

# Drivers of Student Performance: Insights from Europe

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 Program for International Student Assessment (PISA), a project of the Organisation for Economic Co-operation and Development (OECD). 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 reports that consider what factors drive student performance. In this report, we analyze the results of the 27 European Union (EU) countries and 12 non-EU countries that participated in the 2015 PISA. Europe is a large and diverse region, and the PISA results reflect this, with performance ranging from poor to great. As a whole, the EU's performance has been flat since 2006; performance in non-EU countries has improved slightly. There is a clear imperative for the lower-performing countries to improve faster, and for the more developed European systems not only to maintain performance, but also to innovate to prepare students for their future.

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

### **Student mindsets have more influence on outcomes than socioeconomic background.**

It is hardly news that students' attitudes and beliefs—what we term their “mindsets”—influence their academic performance. The magnitude of this effect, and which mindsets matter most, is still under debate, and we focused our research on this topic. We know from years of academic research that student socioeconomic status matters for student performance. We therefore measured the effect of mindsets that is not explained by socioeconomics alone.

By analyzing the PISA data, we found that in Europe mindset factors explain a greater proportion of a student's PISA score (29 percent) than even the home environment (18 percent). In all other regions we surveyed, mindsets have at least double, and up to triple, the impact of home environment on PISA results, a pattern that reinforces the importance of this finding. Mindsets matter everywhere.

Some mindsets are more important than others. In the 2015 PISA assessment, the most predictive mindset is the ability to identify what motivation looks like in day-to-day life (including doing more than expected and working on tasks until everything is perfect). We call this “motivation calibration,” as it involves a student “calibrating” what types of behaviors motivated students exhibit. Motivation calibration's impact on PISA science score is more than twice the impact of self-identified motivation (wanting to be the best and wanting to get top grades). Students who have good motivation calibration scored 12 to 13 percent (or 50 to 60 PISA points) higher on the science test than poorly calibrated ones. In contrast, scores are just 5 percent higher for students with high self-identified motivation. These relationships hold after controlling for socioeconomic status, location, and type of school. The motivation calibration relationship is particularly strong for students in poorly performing schools, where having a well-calibrated motivation mindset is equivalent to vaulting into a higher socioeconomic status. In these schools, students from the lowest socioeconomic quartile who are well calibrated perform better than those from the highest socioeconomic quartile who are poorly calibrated.

Other mindsets that are predictive of student outcomes include believing that one's school science work will be useful for one's future career, having low test anxiety, and having a strong sense of belonging to one's school. We also found that students with a strong growth mindset (those who believe they can succeed if they work hard) outperform students with









## Currently over half of European students are receiving too little teacher-directed instruction

a fixed mindset (those who believe that their capabilities are static) by 11 percent in EU countries and 15 percent in non-EU countries.

The prevalence of beneficial mindsets varies between boys and girls. While girls are more likely to have strong motivation calibration, they are also more likely to have high levels of test anxiety.

To be clear, mindsets alone cannot overcome economic and social barriers, and researchers debate the extent to which parental or school-system-level interventions can shift student mindsets. Our research does, however, suggest that mindsets matter a great deal, particularly for those living in the most challenging circumstances.

### **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 is “teacher-directed instruction”, in which the teacher explains and demonstrates scientific ideas, discusses questions, and leads classroom discussions. The second is “inquiry-based teaching”, which includes a diverse range of practices from conducting practical experiments to understanding how science can be applied in real life, to encouraging students to create their own questions.

Our research found that student outcomes are highest with a combination of teacher-directed instruction in most to all classes and inquiry-based teaching in some classes. If all students experienced this blend of instruction, average PISA scores in Europe would be 3.7 to 4.2 percent (or 19 PISA points) higher, equivalent to more than half a school year of learning. Currently over half of European students are receiving too little teacher-directed instruction.

It's also important to note, moreover, that some kinds of inquiry-based teaching are better than others. In Europe, more structured inquiry-based activities yield higher PISA

scores. Explaining how a science concept can be applied to a real-world situation improves scores in both EU and non-EU countries. Conducting and drawing conclusions from scientific experiments also improves scores significantly. Less structured methods of inquiry, however, such as allowing students to design their own experiments, result in lower scores across the board.

Given the strong support for inquiry-based pedagogy, this seems 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 will struggle. Better teacher training, high-quality lesson plans, and school-based instructional leadership can help. So can giving principals and teachers the confidence to focus on fewer incidences of well-planned inquiry, rather than trying to use these methods exclusively.

While teacher-directed instruction has the most positive impact on PISA scores, inquiry-based practices do better in promoting students' joy in science and instilling the belief that doing well in school will help them have a brighter future. We believe that is why blending teacher-directed instruction with inquiry-based teaching produces the greatest overall benefit across Europe.

### **While technology can support student learning outside of school, its record in school is mixed, with the best results from technology 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) and the impact of ICT for 15-year-olds, at home and during school. Students who reported their first digital exposure before the age of six score 9 to 16 percent higher than those exposed at age 13 or later (controlling for socioeconomic status, school type, and location). Higher-socioeconomic-status students are more likely to start using devices at an early age. They also get more benefit from early exposure, which has worrying implications for the equity gap.

At home, one to four hours of Internet use per day for 15-year-olds is associated with the highest science performance, 10 to 13 percent (or 45 to 61 PISA points) higher than for students with no after-school Internet use (again, after controlling for socioeconomic status, school type, and location). There appears to be declining impact—and possibly negative behavioral implications—when students spend four hours or more a day before a screen.



The impact of ICT use on students during the school day is much more mixed: from -16 percent to +12 percent, depending upon the type of hardware. Most important, we found that deploying ICT to teachers, rather than students, works best. For example, in non-EU countries, adding one teacher computer per classroom has over ten times the impact of adding a student computer to that same classroom. Across Europe, some student-based classroom technologies, such as laptops, tablets, and e-book readers, actually appear to hurt performance.

These results, however, describe the impact of education technology as currently implemented, not its eventual potential. They evaluate only hardware, not software, and do not account for rapid evolution. Even so, European leaders should not assume the impact of ICT will always be positive or even neutral. Systems should ensure that ICT

programs are integrated with curriculum and instruction and are supported by teacher professional development and coaching.

As we share these three findings, we are mindful of their limits. One cannot find 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 all relevant issues. Many questions still need to be resolved through a thoughtful research agenda and longitudinal experimentation. That said, we believe that these three findings provide important insights into how students succeed—and that European 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 (Exhibit 1).<sup>1</sup>

While the two earlier reports focused on interventions at the system level, for this report, we have undertaken 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

**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	<ul style="list-style-type: none"> <li>• <b>Providing motivation and scaffolding for low-skill teachers</b> <ul style="list-style-type: none"> <li>– Scripted teaching materials</li> <li>– External coaches</li> <li>– Instructional time on task</li> <li>– School visits by center</li> <li>– Incentives for high performance</li> </ul> </li> <li>• <b>Getting all schools to a minimum quality level</b> <ul style="list-style-type: none"> <li>– Outcome targets</li> <li>– Additional support for low performing schools</li> <li>– School infrastructure improvement</li> <li>– Provision of textbooks</li> </ul> </li> <li>• <b>Getting students in seats</b> <ul style="list-style-type: none"> <li>– Expand school seats</li> <li>– Fulfill students’ basic needs in order to raise attendance</li> </ul> </li> </ul>	<ul style="list-style-type: none"> <li>• <b>Data and accountability foundation</b> <ul style="list-style-type: none"> <li>– Transparency to schools and/or public on school performance</li> <li>– School inspections and inspections institutions</li> </ul> </li> <li>• <b>Financial and organizational foundation</b> <ul style="list-style-type: none"> <li>– Optimization of school and teacher volumes</li> <li>– Decentralizing financial and administrative rights</li> <li>– Increasing funding</li> <li>– Funding allocation model</li> <li>– Organizational redesign</li> </ul> </li> <li>• <b>Pedagogical foundation</b> <ul style="list-style-type: none"> <li>– School model/streaming</li> <li>– Language of instruction</li> </ul> </li> </ul>	<ul style="list-style-type: none"> <li>• <b>Raising caliber of entering teachers and principals</b> <ul style="list-style-type: none"> <li>– Recruiting programs</li> <li>– Preservice training</li> <li>– Certification requirements</li> </ul> </li> <li>• <b>Raising caliber of existing teachers and principals</b> <ul style="list-style-type: none"> <li>– In-service training programs</li> <li>– Coaches</li> <li>– Career tracks</li> <li>– Teacher and community forums</li> </ul> </li> <li>• <b>School-based decision making</b> <ul style="list-style-type: none"> <li>– Self-evaluation</li> <li>– Independent and specialized schools</li> </ul> </li> </ul>	<ul style="list-style-type: none"> <li>• <b>Cultivating peer-led learning for teachers and principals</b> <ul style="list-style-type: none"> <li>– Collaborative practice</li> <li>– Decentralizing pedagogical rights to schools and teachers</li> <li>– Rotation and secondment programs</li> </ul> </li> <li>• <b>Creating additional support mechanisms for professionals</b> <ul style="list-style-type: none"> <li>– Release professionals from administrative burden by providing additional administrative staff</li> </ul> </li> <li>• <b>System-sponsored experimentation/innovation across schools</b> <ul style="list-style-type: none"> <li>– Providing additional funding for innovation</li> <li>– Sharing innovation from frontline to all schools</li> </ul> </li> </ul>

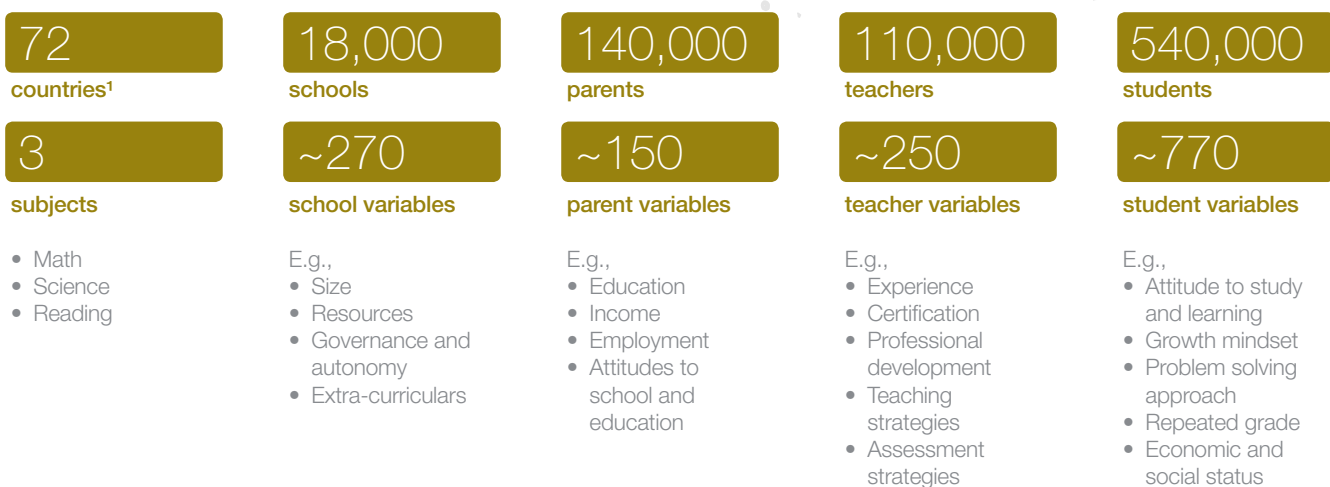
**COMMON ACROSS ALL JOURNEYS**

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



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

<sup>1</sup> 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

nearly 540,000 students in 72 countries. PISA test takers also answer a rich set of attitudinal questions; students, teachers, parents, and principals complete surveys that provide 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.<sup>2</sup> The survey questions therefore largely addressed science teaching and learning.

