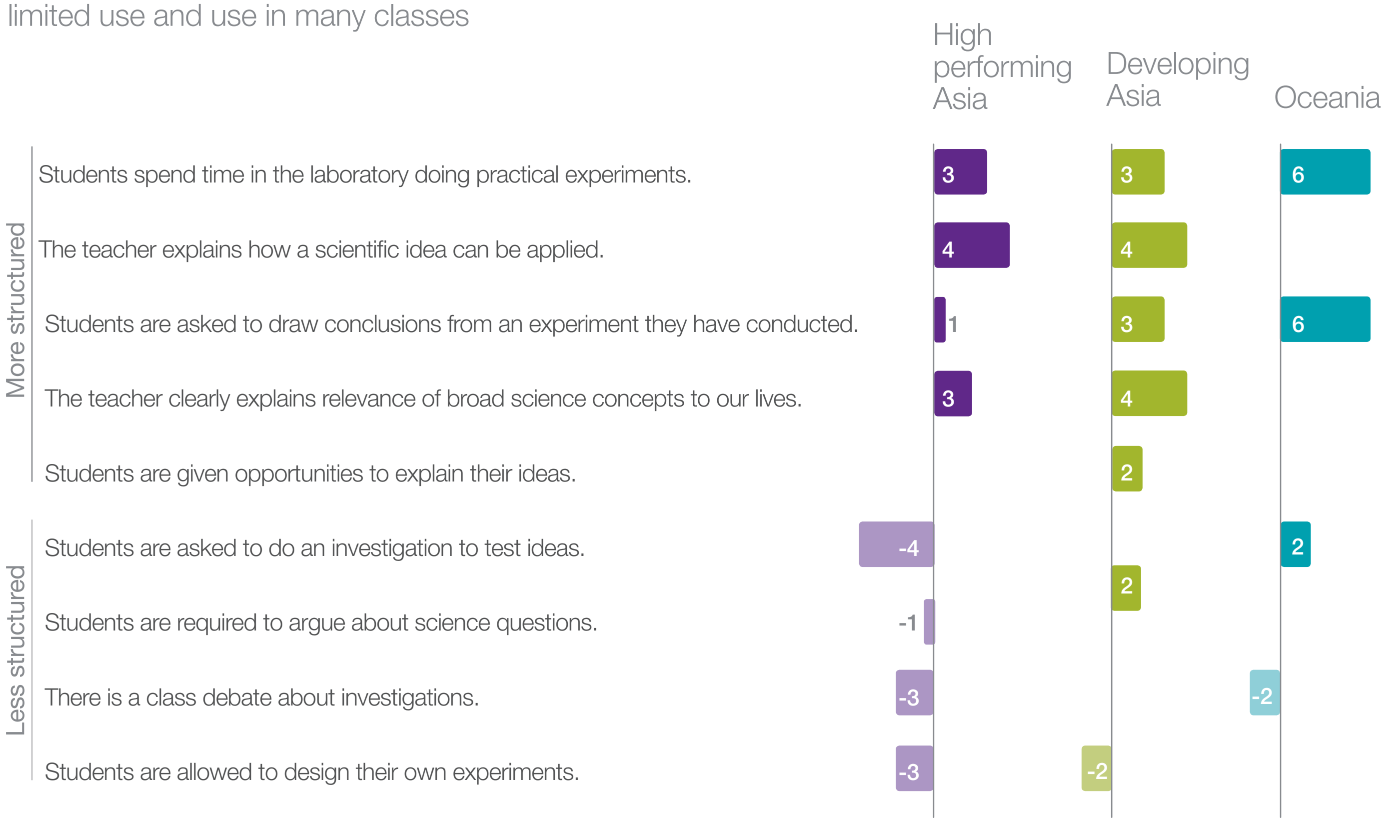
1 Regression results used, controlling for variables like ESCS, school performance. If the result for a particular TD/IB combination is not statistically significant (at 90% significance level), it will be treated as 0, like the baseline
2 Amount of TD/IB with highest score increase from regression output
Source: OECD PISA 2015, McKinsey analysis



This "sweet spot" is the same in the four other regions we studied (Europe, Latin America, Middle East and North Africa, and North America). There is one exception. In Developing Asia, no teacher-practice combination is significantly correlated with higher outcomes; this result may, however, be due to lack of data. We estimate that moving all High-performing Asia students into this sweet spot would improve scores across the region by 3.8 percent, by 3.4 percent for those in Oceania, and by 1.2 percent in Developing Asia (Exhibit 22).

EXHIBIT 23: DIFFERENT TEACHING PRACTICES DELIVER DIFFERENT RESULTS.

Impact of Inquiry-based practices
Expected % increase in PISA science score[1] between limited use and use in many classes



1 Regression results shown, normalized over the average PISA score.
2 Statistically significant controlling for ESCS, school type and location; blank values show no significant change.
Source: OECD PISA 2015, McKinsey analysis

In developing countries, what may be more important is to raise the floor to provide consistency in teaching. Our 2010 report suggested that countries that successfully transitioned from poor to fair provided motivation and support for less-skilled teachers through such practices as coaching and providing scripted lesson plans. Simply moving toward greater use of effective teacher-directed methods could be a part of this more directive approach.

These results should be considered in context. They do not take into account how good the teaching itself is. There are certainly quality gaps in teacher-directed classrooms. The gaps are even bigger, though,in inquiry-based classrooms, given the need to manage across multiple teams of students, ensure student safety in experimentation, set standards, monitor progress, and support students of different capabilities. Furthermore, inquiry-based approaches are composed of specific practices, and these have discrete effects. More-structured inquiry-based methods have a stronger positive correlation with PISA scores (Exhibit 23).

Country Spotlight: How Singapore supports teachers to balance teacher-directed and inquiry-based instruction

Consistent with our report, student outcomes are highest in Singapore when extensive teacher-directed instruction is supplemented with a moderate use of inquiry-based teaching. Students in Singapore who experience this balance scored 32 PISA points higher than those who did not—equivalent to almost a full school year.

Developing the expertise and intuition for determining the most effective balance of instructional methods for each class is challenging, not least due to the fact that it requires constant re-evaluation as individual student needs evolve. To support teachers, the Ministry therefore invests extensively in ongoing professional development.