Standardized tests have their shortcomings. They cannot measure important soft skills or non-academic outcomes, and they are subject to behaviors such as teaching to the test and gaming the system. Even so, 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 Europe.<sup>3</sup> For the purpose of this report, we separated Europe into the EU and non-EU countries that took PISA in 2015 (Exhibit 3). We also included Israel in our grouping of non-EU countries, because Israel's academic achievement and level of economic



**EXHIBIT 03:** GIVEN THE DIVERSITY OF EUROPE, WE ANALYZED TWO SUBREGIONS.

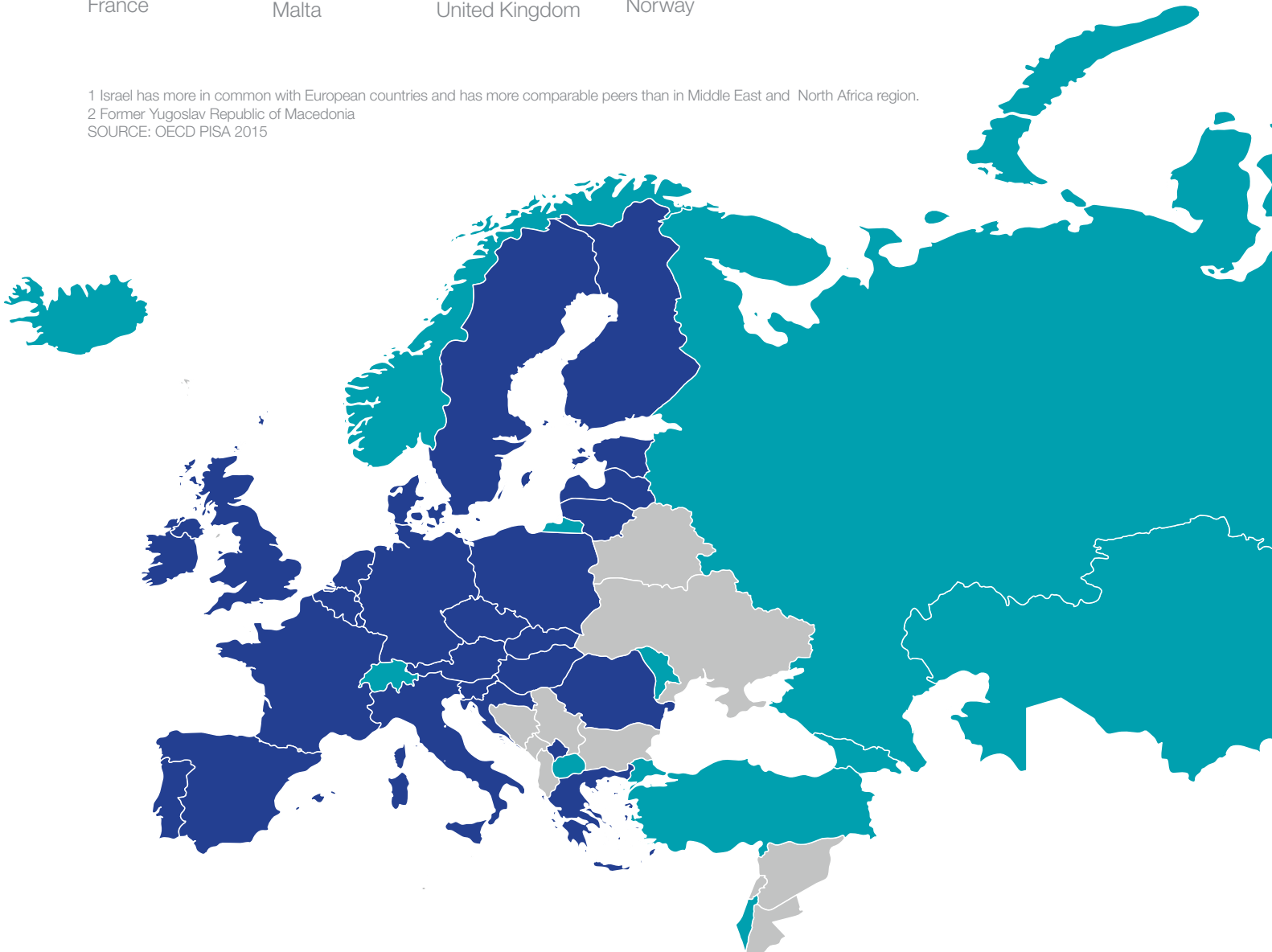
**■ European Union (EU)**

- Austria
- Belgium
- Bulgaria
- Croatia
- Czech Republic
- Denmark
- Estonia
- Finland
- France
- Germany
- Greece
- Hungary
- Ireland
- Italy
- Latvia
- Lithuania
- Luxembourg
- Malta
- Netherlands
- Poland
- Portugal
- Romania
- Slovak Republic
- Slovenia
- Spain
- Sweden
- United Kingdom

**■ Non-EU**

- Georgia
- Iceland
- Israel<sup>1</sup>
- Kazakhstan
- Kosovo
- FYROM<sup>2</sup>
- Moldova
- Montenegro
- Norway
- Russian Federation
- Switzerland
- Turkey

1 Israel has more in common with European countries and has more comparable peers than in Middle East and North Africa region.  
 2 Former Yugoslav Republic of Macedonia  
 SOURCE: OECD PISA 2015





development are closer to that of European nations than to its Middle Eastern neighbors.

While we concentrate on the 2015 PISA results, we also consider previous results, using a range of traditional and advanced analytical techniques. First, we used a supervised machine-learning and feature-discovery tool that identified variables and groups of variables that were most predictive of student performance. We then applied more traditional descriptive and statistical analyses to factors that were shown to be 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 macro performance, but also at differences in patterns by the system performance levels outlined in our 2010 report, and by students' economic, social,

and cultural status (ESCS; see the analytical appendix for an explanation). Our research resulted in three key findings regarding mindsets, teaching practices, and information technology. These three findings emerged as being both highly predictive of student performance and potentially responsive to school-system interventions.

In what follows, we first examine Europe's education performance in historical terms and then discuss each of the three findings, before suggesting possible implications for school systems. Our intention is to offer insights that policy makers and practitioners can use to make improvements □





# setting the context:

Europe's current performance.

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

**In terms of overall quality,** PISA scores in Europe span the performance spectrum. Estonia and Finland are among those leading the pack, while Bulgaria, Cyprus, and Romania lag well behind the OECD average (Exhibit 4, which for context includes Singapore, the global top performer in all three subjects) PISA scores in the non-EU countries generally fall below the OECD average, except in Norway, Russia, and Switzerland.

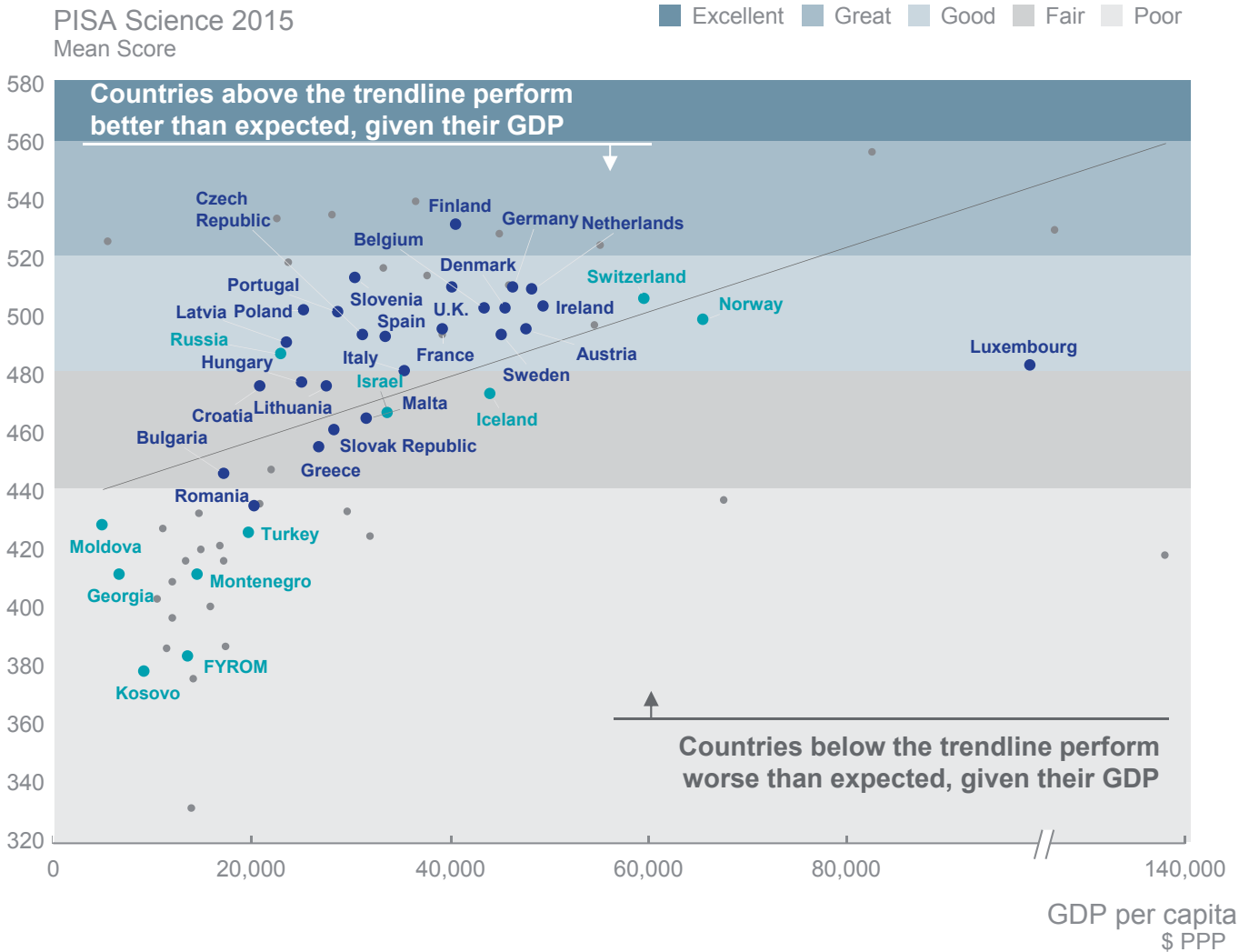
## EXHIBIT 04: EUROPEAN PISA SCORES SPAN THE PERFORMANCE SPECTRUM.

■ European Union (EU) ■ Non-EU

Science 2015			Reading 2015			Math 2015		
Rank	Country	Mean	Rank	Country	Mean	Rank	Country	Mean
1	Singapore	556	1	Singapore	535	1	Singapore	564
3	Estonia	534	4	Finland	526	8	Switzerland	521
5	Finland	531	5	Ireland	521	9	Estonia	520
13	Slovenia	513	6	Estonia	519	11	Netherlands	512
15	United Kingdom	509	9	Norway	513	12	Denmark	511
16	Germany	509	11	Germany	509	13	Finland	511
17	Netherlands	509	13	Poland	506	14	Slovenia	510
18	Switzerland	506	14	Slovenia	505	15	Belgium	507
19	Ireland	503	15	Netherlands	503	16	Germany	506
20	Belgium	502	17	Sweden	500	17	Poland	504
21	Denmark	502	18	Denmark	499	18	Ireland	504
22	Poland	501	19	France	499	19	Norway	502
23	Portugal	501	20	Belgium	499	20	Austria	497
24	Norway	498	21	Portugal	498	23	Russia	494
26	Austria	495	22	United Kingdom	498	24	Sweden	494
27	France	495	25	Spain	496	26	France	493
28	Sweden	493	26	Russia	495	27	United Kingdom	492
29	Czech Republic	493		OECD average	493	28	Czech Republic	492
30	Spain	493	28	Switzerland	492	29	Portugal	492
31	Latvia	490	29	Latvia	488	30	Italy	490
	OECD average	493	30	Czech Republic	487		OECD average	490
32	Russia	487	31	Croatia	487	31	Iceland	488
33	Luxembourg	483	33	Austria	485	32	Spain	486
34	Italy	481	34	Italy	485	33	Luxembourg	486
35	Hungary	477	35	Iceland	482	34	Latvia	482
36	Lithuania	475	36	Luxembourg	481	35	Malta	479
37	Croatia	475	37	Israel	479	36	Lithuania	478
38	Iceland	473	38	Lithuania	472	37	Hungary	477
39	Israel	467	39	Hungary	470	38	Slovak Republic	475
40	Malta	465	40	Greece	467	39	Israel	470
41	Slovak Republic	461	42	Slovak Republic	453	41	Croatia	464
42	Greece	455	43	Malta	447	42	Greece	454
44	Bulgaria	446	46	Romania	434	44	Romania	444
48	Romania	435	48	Bulgaria	432	45	Bulgaria	441
50	Moldova	428	50	Turkey	428	49	Turkey	420
52	Turkey	425	53	Montenegro	427	50	Moldova	420
59	Montenegro	411	56	Moldova	416	52	Montenegro	418
60	Georgia	411	62	Georgia	401	57	Georgia	404
67	FYROM <sup>1</sup>	384	67	FYROM <sup>1</sup>	352	66	FYROM <sup>1</sup>	371
68	Kosovo	378	69	Kosovo	347	68	Kosovo	362

<sup>1</sup> Former Yugoslav Republic of Macedonia  
Source: PISA 2015

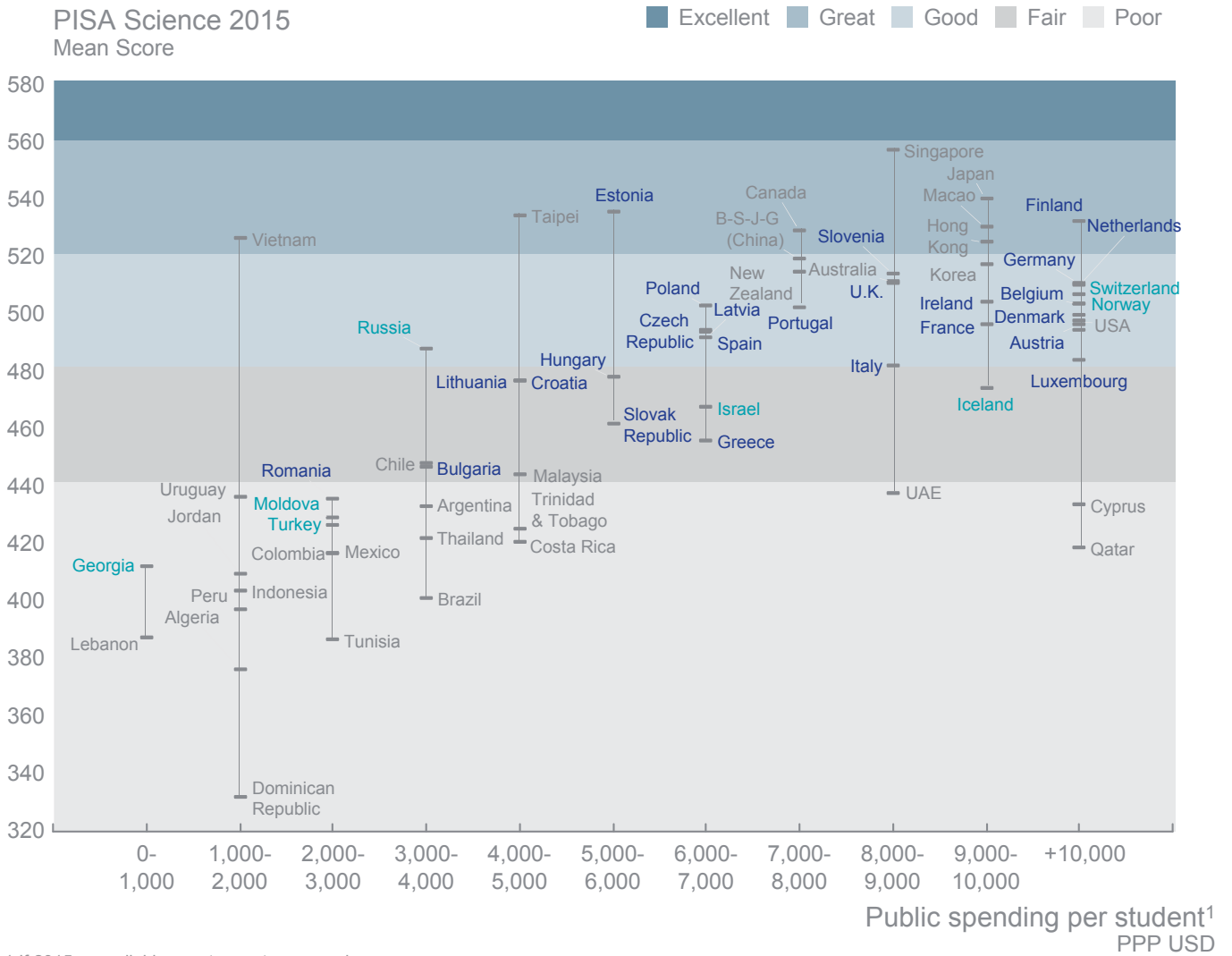
**EXHIBIT 05:** MOST EU COUNTRIES PERFORM BETTER THAN EXPECTED GIVEN THEIR GDP; MOST NON-EU COUNTRIES PERFORM WORSE.



SOURCE: PISA 2015

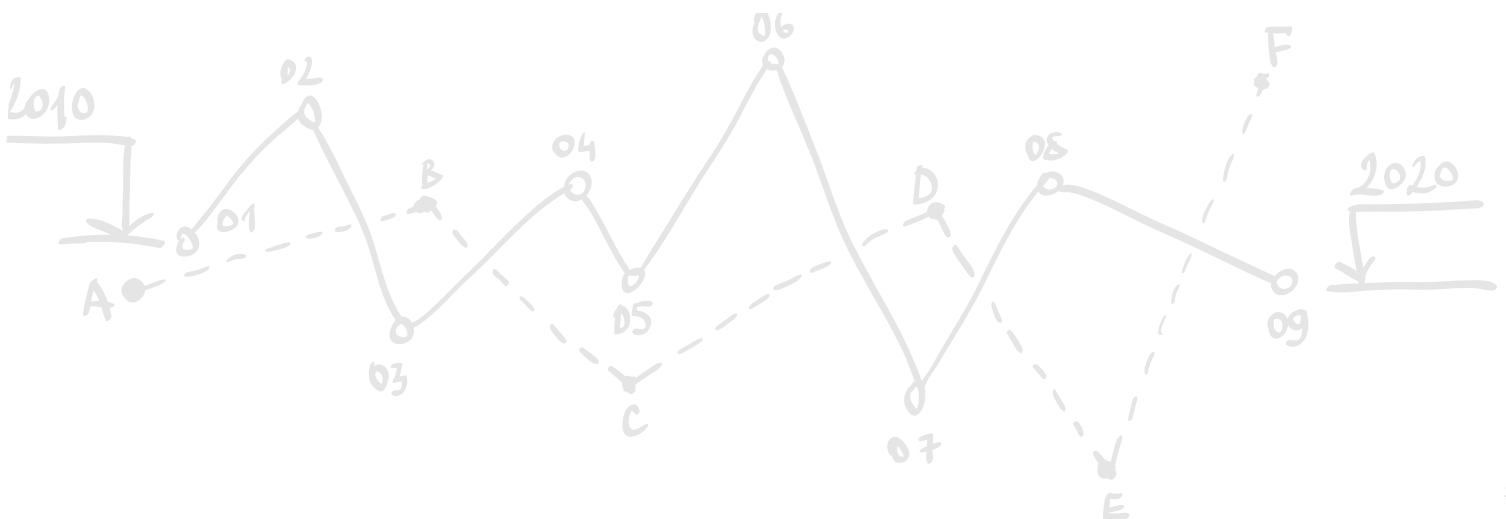
In the EU, most countries perform well against peers with a similar level of GDP, whereas many of the non-EU countries underperform in PISA tests, given their GDP levels (Exhibit 5). This could be partly explained by the fact that EU per-pupil education spending is very high relative to the rest of the world, and these countries are reaping the reward of this investment (Exhibit 6).