All teachers are entitled to 100 hours of sponsored professional development every year, including school-based coaching models, such as classroom observations and collaborative lesson planning, and off-site workshops. Instructional leaders based at every school coach beginner teachers on the use of a repertoire of teaching strategies, including inquiry-based methods. Through structured mentorship programs, beginner teachers are paired with senior teachers who provide ongoing lesson planning and teaching support.

Within schools, teachers participate in weekly collaborative planning time and school-based professional learning communities to continuously develop curriculum content knowledge and pedagogical knowledge. Across schools, subject-based network learning communities were established where teachers of the same subject discipline work collaboratively to drive instructional leadership in their subjects. Recently in 2017, the Singapore Teaching Practice (STP) was launched to develop a Singapore model of teaching and learning. STP aims to document, codify and explain effective teaching practices to provide a common reference point for all educators to enhance their professional practice. These collaborative platforms allow educators to identify and propagate good practices throughout the school system.

The Ministry's professional development courses are designed using a blend of teacher-directed and inquiry-based approaches to enable teachers to learn, apply and reflect on the new pedagogical knowledge and skills acquired. These courses typically have two parts. In the first, teachers are introduced to new pedagogy to apply in their own classrooms. In the second, they come back together to share their learning for consolidation purposes to sustain ongoing reflection and integration of learning into their day to day practice.

These findings on the limitations of some inquiry-based methods may seem counterintuitive, given that there is strong support for inquiry-based pedagogy. We offer two hypotheses for why these methods are not translating into better student outcomes. First, students cannot progress to inquiry-based methods without a strong foundational knowledge gained through teacher-directed learning. Second, inquiry-based instruction is more challenging to deliver, and teachers who attempt it without sufficient training and support tend to struggle. This is especially true in poor-to-fair school systems.

Inquiry-based practices may have benefits beyond improving student scores. Experiencing inquiry-based teaching increases students' joy in science by approximately half a standard deviation between "never" and "some classes," and another half a standard deviation between "some classes" and "many

classes." Experiencing increasing amounts of teacher-directed teaching also increases students' joy in science but by less than half as much. This matters because passion for a topic is linked to increased perseverance in studying. Inquiry-based teaching has a similar positive impact on students' "instrumental motivation"—that is, their belief that science is worthwhile for their future careers. This is important as students graduate from high school and choose whether to pursue further study or careers in science.

For school systems, knowing all this is only the start, and it raises a slew of questions about how to find the right balance between these styles of teaching and how to improve the quality of each. At a minimum, our research suggests that teachers need to fully understand the content they are teaching, and be able to explain it, before jumping into inquiry-based instruction □

Finding 3: School-based technology yields the best results when placed in the hands of teachers

The potential of technology is obvious. It can help to individualize learning, assist teachers with curricula and lesson plans, and equip students with the digital skills that will be a big part of the 21st-century economy. Spending on information and communications technology (ICT) in education is rising—and so are the hopes that ICT can help to improve performance.

The level and implementation of ICT in education in the Asia–Pacific region is diverse. In Developing Asian countries, the priority has been to equip classrooms with hardware. Indonesia, for example, announced plans in 2015 to provide a tablet for every K–12 student. As for schools in High-performing Asia and Oceania, ICT priorities have moved toward creating an integrated learning approach. The Japanese government recently announced plans to make computer programming compulsory at all public elementary schools by 2020. Beginning in 2014, Australia and New Zealand implemented a "bring your own device" (BYOD) program to encourage student-driven learning.

Given all the money and attention ICT is getting, however, it is important to ask whether it actually improves learning. A 2015 OECD global report[19] concluded that the evidence that it does is "mixed at best." Among countries that had invested heavily in ICT, the report concluded that there was "no appreciable improvements in student achievement in reading, mathematics, or science." Others worry that technology in the classroom dehumanizes education and disempowers teachers.

Using the PISA data, we explored the impact of first exposure to ICT and the impact of ICT on 15-year-old students at home and in the classroom.

Age of first ICT exposure:

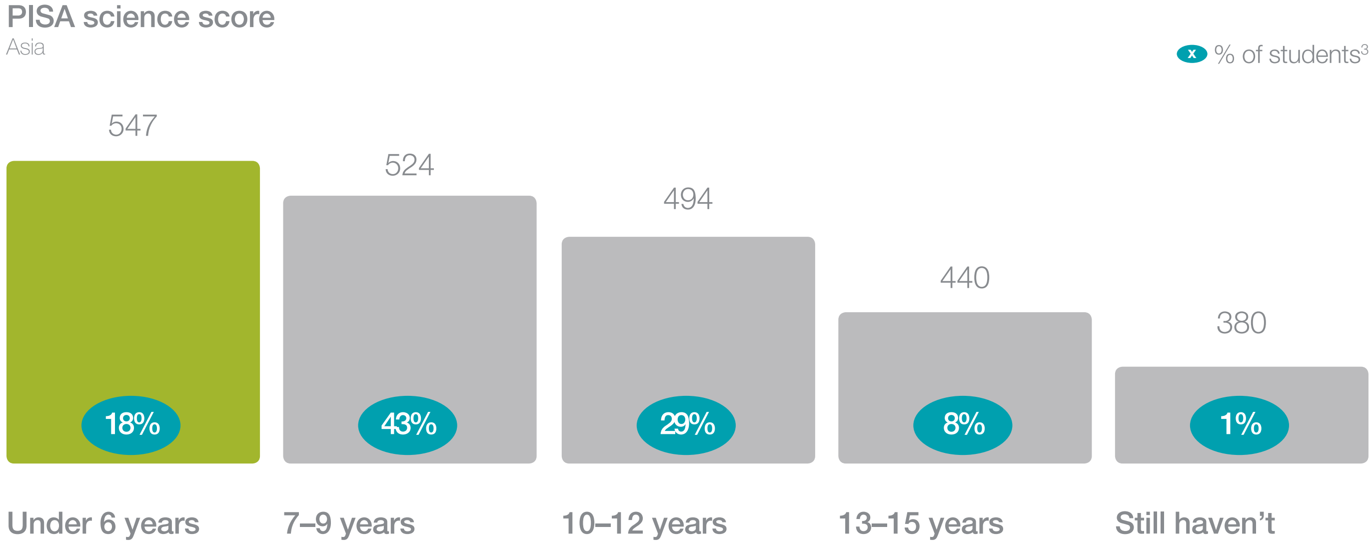
The PISA survey asked students how old they were when they first used a digital device or computer. Students with digital exposure before age six performed about 24 percent better than those exposed at age 13 or later[20] (Exhibit 24). That figure was higher (26 to 27 percent) in High-performing Asia and Oceania, and lower in Thailand (16 percent). Thailand was the only Developing Asia country to take the ICT survey.

It should be noted that 15-year-olds today reporting on their experience before the age of six are referring to technology that is a decade old, and we do not know the nature of their exposure. Constant updates on the effects of technology are required to gain a more accurate picture.

ICT at home:

When 15-year-old students were asked how much time they spend using the Internet at home, interesting differences emerged. In Thailand and Oceania, moderate use of the Internet (two to four hours per day) correlated with higher PISA scores. Beyond four hours, the positive effects tended to decline. However, in most High-performing Asia systems, students who spent more than about an hour per day on the Internet saw declining benefits.

EXHIBIT 24: AVERAGE ASIA PISA SCIENCE SCORE, BY AGE OF FIRST DIGITAL EXPOSURE.[1]

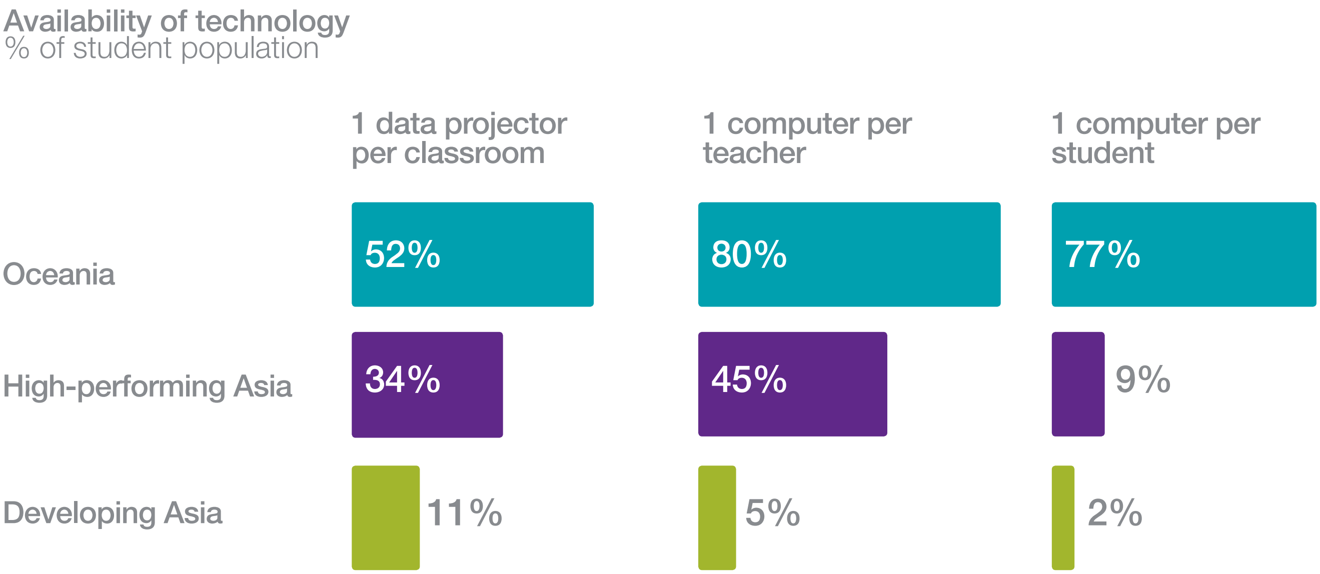


1 Only for countries that took ICT survey: Australia, B-S-J-G (China), Taiwan, Hong Kong (China), Japan, Korea, Macao (China), New Zealand, Singapore, and Thailand.
2 Statistically significant controlling for PISA's index of economic, social, and cultural status (ESCS), school type and location; developing countries not included due to high proportion of null responses
3 Figures may not sum to 100%, because of rounding.
Source: OECD PISA 2015, McKinsey analysis

Why might this be? One hypothesis is that culture is driving this: it is not so much that browsing the Internet is worse for High-performing Asia students, it is that successful students in High-performing Asia choose to browse less, as they are under parental pressure to study rather than going online. Across High-performing Asia, 65 percent of students spend more than 30 minutes online a day, versus 95 percent in Oceania.

Of course, how students spend their time also matters. External research has demonstrated that going online for educational purposes and for interactive game-based learning has positive effects, while participation in social media appears to be negative.[21]

EXHIBIT 25: THE AVAILABILITY OF TEACHER, STUDENT, AND CLASSROOM TECHNOLOGY VARIES WIDELY.



Source: OECD PISA 2015, McKinsey analysis

ICT at school:

PISA's principal and student surveys enable us to compare both the prevalence of technology in schools across the region and its effect on scores.

Oceania reports the highest level of ICT (Exhibit 25). Over three-quarters of schools have at least one computer per teacher and one computer per student, and over half have a data projector for every classroom. In High-performing Asia, over a third of schools have at least one data projector per classroom and one computer per teacher, while 9 percent have one computer per student. In Developing Asia, only 11 percent of schools have at least one data projector per classroom, and rates of student and teacher computers are even lower.