## EXHIBIT 06: COST-EFFECTIVENESS OF EDUCATION SPENDING VARIES.

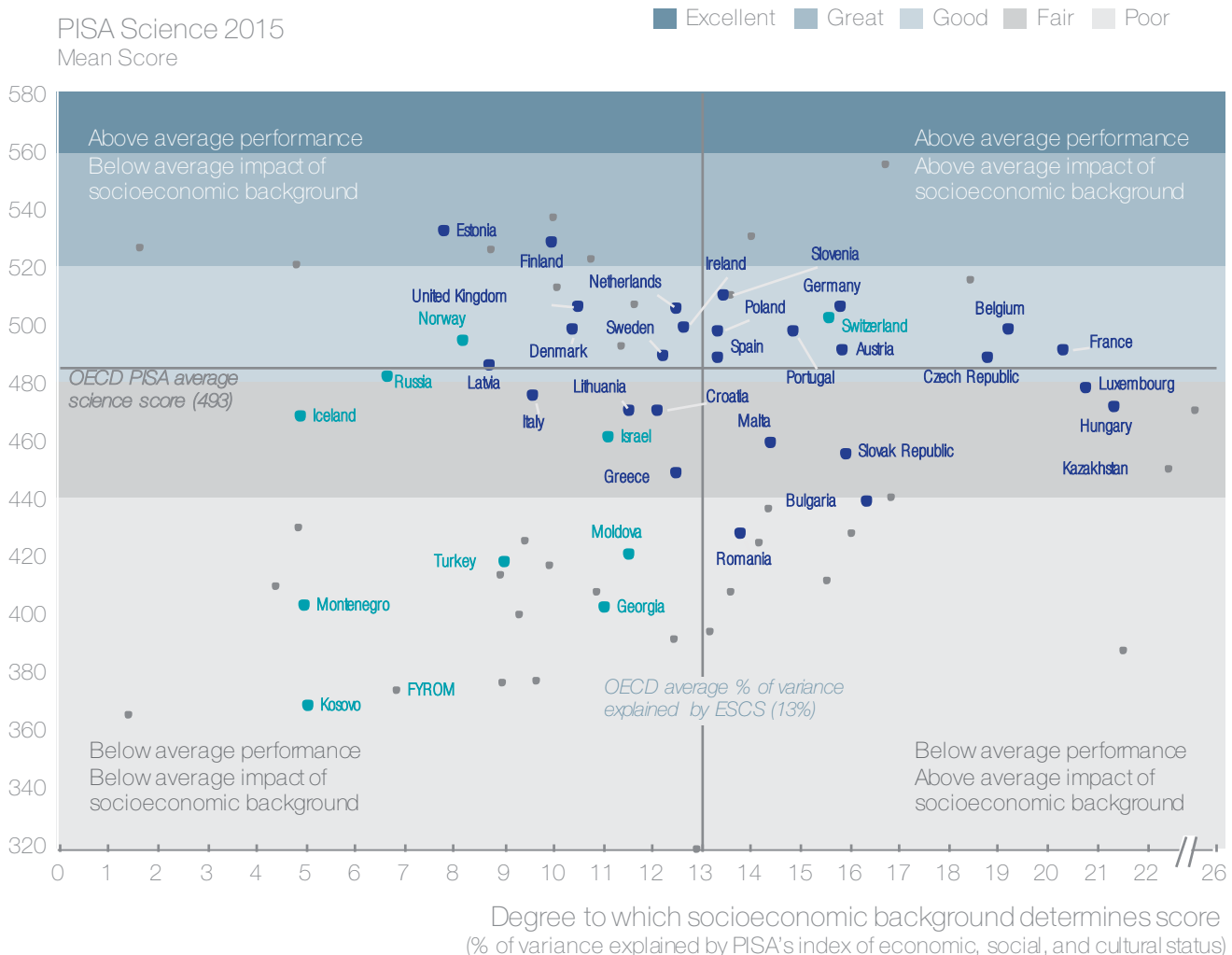


<sup>1</sup> If 2015 unavailable, most recent year used.

SOURCE: World Bank EdStats; IMF; UNESCO; PISA, Global Insight; McKinsey & Company



## EXHIBIT 07: HOW SOCIOECONOMIC BACKGROUND INFLUENCES PERFORMANCE.



SOURCE: PISA 2015

Socioeconomic equity varies significantly across Europe. One measure of this is the extent to which students' socioeconomic status explains their scores: the less socioeconomic status explains scores, the more equitable the system. In general, European countries are slightly more equitable than the OECD on this measure, but there is significant variation. In Estonia, Iceland, Kosovo, the Former Yugoslav Republic of Macedonia (FYROM), Montenegro, and Russia, less than 8 percent of the variance in score is explained by socioeconomic status. In France, Hungary, Kazakhstan, and Luxembourg, more than 20 percent of variance is explained by socioeconomic status (Exhibit 7).



**EXHIBIT 08:** ENROLLMENT RATES ARE HIGHER IN EU COUNTRIES AT PRE-PRIMARY AND UPPER SECONDARY LEVELS.

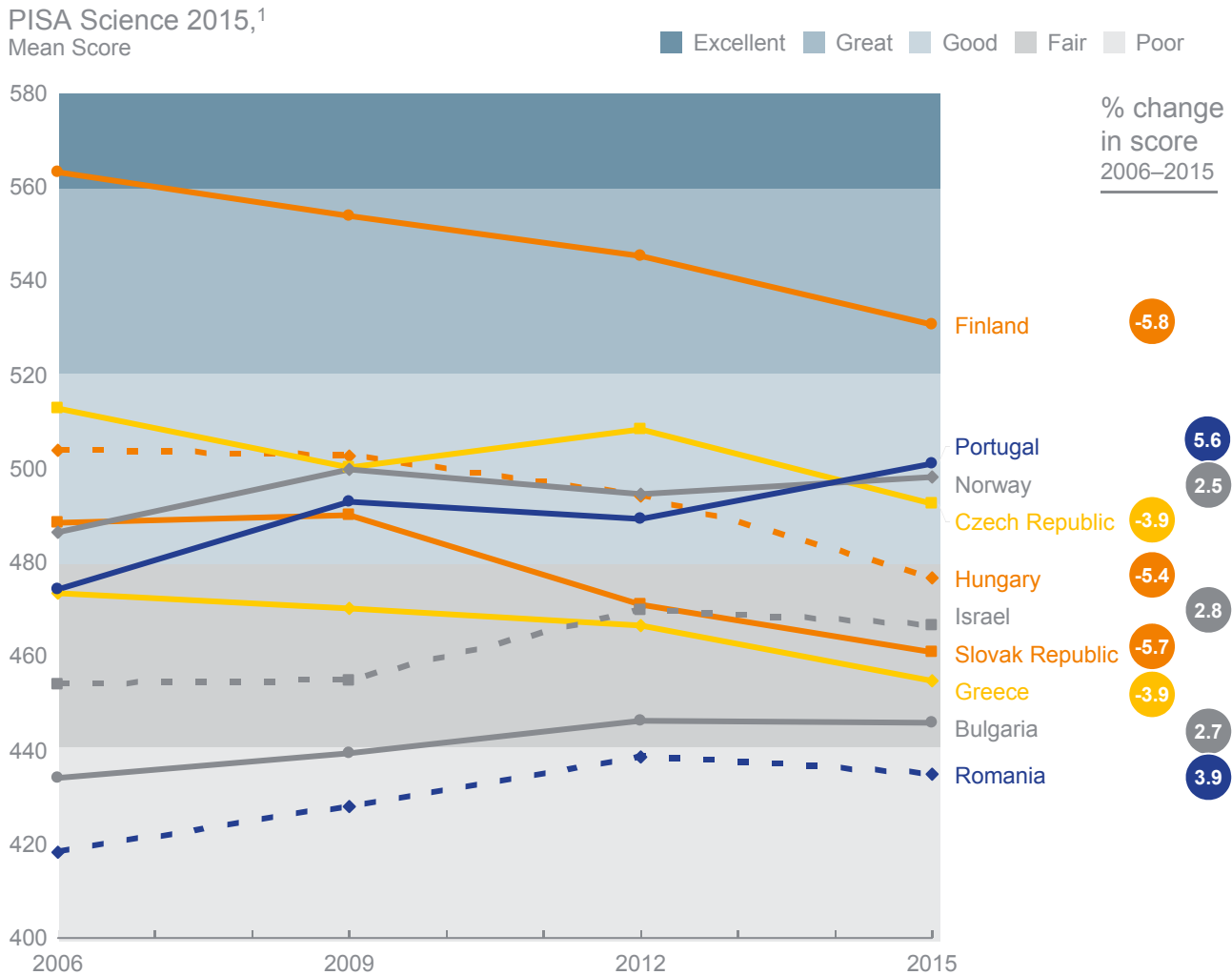
Net Enrollment Rate, 2015<sup>1</sup>  
(%)



1 If 2015 wasn't available, latest data available was used. 2 No data for Germany, Czech Republic, Slovakia, Kosovo or Austria  
SOURCE: UNESCO

Data from UNESCO show that enrollment rates in the EU are high at all levels of education; this is not the case for non-EU nations (Exhibit 8). Both regions have average enrollment rates of more than 90 percent for primary and lower secondary levels. But pre-primary enrollment averages 85 percent in the EU versus 72 percent in non-EU countries, and upper-secondary rates average 82 percent in the EU versus 77 percent in non-EU countries.