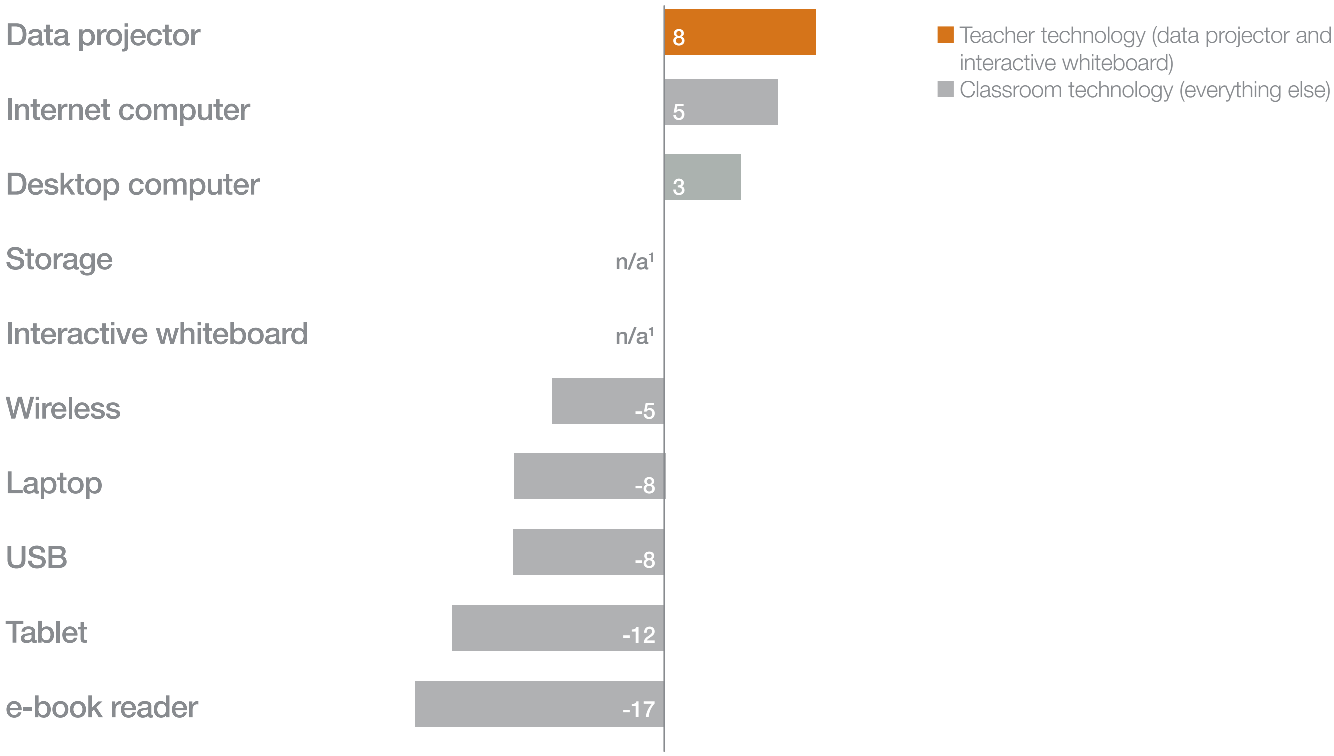
Regardless of type of school or student, we found that ICT used in support of teachers has a much bigger influence on educational outcomes than ICT deployed directly to students. Across Asia, adding data-projectors to classrooms has a bigger impact on score than adding any other device. There is a 20 percent improvement in score (86 PISA points) between having one data projector per classroom versus one data projector shared across four classes.

Analyzing the results of the ICT student survey for those systems that took this option[22] reinforces the benefits of data projectors. Students whose teachers use data projectors score 8 percent higher than those who do not. Other types of technologies, such as tablets and e-book readers, however, seem to actually hurt student performance (Exhibit 26).

These findings are consistent with the body of research showing that it is how technology is used that is critical. Technology tends to be most powerful when used as a supplement and support to teaching, rather than as a replacement. For example, data projectors can facilitate effective teacher demonstrations, provide real-time

EXHIBIT 26: DIFFERENT TECHNOLOGIES DELIVER DIFFERENT RESULTS.

Impact of specific technology used by students at school
% change in PISA science score between "no" and "yes and use"[1]



1 Statistically significant controlling for PISA's index of economic, social, and cultural status (ESCS), school type and location except for Storage and Interactive Whiteboard (effect not statistically significant)
Source: OECD PISA 2015, McKinsey analysis

coaching on student work, and improve classroom management. When student-directed technology such as tablets or laptops are first introduced to a classroom, on the other hand, they may supplant previously effective teaching time and hamper performance.

Given the evidence of the negligible or even negative impact of student-centered technology, school systems might be tempted to abandon their ICT efforts. Not so fast. The PISA survey describes the impact of education technology as currently implemented, not its eventual potential. The results tell us only about hardware, not about software or about specific interventions such as well-executed personalized learning. Also, education technology is evolving rapidly, and it is possible that specific interventions, including software and implementation strategies, can raise achievement.

Screens are not the problem when it comes to student outcomes—but neither do they appear to be the answer. School systems should be careful not to assume that all technology is worthwhile or even neutral for student achievement. Asian educators should work to ensure that ICT is fully integrated with instruction and to support teachers to enable them to use ICT effectively □

Finding 4: Early childhood education has a positive impact on student scores, but quality and type of care is important

More than half of the synaptic connections that allow people to think, see, hear, and speak are formed before age three.[23] Although brain plasticity persists into adulthood, the brain is most receptive to interventions in early childhood. That is the promise of quality early childhood education (ECE), and indeed such programs have been shown to improve academic and social outcomes, especially for disadvantaged children.[24] Although there are some concerns about fade-out in later years, good ECE programs can help to narrow the achievement gap by helping disadvantaged children gain cognitive, social, and other skills before starting kindergarten.

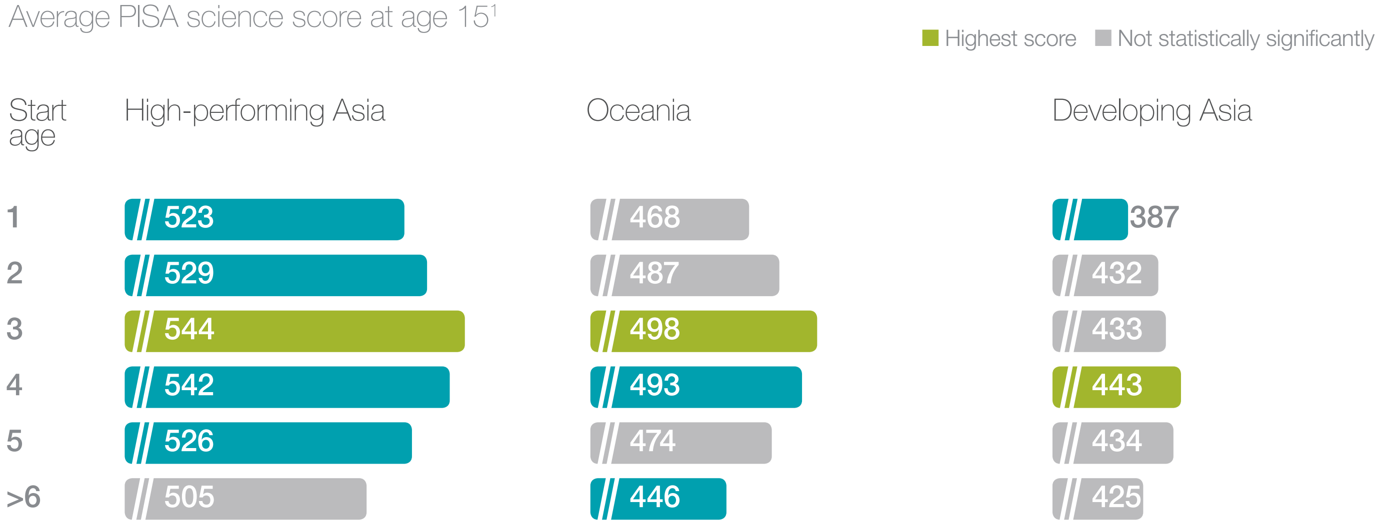
The PISA survey asked students how old they were when they started formal education. Our findings, like other research, validate the overall positive impact of ECE at age 15. Across Asia, 73 percent of students told PISA they had received some formal ECE by the age of five. Those who had received some ECE perform 21 PISA points (more than half a school year) better on the PISA science test a decade later than those who did not, after controlling for student socioeconomic status and type and location of school.

Students in Oceania with some ECE score 11 PISA points higher than those without, whereas those in High-performing Asia score just six PISA points higher. (There was not enough data for Developing Asia to draw statistically significant conclusions.) Students in High-performing Asia and Oceania do best when they start ECE at age three, while in Developing Asia, those who began at age four have the highest academic outcomes at age 15 (Exhibit 27). This may reflect variation in the quality of care available for younger children across Asia.

Parents in Hong Kong, Macao, and South Korea, all of them High-performing school systems, answered questions about their children's early education. Based on their responses, we

EXHIBIT 27: STUDENTS HAVE THE BEST OUTCOMES WHEN THEY START ECE AT AGE THREE IN MORE-DEVELOPED REGIONS IN ASIA, VERSUS AGE FOUR IN DEVELOPING ASIA.

Impact of attending ECE, by starting age.
Average PISA science score at age 15[1]



1 Calculated based on regression controlling for PISA's index for economic, social, and cultural status (ESCS), private/public schools, and urban/rural location, with expected change added to the intercept to get average score. Developing Asia starting at age 4 significant at 90% level; other ages not statistically significantly better than no early childhood education
Source: OECD PISA 2015, McKinsey analysis

found that children who attended structured pre-primary programs score 20 more PISA points at age 15, equivalent to half a year of schooling, compared to those who received only supervision and care. Students who received either type of ECE experience performed better than those who received none.

This raises the question: What is "quality" in ECE? How can it be measured? The elements are clear: a focus on not just cognitive skills but also social and emotional skills and physical and mental health; trained teachers; low staff-to-child ratios; adequate infrastructure; clear learning standards; and positive student–teacher relationships. Several accepted assessments of quality exist based on both measurement of minimum standards and direct-observation toolkits.[25]

Of course, ECE is about more than scoring well on PISA tests many years later. Non-cognitive attributes such as physical and mental health, as well as social and emotional development, are equally important but not measured here. Nonetheless, on the basis of the PISA data, we can conclude that good ECE can help boost PISA science scores a decade or more later. This suggests that Asian governments should continue to prioritize providing ECE, while monitoring its quality ◻

Conclusion

Our research has mapped some areas previously blank and also identified new territories worthy of further exploration. For each of the four findings, there is a clear need for additional research. Within mindsets, the priority is to determine what interventions can make a difference in shifting student mindsets and what effect these interventions have on student outcomes. For teaching practices, more research is needed into how to effectively combine teacher-directed and inquiry-based teaching. In ICT, we need more rigorous longitudinal studies that consider not only what hardware works but also what software and system supports lead to successful outcomes. Across the board, more research is needed on how to strike the right balance between increasing access versus improving quality. This is particularly relevant in rolling out government-provided ECE. In an important sense, then, this report—like our previous two—is part of a longer journey.

With its emphasis on data and analysis, this research aims to help regional school systems improve. Even a survey as large and rigorous as the PISA data set provides only some of the answers. But we believe that the four findings outlined here, combined with the conclusions of our 2010 report on the world's most improved school systems, provide useful insights to guide Asian policy makers as they make their way to their ultimate destination—improving the education and thus the lives of the region's students ■

analytical appendix

To analyze the PISA dataset, we used a variety of modern machine learning and traditional statistical techniques.

First, we used SparkBeyond, an automated feature-discovery engine that uses large-scale combinatorial testing of millions of transformations on raw data to identify relevant drivers of outcomes—in our case, PISA student scores. SparkBeyond can create features from numeric, time series, text, and other inputs, and works best with complex data sets with thousands of variables and millions of data points. For the 2015 OECD PISA data, this entailed testing more than 1,000 survey variables derived from student, teacher, parent, and principal surveys for the approximately 540,000 students who took the PISA examination. This identified variables and groups of variables that were most predictive of student performance.

We excluded from our SparkBeyond and subsequent analysis highly predictive variables where the direction of causality was strongly in question, including grade repetition, student self-efficacy, environmental awareness, expected educational attainment, and epistemological beliefs.

We then carried out traditional descriptive and predictive statistical analyses on the identified features that were most important in determining performance both within 2015 dataset and across the PISA surveys since 2000.

For every analysis, we tested whether findings held in a regression controlling for economic, social, and cultural status (ESCS), type of school (SC013Q01: is your school a public or private school school?) and location of school (SC001Q01: which of the following definitions best describes the community in which your school is located?).

For the 2015 OECD PISA data, this entailed testing more than 1,000 survey variables derived from student, teacher, parent, and principal surveys for the approximately 540,000 students who took the PISA examination.

Where the regression results were consistent with the descriptive analysis, we have used the descriptive analysis in the report. Where the regression tells a different story from the description, we have reported regression coefficients to preserve the rigor of our findings.

We also tested our insights by school and student segment, creating two more screens—specifically, school performance level and student socioeconomic status.

School performance:
we used the numerical cut-offs from our 2010 report to define poor, fair, good, great, and excellent school systems. Each category represents approximately one school-year equivalent, or 40 PISA points.