## EXHIBIT 09: BIGGEST PISA SCORES UPS AND DOWNS, BY COUNTRY



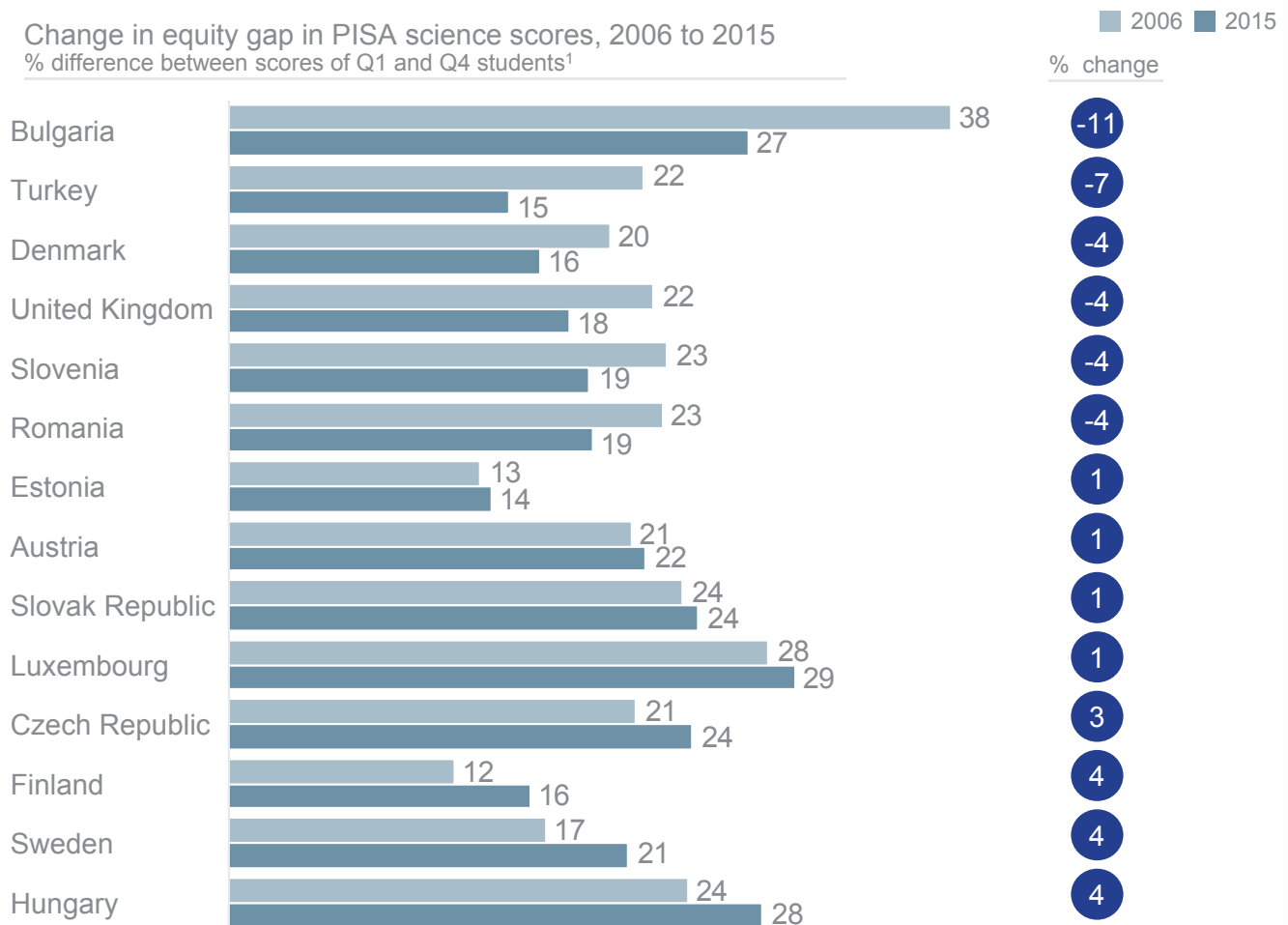
<sup>1</sup>Includes only countries that participated in all PISA cycles from 2006 to 2015.  
SOURCE: PISA 2006–2015

### Performance over time

In the EU, PISA scores have been flat since 2006; the composite score in both years was 490.<sup>4</sup> Science declined by a single percentage point, reading increased by one, and math was the same. For non-EU countries, the composite score has risen 1 percent since 2006, from 462 to 468. Science remained flat, while math and reading improved by 1 percent and 3 percent respectively.

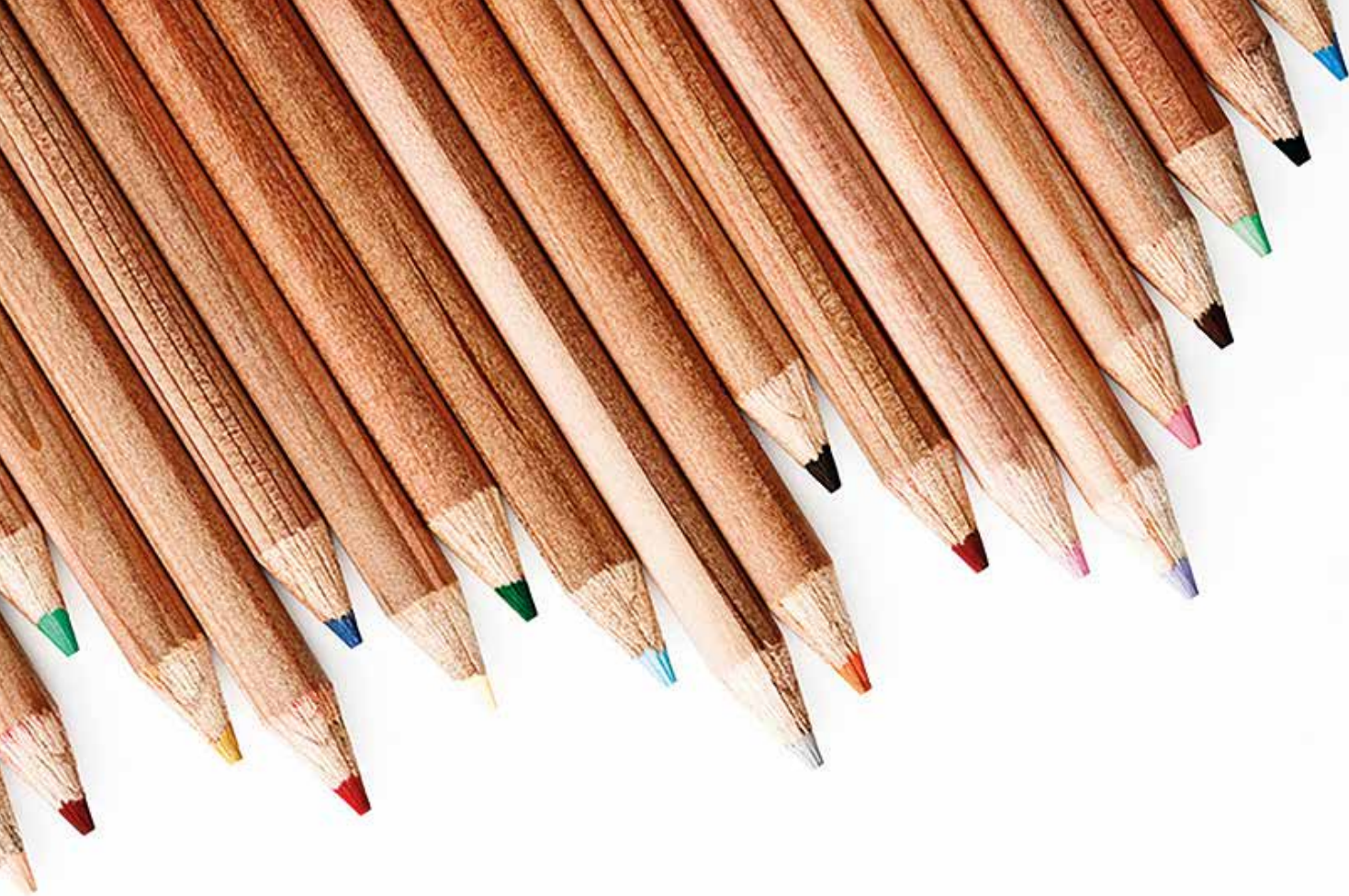
This broad picture, however, hides significant national variations. Portugal has improved the most (5.6 percent since 2006), and Finland's decline of 5.8 percent was the biggest change in that direction (Exhibit 9).

## EXHIBIT 10: BIGGEST CHANGES IN EQUITY, BY COUNTRY.



<sup>1</sup>OECD also uses change in score-point difference in science score associated with 1-unit increase on ESCS index to measure equity changes. For some countries in Europe, this yields slightly different outcomes; OECD's analysis can be found in Figure I.6.17 in *PISA 2015 Results, Volume I, Excellence and Equity in Education*.  
SOURCE: PISA 2006–2015

Overall, average equity has improved in both EU and non-EU countries, with the difference in scores between students from the highest and lowest socioeconomic quartiles narrowing by two to three percentage points. At the country level, the largest improvements have been in Bulgaria and Turkey, where the gap narrowed 11 and seven percentage points, respectively. Finland, Hungary, and Sweden are outliers in the opposite direction, with an increase of four percentage points (Exhibit 10). Recent high immigration levels may be a factor in exacerbating equity gaps, but gaps have widened even across native students in these countries.



Europe's performance on PISA therefore spans the gamut, from poor performers to some of the best in the world, and from stagnation to fast improvement.


This is where Europe stands. The challenge is how to do better, faster, in terms of both performance and equity.

What mindsets are most beneficial for students?

What does great teaching look like?

What is the role of technology?

The following three findings, based on the PISA data, complement our previous work by exploring these questions □



## Finding 1: Student mindsets have more influence on outcomes than socioeconomic background

**The role of mindsets** in educational achievement is a nascent but intriguing field of study. Recent research has examined the impact of traits including passion, perseverance and ‘grit’<sup>5</sup>, growth mindsets<sup>6</sup>, curiosity, conscientiousness, optimism, and self-control in children’s success. While some researchers claim that mindsets can be taught, others have questioned both the magnitude of the effect, and the usefulness of interventions in this area.<sup>7</sup>

Our review of the role of mindsets had three objectives: 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 several categories: mindset factors, home environment (including socioeconomic status),

school factors, teacher factors, student behaviors, and others.<sup>8</sup> 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 motivation, expectations, and sense of belonging.

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 (whether they will complete college) than the other way around, so we excluded this variable from our model.

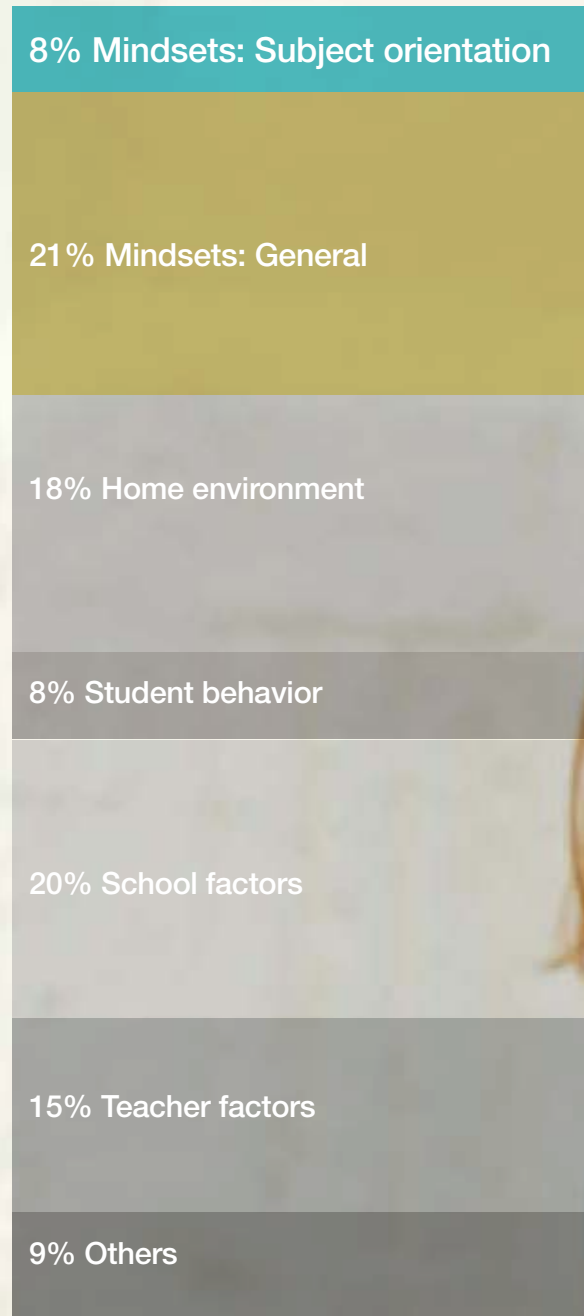
We then determined how influential each category was in predicting student performance.<sup>9</sup> Our conclusion: controlling for all other factors, student mindsets are more powerful, at 29 percent of total predictive power, than home factors, at 18 percent (Exhibit 11). Furthermore, general mindsets account for two-thirds of the effect found. In other regions, student mindsets have an even stronger impact (double or even triple the impact of home environment), reinforcing the importance of this finding.



**EXHIBIT 11:**  
MINDSETS ECLIPSE  
HOME ENVIRONMENT  
IN PREDICTING  
STUDENT  
ACHIEVEMENT.

**FACTORS DRIVING  
EUROPEAN STUDENT  
OECD PISA SCIENCE  
PERFORMANCE 2015**

% of predictive power by  
category of variable





### 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”

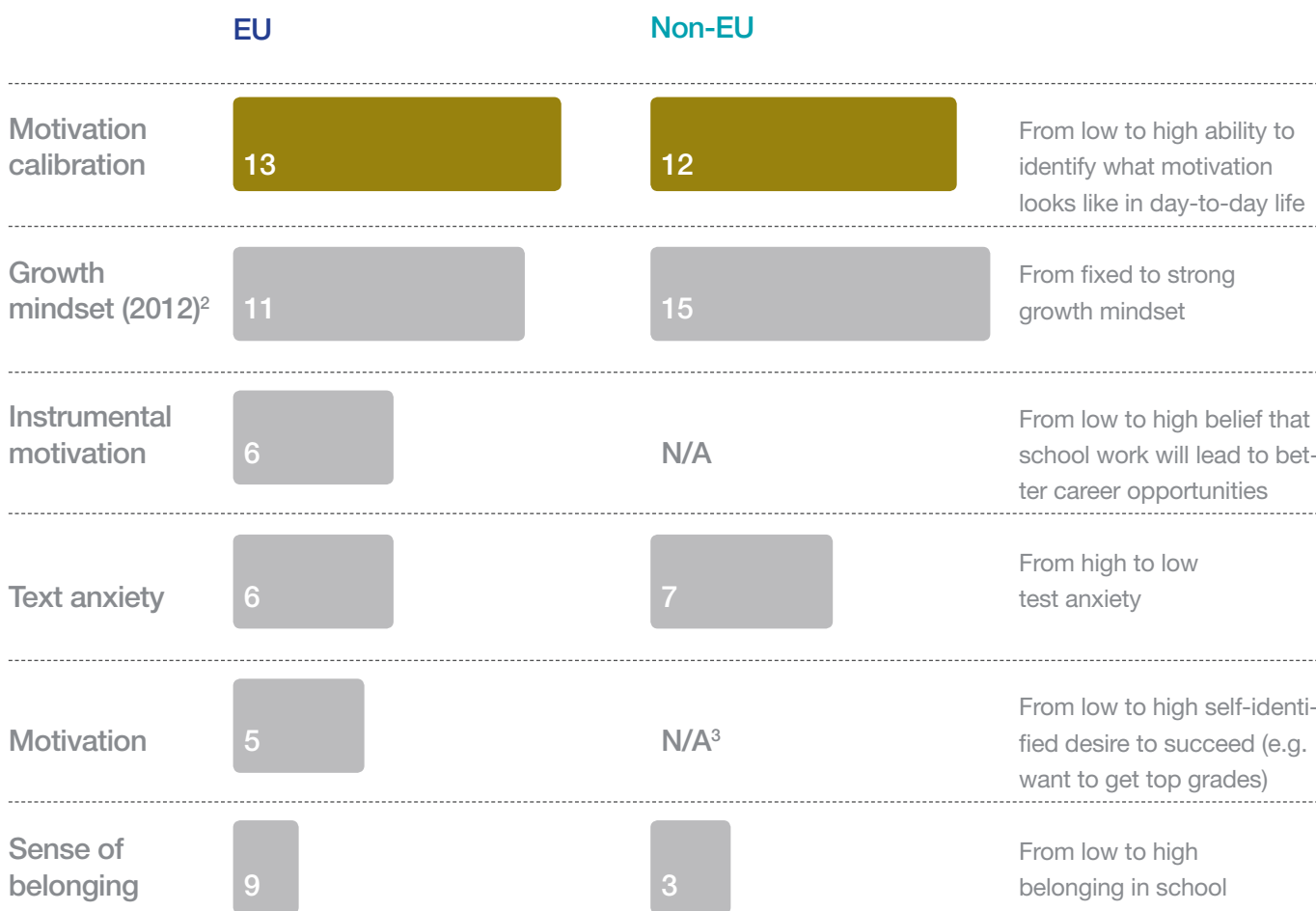
“I feel like I belong at school”

“If I put in enough effort, I can succeed”

## EXHIBIT 12: WHAT MINDSETS MATTER MOST?

### Score improvement for top general mindsets<sup>1</sup>

Percent increase in PISA Science score



<sup>1</sup> Statistically significant in regressions, controlling for student socioeconomic status, school type, and school location, except for instrumental motivation for non-EU countries.

<sup>2</sup> Uses data from 2012 PISA, since not available in 2015; uses 2012 math score, since it was focus of that year's test.

<sup>3</sup> No observed pattern descriptively for motivation in non-EU countries; however, statistically significant positive effect in a regression.

SOURCE: OECD PISA 2012, 2015, McKinsey analysis

Our research also found that some specific mindsets are more important than others in improving student outcomes (Exhibit 12).

“Motivation calibration” is the most important factor for both EU and non-EU students in 2015. This term refers to the ability of students to assess correctly what motivation looks like, such as “working on tasks until everything is perfect” and “doing more than what is expected.” To measure this, PISA asked test takers to assess the motivation of three hypothetical students (Exhibit 13). Based on the responses to these questions, we created an index of motivation calibration (see the analytical appendix).



## EXHIBIT 13: WHAT IS MOTIVATION CALIBRATION?



Motivation calibration is the ability of students to determine “Is the following student motivated?”

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

**Peter** mostly remains interested in the tasks he starts and sometimes does more than what is expected of him.

**Esther** wants to get top grades at school and continues working until everything is perfect.

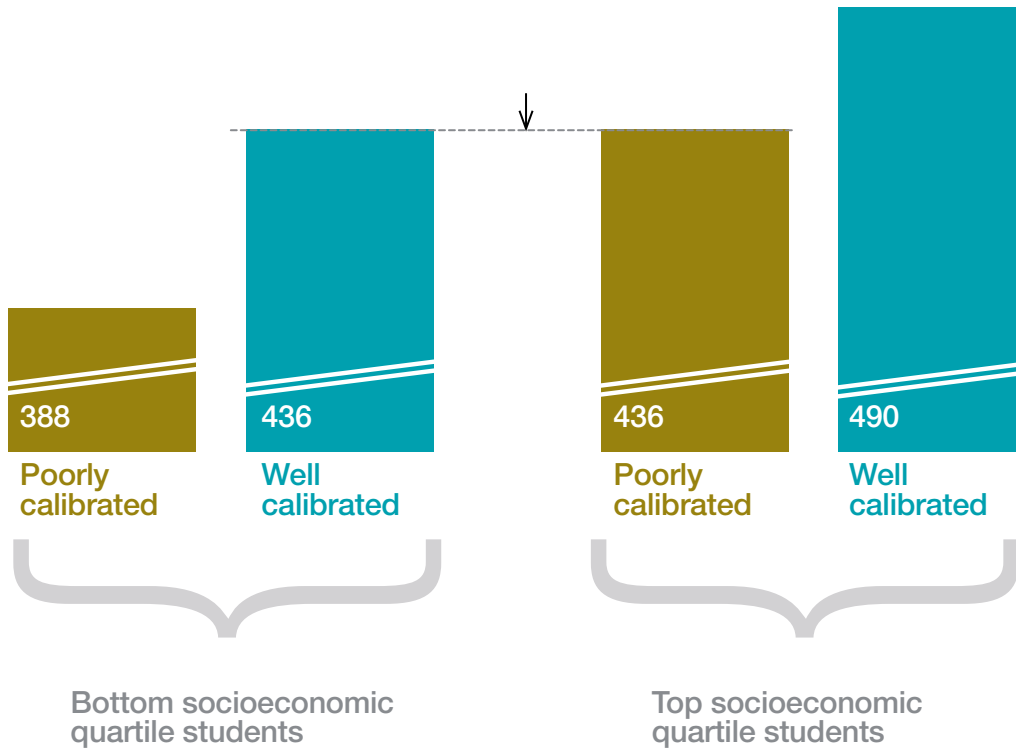
Source: OECD PISA 2015, McKinsey analysis

What we found was that simply understanding what motivation looks like in day-to-day life is a powerful performance indicator. In the EU, for example, students who have good motivation calibration score 13 percent (or 61 PISA points) higher than poorly calibrated students. This relationship holds even after controlling for socioeconomic status, location, and type of school. In contrast, students who self-identify as “wanting to be the best and wanting top grades” score just 5 percent higher than those who do not. 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 these look like. Calibrating to a norm helps to improve students’ actual study habits.