- Excellent: >560 points
- Great: 520-560 points
- Good: 480-520 points
- Fair: 440-480 points
- Poor: <440 points

Distribution of students by school performance level

Students	Poor (%)	Fair (%)	Good (%)	Great (%)	Excellent (%)
N America	14	23	39	18	5
Latin America	76	15	6	2	0
W Europe	25	19	26	18	13
E Europe	22	24	34	16	5
MENA	89	8	2	1	0
Asia	43	16	15	13	13

Then we applied these cut-offs to individual schools as well as to school systems. We did this because there may be pockets of poorly performing schools in otherwise good systems. In these schools, the interventions applicable to poor systems may apply, even if they are in a country that on the whole performs at a "good" level. Based on this analysis, we could determine the percentage of students in differently performing schools for each region and country

Student socioeconomic status:

We use the term "student-socioeconomic-status quartile" throughout the report. This refers to PISA's ESCS indicator that integrates a number of measures related to students' backgrounds, including their parents' occupations, education levels, and possessions. We created ESCS quartiles by region based upon student weights.

Target variables and plausible values

We used the 2015 PISA science score as the target variable because the 2015 test focused on science both for the assessment and survey questions (in 2012, PISA focused on math, and in 2009, on reading). To calculate the PISA science score at the student level, we averaged the results of all the plausible values for science (PV1 to PV10 for science).

To roll up scores at the regional level, we used student weights to represent each country based on its student population. For example, the Latin American numbers all refer to weighted average student scores across Latin America; the same is true for all other regions.

For consistency with OECD publications, we used a slightly different methodology in the overview of historical regional performance. This approach creates a country-level average, first using student weights (such as "average score for Brazil"), but then takes the straight average of the scores of countries in a particular region or a group (such as "all OECD countries").

Description of specific variables

In addition to using existing OECD PISA variables and indices, we created our own indices for some analyses.

Motivation calibration:

Motivation calibration is a measure of a student's ability to recognize motivation in others, or the extent to which the student's definition of motivation agrees with the standard definition. Specifically, we took the PISA question ST121, which presented three student archetypes and asked the respondent to what extent they agree that each archetype is motivated on a four-point scale, ranging from "strongly disagree" to "strongly agree."

Based on our assessment of the motivation level of each archetype, we assigned a weight of -2 to the first student (NAME 1—highly unmotivated), +1 to the second student (NAME 2—somewhat motivated), and +2 to the third student (NAME 3—highly motivated).

For example, a student who strongly disagreed that <NAME 1> is motivated, agreed that <NAME 2> is motivated, and strongly agreed that <NAME 3> is motivated would accumulate the following score:

- 1 * -2 = -2: one point for strongly disagree with a weight of -2 for <NAME 1>
- 3 * 1 = 3: three points for agree with a weight of 1 for <NAME 2>
- 4 * 2 = 8: four points for strongly agree with a weight of 2 for <NAME 3>
- Total score: -2 + 3 + 8 = 9

ST121 **Please read the descriptions about the following three students. Based on the information provided here, how much would you disagree or agree with the statement that this student is motivated?** (Please select one response in each row.)

		Strongly disagree	Disagree	Strongly Agree	Agree
ST121Q01NA	<NAME 1> gives up easily when confronted with a problem and is often not prepared for his classes. <Name 1> is motivated.	☐1	☐2	☐3	☐4
ST121Q02NA	<NAME 2> mostly remains interested in the tasks she starts and sometimes does more than what is expected from her. <Name 2> is motivated.	☐1	☐2	☐3	☐4
ST121Q03NA	<NAME 3> wants to get top grades at school and continues working on tasks until everything is perfect. <Name 3> is motivated.	☐1	☐2	☐3	☐4

ST034 **Thinking about your school: to what extent do you agree with the following statements?** (Please select one response in each row.)

		Strongly disagree	Disagree	Strongly Agree	Agree
ST034Q01TA	I feel like an outsider (or left out of things) at school.	☐1	☐2	☐3	☐4
ST034Q02TA	I make friends easily at school.	☐1	☐2	☐3	☐4
ST034Q03TA	I feel like I belong at school.	☐1	☐2	☐3	☐4
ST034Q04TA	I feel awkward and out of place in my school.	☐1	☐2	☐3	☐4
ST034Q05TA	Other students seem to like me.	☐1	☐2	☐3	☐4
ST034Q06TA	I feel lonely at school.	☐1	☐2	☐3	☐4

ST119 **To what extent do you disagree or agree with the following statements about yourself?** (Please select one response in each row.)

		Strongly disagree	Disagree	Strongly Agree	Agree
ST119Q01NA	I want top grades in most or all of my courses.	☐1	☐2	☐3	☐4
ST119Q02NA	I want to be able to select from among the best opportunities available when I graduate.	☐1	☐2	☐3	☐4
ST119Q03NA	I want to be the best, whatever I do.	☐1	☐2	☐3	☐4
ST119Q04NA	I see myself as an ambitious person.	☐1	☐2	☐3	☐4
ST119Q05NA	I want to be one of the best students in my class.	☐1	☐2	☐3	☐4

We defined a cutoff of 8 points in the aggregated score, which ensures that only the following students are classified as having a strong motivation calibration:

- Students who strongly agree that <NAME 3> is motivated, and whose agreement on <NAME 1>'s motivation does not exceed their agreement on <NAME 2>'s motivation
- –OR— Students who agree that <NAME 3>'s is motivated; agree that <NAME 2> is motivated, and strongly disagree that <NAME 1> is motivated
- –OR— Students who agree that <NAME 3> is motivated; strongly agree that <NAME 2> is motivated, and disagree or strongly disagree that <Name 1> is motivated

Sense of belonging:

We grouped the index BELONG (based on ST034) as follows:

- Low belonging: BELONG < 0
- High belonging: BELONG >=0

Motivation:

We grouped the index MOTIVAT (based on ST119) as follows:

- Low belonging: MOTIVAT < 0
- High belonging: MOTIVAT >=0

Test anxiety:

We grouped the index ANXTEST (based on ST118) as follows:

- Low belonging: ANXTEST < 0
- High belonging: ANXTEST >=0

Instrumental motivation:

We grouped the index INSTSCIE (based on ST113) as follows:

- **Low instrumental motivation: INSTSCIE < 0**
- **High instrumental motivation: INSTSCIE >=0**

Growth vs. fixed mindset:

To assess the impact of a growth versus fixed mindset, we used selected 2012 PISA survey question ST43 and ST91 from the student survey.

We created an index by adding the response values for each of the four sub-questions related to growth versus fixed mindsets, after reversing the sequence of response values for the last question to account for the negative framing of the prompt.