**EXHIBIT 14:** HAVING A WELL-CALIBRATED MOTIVATION MINDSET IS EQUIVALENT TO LEAPFROGGING INTO A HIGHER SOCIOECONOMIC QUARTILE.

**European low-performing schools<sup>1</sup>**

Average PISA science score 2015

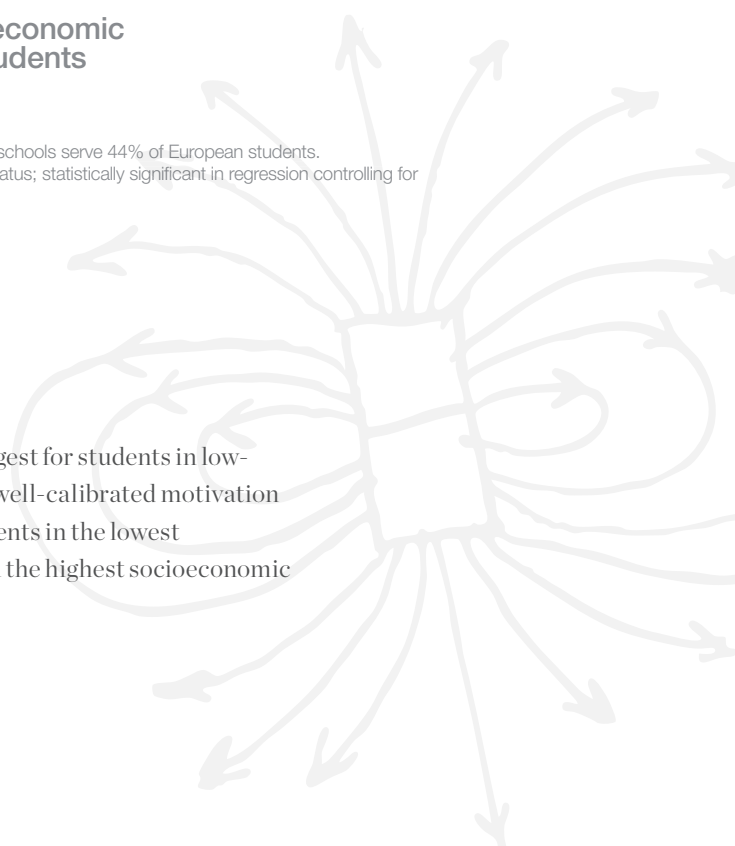


1 Schools with an average PISA score of less than 480 (defined as “poor” and “fair” schools). These schools serve 44% of European students.

2 Using PISA’s index for economic, social, and cultural status (ESCS) as a proxy for socioeconomic status; statistically significant in regression controlling for school type and location.

Source: OECD PISA 2015, McKinsey analysis

The relationship between motivation calibration and PISA scores is strongest for students in low-performing schools. In fact, for those in low-performing schools, having a well-calibrated motivation mindset is equivalent to vaulting into a higher socioeconomic status. Students in the lowest socioeconomic quartile who are well calibrated perform as well as those in the highest socioeconomic quartile who are poorly calibrated (Exhibit 14).





**EXHIBIT 15:** POOR STUDENTS IN POORLY PERFORMING SCHOOLS ALSO TEND TO HAVE POOR MOTIVATION CALIBRATION.

% of European students with well-calibrated motivation



SOURCE: OECD PISA 2015, McKinsey analysis

Unfortunately, the students in poor schools, who would most benefit from high motivation calibration, are least likely to have it. Only 44 percent of low-socioeconomic-status students have high motivation calibration, compared with 76 percent of high-socioeconomic-status students in good schools (Exhibit 15).

Using the example of motivation calibration, we investigated how scores might improve across the region if mindsets could be changed. In the EU, if the 34 percent of students with low motivation calibration could be shifted to a well-calibrated mindset, this could result in a 4.2 percent overall score improvement. In non-EU countries, this would affect 45 percent of students and increase scores 5.1 percent, equivalent to two-thirds of a year of schooling.



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 11 percent in EU countries and by 15 percent in non-EU countries.

To be clear, mindsets alone cannot overcome economic and social barriers. This research does suggest, however, that mindsets 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 systemwide 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.

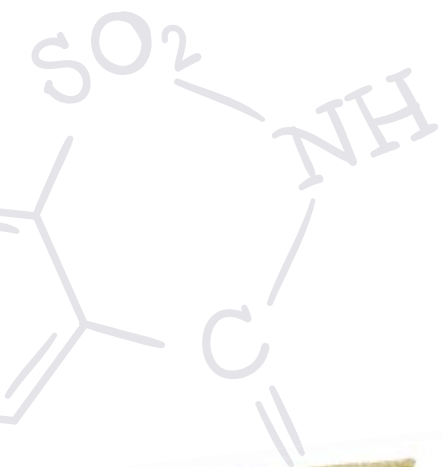
For example, on growth mindsets, a 2015 study of 1,500 secondary-school students in 13 different schools, rich and poor, from all over the United States, found that growth-mindset and sense-of-purpose interventions delivered significant results. The researchers administered two 45-minute online modules 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 students 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.<sup>10</sup>

Similarly, on motivation calibration, recent research suggests that metacognition and self-regulation strategies can improve student outcomes. Interventions to help students plan, monitor, and evaluate their learning have been demonstrated to be a promising way to improve their motivation and perseverance as they tackle challenging academic content.<sup>11</sup>

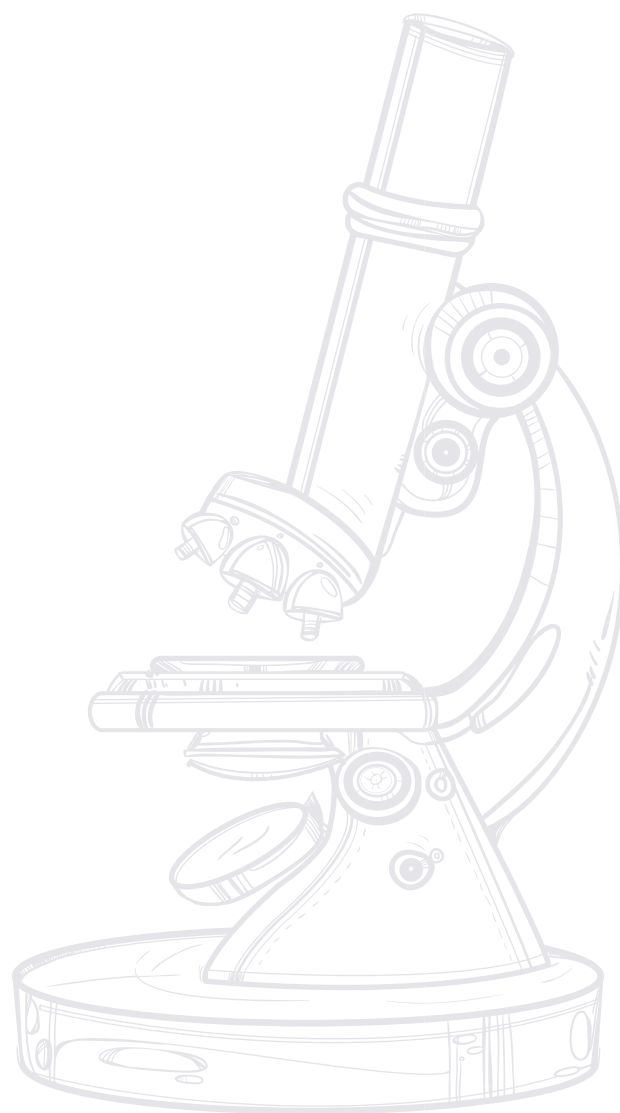
Such research is a work in progress, but these and other experiments indicate that harnessing the power of mindsets may be a promising way to support achievement—in addition, of course, to teaching fundamental academic content. Academics and policy makers in Europe should be encouraged to design, implement,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



## 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. Inquiry-based teaching spans a diverse range of practices: conducting and drawing conclusions from practical experiments, understanding how science can be applied in real-life, and more unstructured activities such as encouraging students to create their own questions, design experiments to test their hypotheses, and argue about science questions (Exhibit 16). There is active debate over which approach is preferable and which specific practices lead to better student outcomes.





**EXHIBIT 16:** 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.

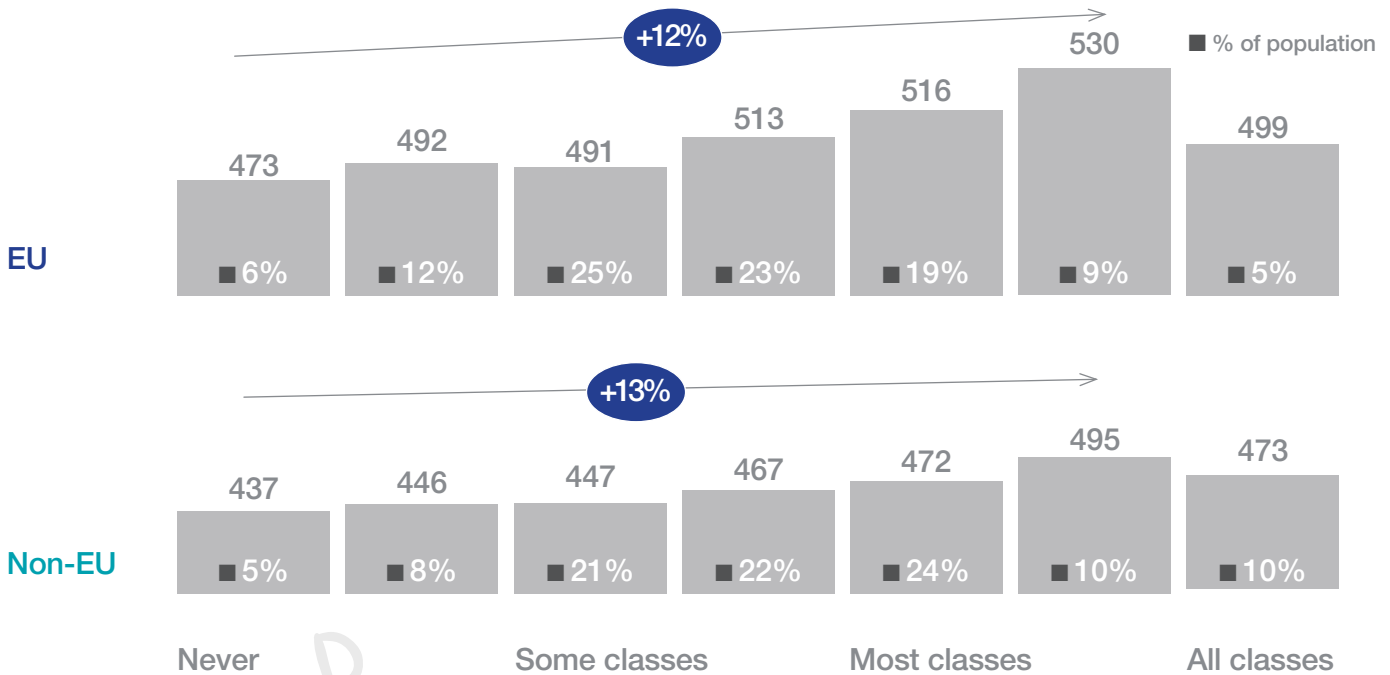
SOURCE: OECD PISA 2015



## EXHIBIT 17: WHEN TEACHERS TAKE THE LEAD, PISA SCORES ARE HIGHER.

### Impact of teacher-directed instruction<sup>1</sup>

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



<sup>1</sup> Statistically significant in regression controlling for student socioeconomic status, school type, and school location  
 SOURCE: OECD PISA 2015, McKinsey analysis