The resulting index takes values from 4 to 16, with lower scores representing a growth mindset and higher scores representing a fixed mindset. Looking at the distribution of students globally, we devised the following definitions.

- **Strong growth mindset: students with a score of 4 or 5 reflect a growth mindset on at least three of the sub-questions, and are directionally aligned on the remaining question. These represent 23 percent of the global population.**

- **Neutral or weak growth mindset: students with a score of 6 to 9 reflect a neutral or weak growth mindset and represent 69 percent of the global population.**

ST118 **To what extent do you disagree or agree with the following statements about yourself?** (Please select one response in each row.)

		Strongly disagree	Disagree	Strongly Agree	Agree
ST118Q01NA	I often worry that it will be difficult for me taking a test.	☐1	☐2	☐3	☐4
ST118Q02NA	I worry that I will get poor <grades> at school.	☐1	☐2	☐3	☐4
ST118Q03NA	Even if I am well prepared for a test I feel very anxious.	☐1	☐2	☐3	☐4
ST118Q04NA	I get very tense when I study for a test.	☐1	☐2	☐3	☐4
ST118Q05NA	I get nervous when I don't know how to solve a task at school.	☐1	☐2	☐3	☐4

ST113 **How much do you agree with the statements below?** (Please select one response in each row.)

		Strongly disagree	Disagree	Strongly Agree	Agree
ST113Q01TA	Making an effort in my <school science> subject(s) is worth it because this will help me in the work I want to do later on.	☐1	☐2	☐3	☐4
ST113Q02TA	What I learn in my <school science> subject(s) is important for me because I need this for what I want to do later on.	☐1	☐2	☐3	☐4
ST113Q03TA	Studying my <school science> subject(s) is worthwhile for me because what I learn will improve my career prospects.	☐1	☐2	☐3	☐4
ST113Q04TA	Many things I learn in my <school science> subject(s) will help me to get a job.	☐1	☐2	☐3	☐4

ST043 **Thinking about your math lessons: to what extent do you agree with the following statements?** (Please select one response in each row.)

		Strongly disagree	Disagree	Strongly Agree	Agree
(a)	If I put in enough effort I can succeed in mathematics	☐1	☐2	☐3	☐4
(b)	Whether or not I do well in maths is up to me	☐1	☐2	☐3	☐4
(c)	If I wanted to, I could do well in mathematics	☐1	☐2	☐3	☐4
(d)	I do badly in mathematics whether or not I study for my exams	☐1	☐2	☐3	☐4

SC004 The goal of the following set of questions is to gather information about the student-computer ratio for students in the <national modal grade for 15-year-olds> at your school.
(Please enter a number for each response. Enter "0" [zero] if there are none.)

		Number
SC004Q01TA	At your school, what is the total number of students in the <national modal grade for 15-year-olds>?	
SC004Q02TA	Approximately, how many computers are available for these students for educational purposes?	
SC004Q03TA	Approximately, how many of these computers are connected to the Internet/ World Wide Web?	
SC004Q04NA	Approximately, how many of these computers are portable (e.g. laptop, tablet)?	
SC004Q05NA	Approximately how many interactive whiteboards are available in the school altogether?	
SC004Q06NA	Approximately how many data projectors are available in the school altogether?	
SC004Q07NA	Approximately how many computers with internet connection are available for teachers in your school?	

ST125 How old were you when you started <ISCED 0>?
(Please choose from the drop-down menu to answer the question.)

Years

Please choose ▼
Option A
Option B
Option C
Option ...

Drop-down menu, offering answers "1 year or younger", 2 years, 3 years, 4 years, 5 years, "6 years or older", "I did not attend <ISCED 0>", "I do not remember".

- Fixed mindset: students with a score of 10 to 16 have an average response of 2.5 or more on the four questions, meaning that they tend to be misaligned with the principles of a growth mindset. They represent 8 percent of the global population.

We compared students with a fixed mindset to students with a strong growth mindset in our analysis. In addition, we found that incremental gains were seen at each stage from fixed to neutral and from weak growth to strong growth.

Teaching practices:

To assess teaching practices, the PISA survey asked a series of questions about teacher-directed instruction (ST103) and inquiry-based instruction (ST098). This question does not allow us to assess the intensity of the teaching practices in a given class, but only the frequency with which they occur.

Students responded on a frequency scale that was slightly different for each set of questions:

Teacher-directed learning (ST103)
1 = Never or almost never
2 = Some lessons
3 = Many lessons
4 = Every lesson or almost every lesson

Inquiry-based learning (ST098)
1 = In all lessons
2 = In most lessons
3 = In some lessons
4 = Never or hardly ever

We consolidated each student's responses into averages on a scale from 1 to 4—one average for teacher-directed instruction and another for inquiry-based instruction (with the numbers reversed to be comparable). These averages form the basis for our analysis of teaching practices.

The OECD also created a numerical index of teacher-directed (TDTEACH) and inquiry-based learning (IBTEACH), which is calibrated such that the OECD average is 0 and the standard deviation is 1. When we ran regressions on the TDTEACH and IBTEACH variables, our results were consistent with theirs. However, we chose to present the data using our own indices because we believed these gave a clearer picture what was happening in the classroom.

ICT at school:

to create a like-for-like comparison of the impact of ICT hardware, we used the survey questions asked of school principals from SC004 and normalized the results by classroom size and student-to-teacher ratio. This allowed us to evaluate the effect adding one projector, student computer, or teacher computer to an average class size of 36 students.

Early childhood:

To understand the impact of early-childhood education (ECE) we used the student survey question ST125. We excluded from the analysis students who could not remember when they started ECE. With the remaining students, we counted them as having attended ECE if they started at five years or younger. Students who started at six years or older or who responded "no early-childhood education" we counted as not having attended ECE. Note we did not use the simpler question ST124 ("Did you attend early-childhood education," as only 15 percent of students globally answered this question (versus 82 percent who answered ST125). We also cross-checked results against similar questions in the parent survey for the subset of countries that took the parent survey; the results were consistent ■

1 These five stages inform McKinsey's universal scale of education system performance, which takes into account available assessments such as PISA, TIMSS, TERCE, or local tests. We normalized the data, creating new units that are equivalent to the 2000 PISA scores, and then broke down the results into five categories: poor, fair, good, great, and excellent (see the analytical appendix for more, and also Michael Barber, Chinezi Chijioke, and Mona Mourshed, "How the world's most improved school systems keep getting better," November 2010, on McKinsey.com).

2 Argentina, Kazakhstan, and Malaysia were excluded from the 2015 PISA report but are included in our analyses. The 2015 PISA sample for Malaysia did not meet PISA response-rate standards; the 2015 PISA sample from Argentina did not cover the full target population; and the 2015 PISA sample from Kazakhstan was based only on multiple-choice items.

3 The 2015 computer-based assessment was designed as a two-hour test comprising four 30-minute clusters. Students took two science clusters, plus two others across reading, math, and collaborative problem solving.

4 Malaysia was excluded from the 2015 PISA report because the weighted response rate among the initially sampled Malaysian schools (51 percent) fell short of the standard PISA response rate of 85 percent. We include it here for completeness.

5 As defined according to the International Standard Classification of Education (ISCED): Pre-primary: ISCED level 0 includes preschool and kindergarten programs; Primary: ISCED level 1 typically begins between ages five and seven and lasts for four to six years; Lower secondary: ISCED level 2 begins around the age of 11—equivalent of intermediate school, middle school, or junior high school; Upper secondary: ISCED level 3 immediately follows lower-secondary education and includes general (academic), technical, and vocational education—equivalent of senior high school.

6 Education in China: A snapshot, OECD, 2016, oecd.org.

7 Mae Chu Chang, Sheldon Shaeffer, Samer Al-Samarrai, Andrew B. Ragatz, Joppe de Ree, and Ritchie Stevenson, Teacher reform in Indonesia: The role of politics and evidence in policy making, The World Bank, 2014, worldbank.org.

8 Education policy outlook: New Zealand, OECD, June 2013, oecd.org.

9 For time series analysis, we compared performance from 2006 to 2015 and included systems that have participated in all PISA cycles since 2006.

10 Another way of thinking about equity in education is what percentage of the score could be explained by ESCS. In almost all cases, the direction of change is the same for both metrics. In Hong Kong, however, the percent of score explained by ESCS has not changed, but the percent change in the percent difference between highest and lowest ESCS quartile scores

falls by 26 percent. We believe that this is because the percent of score explained by ESCS is a measure of the tightness of points around the line of best fit, while the change in the difference between ESCS quartile scores is more representative of the slope; the slope of Hong Kong's line of science score (y-axis) by ESCS index (x-axis) has shifted from 25.8 to 18.0, indicating a decline in the influence of ESCS index on score.

11 Susana Claro, David Paunesku, and Carol S. Dweck, "Growth mindset tempers the effects of poverty on academic achievement," Proceedings of the National Academy of Sciences, August 2016, Volume 113, Number 31, 8664–8.

12 Marcus Credé, Michael C. Tynan, and Peter D. Harms, "Much ado about grit: A meta-analytic synthesis of the grit literature," Journal of Personality and Social Psychology, September 2017, Volume 113, Number 3, pp. 492–511; and Leslie Morrison Gutman and Ingrid Schoon, The impact of non-cognitive skills on outcomes for young people, Education Endowment Foundation, November 2013, educationendowmentfoundation.org.uk.

13 Each category was made up of several subvariables. For example, **Home environment:** parent education and occupation, home possessions, language at home; **Student behaviors:** skipping school, activities before school, ICT use out of school; **School factors:** class size, school size, school resource level and funding, school autonomy; **Teacher factors:** teacher qualifications, teacher professional development, teaching practices.

14 To attain statistically meaningful results, we selected the top 100 variables using a feature-identification machine-learning algorithm. Recognizing that the regression wouldn't distinguish collinearity across variables, we mitigated this by placing variables very likely to be collinear in the same category. We cannot control for collinearity between categories.

15 MOTIVAT, PISA's variable for student attitudes, preferences, and self-related beliefs is less correlated to achievement than motivation calibration. Students with low self-described motivation in Asia score 497, while students with high self-described motivation score 514. This is an improvement of 17 points, or 3 percent. However, moving from low to high motivation calibration in Asia corresponds to a score change from 469 to 531, an improvement of 62 points, or 13 percent.

16 This pattern held in Oceania and hHigh-performing Asia; however, smaller portions of students attend poorly performing schools in those regions. A similar leapfrog impact is seen within fair and within good schools in hHigh-performing Asia and Oceania.

17 David Paunesku et al., "Mind-set interventions are a scalable treatment for academic underachievement," Psychological Science, June 2015, Volume 26, Number 6, pp. 784–93.

18 "Meta-cognition and self-regulation," Education Endowment Foundation, August 9, 2017, educationendowmentfoundation.org.uk.

19 OECD, Students, Computers and Learning: Making the Connection, Paris: OECD Publishing, 2015.

20 Early exposure here is defined as under six years old. PISA is silent on the impact of technology on younger children. Other literature does suggest limiting use for infants and toddlers due to negative impacts on sleep; BMI; cognitive, language, and emotional processing; and limited positive benefits.

21 See, for example: Paul A. Kirschner and Aryn C. Karpinski, "Facebook and academic performance," Computers in Human Behavior, November 2010, Volume 26, Number 6, pp. 1237–45; Jeffrey Mingle and Musah Adams, "Social media network participation and academic performance in senior high schools in Ghana," Library Philosophy and Practice, July 21, 2015; Kuan-Cheng Lin, Yu Che Wei, and Jason C. Hung, "The effects of online interactive games on high school students' achievement and motivation in history learning," International Journal of Distance Education Technologies, October–December 2012, Volume 10, Number 4, pp. 96–105; Soohyun Kim, "E effects of Internet use on academic achievement and behavioral adjustment among South Korean adolescents: Mediating and moderating roles of parental factors," Child and Family Studies—Dissertations, December 2011, paper 62, surface.syr.edu; Alex J. Bowers and Matthew Berland, "Does recreational computer use affect high school achievement?" Educational Technology Research and Development, 2013, Volume 61, Number 1, pp. 51–69; and Alberto Posso, "Internet usage and educational outcomes among 15-year-old Australian students," International Journal of Communication, 2016, Volume 10, pp. 3851–76.

22 Australia, B-S-J-G (China), Hong Kong (China), Japan, Macao (China), New Zealand, Singapore, South Korea, Taiwan, and Thailand.

23 National Research Council and Institute of Medicine, From Neurons to Neighborhoods: The Science of Early Development, Editors Jack P. Shonkoff and Deborah A. Phillips, Washington, DC: National Academy Press, 2000.

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