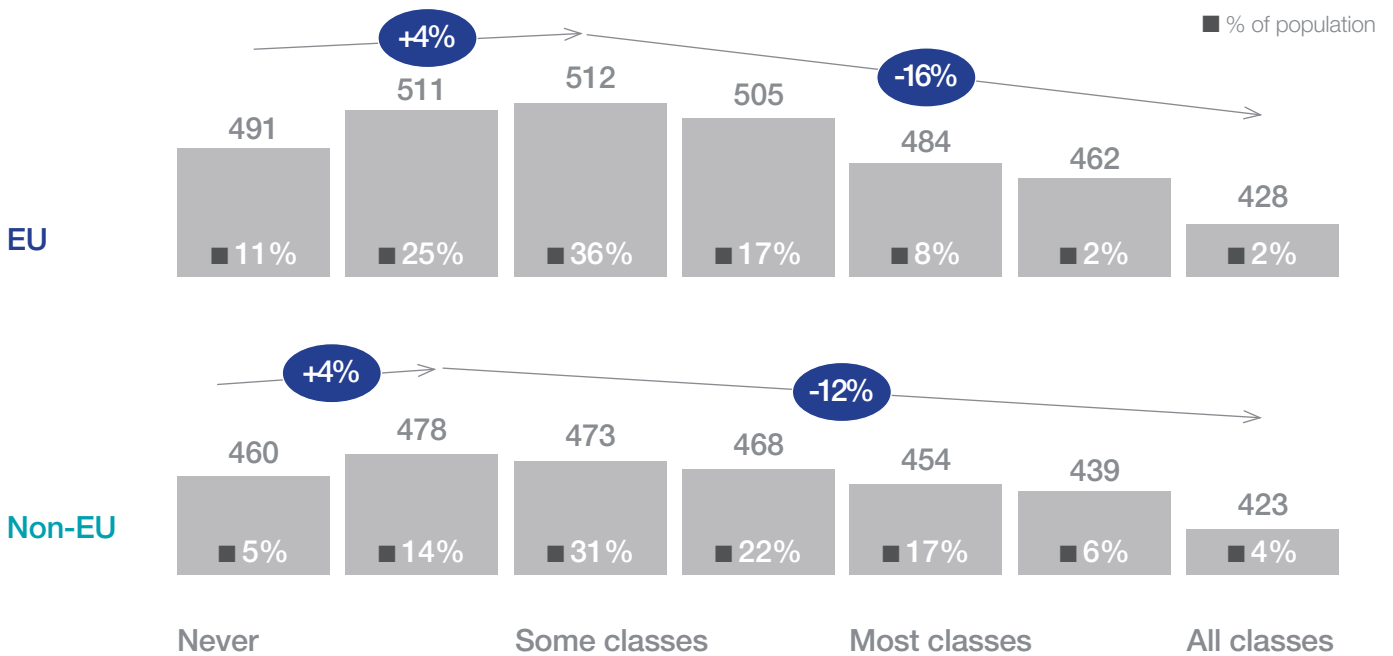
We look first at the macro-impact across all teacher-directed and inquiry-based practices. Then we dive deeper to understand which inquiry-based practices are most beneficial.

Based on PISA 2015 student survey responses in Europe, scores rise with greater use of teacher-directed instruction. Scores increase by 12 to 13 percent as students move from classrooms where teacher-directed instruction is never or hardly ever used to environments where it is used in most to all classes (Exhibit 17).

## EXHIBIT 18: INQUIRY-BASE TEACHING DELIVERS MIXED RESULTS.

### Impact of inquiry-based teaching<sup>1</sup>

Average PISA science score with different amounts of inquiry-based teaching



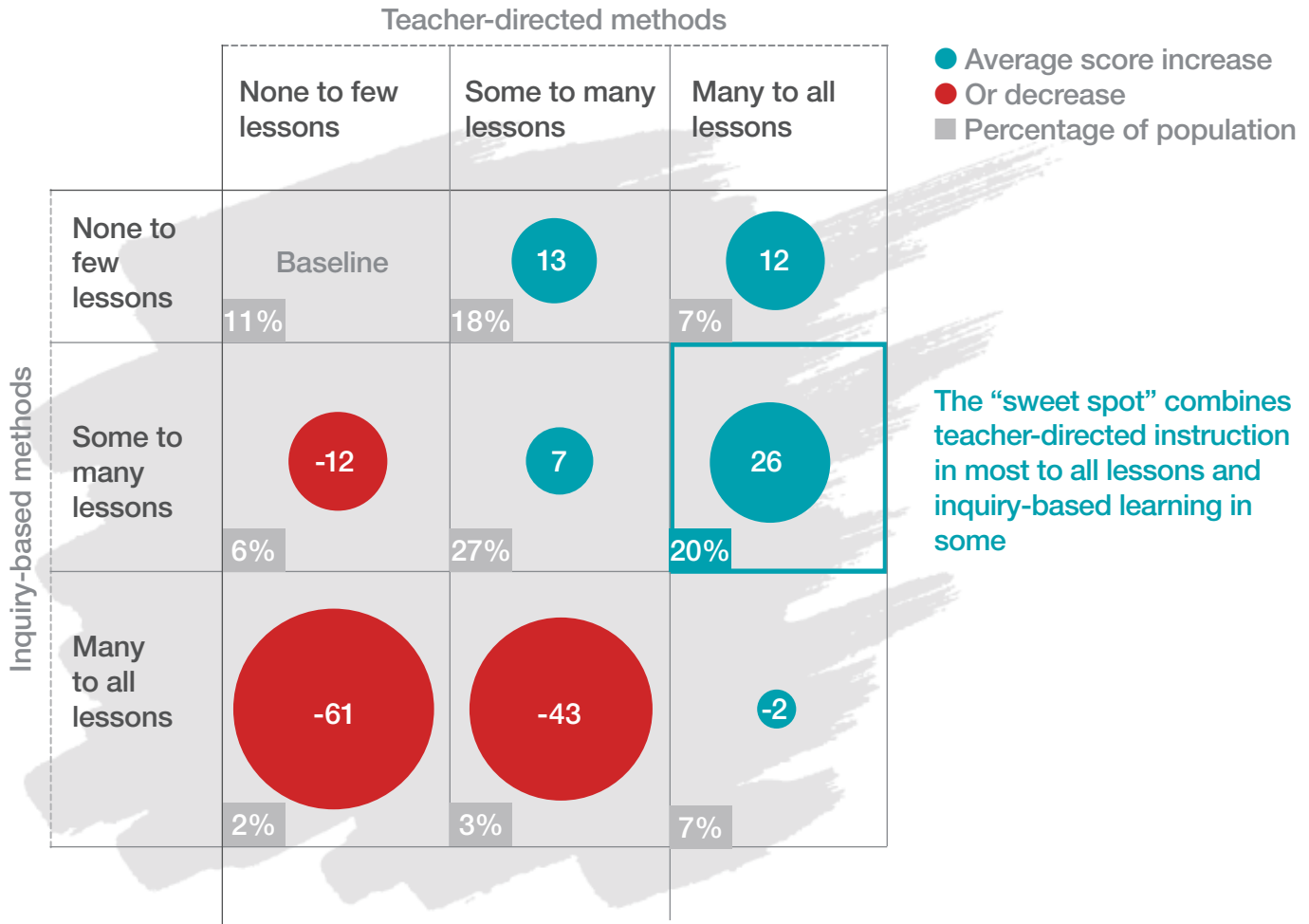
<sup>1</sup> Statistically significant in regression controlling for student socioeconomic status, school type, and school location  
 SOURCE: OECD PISA 2015, McKinsey analysis

The picture for inquiry-based teaching is more complex. While infrequent use of inquiry-based teaching outperforms no use at all, more frequent use is associated with lower scores (Exhibit 18).

At first blush, then, inquiry-based teaching 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 teaching can be effective—but only when strong teacher-directed instruction is in place. This suggests that for students to fully benefit from inquiry-based teaching, teachers must be able to clearly explain scientific concepts, and students need to have content mastery.

**EXHIBIT 19:** FINDING THE SWEET SPOT: THE BEST STUDENT OUTCOMES OCCUR WHEN BOTH TEACHING STYLES ARE USED (EU EXAMPLE).

**Impact of teacher-directed and inquiry-based combinations**  
Average point increase in Europe PISA science score relative to baseline<sup>1</sup>



<sup>1</sup> Statistically significant expected change in score controlling for PISA’s index for economic, social, and cultural status (ESCS), public/private schools, and urban/rural location for all quadrants except for teacher-directed and inquiry-based instruction in many-to-all classes (-2), which was not significant at 95% confidence level.

SOURCE: OECD PISA 2015, McKinsey analysis

Based on the PISA results, the most effective combination appears to be teacher-directed instruction in most or almost all classes, with inquiry-based teaching in some of them. In the EU, students who receive this blend of teaching practices outperform—by more than 80 PISA points—those who experience high levels of inquiry-based teaching without a strong foundation of teacher-directed instruction (Exhibit 19). The pattern is similar for non-EU countries. To put it another way, the more teacher-directed instruction there is, the better it supports inquiry-based teaching.

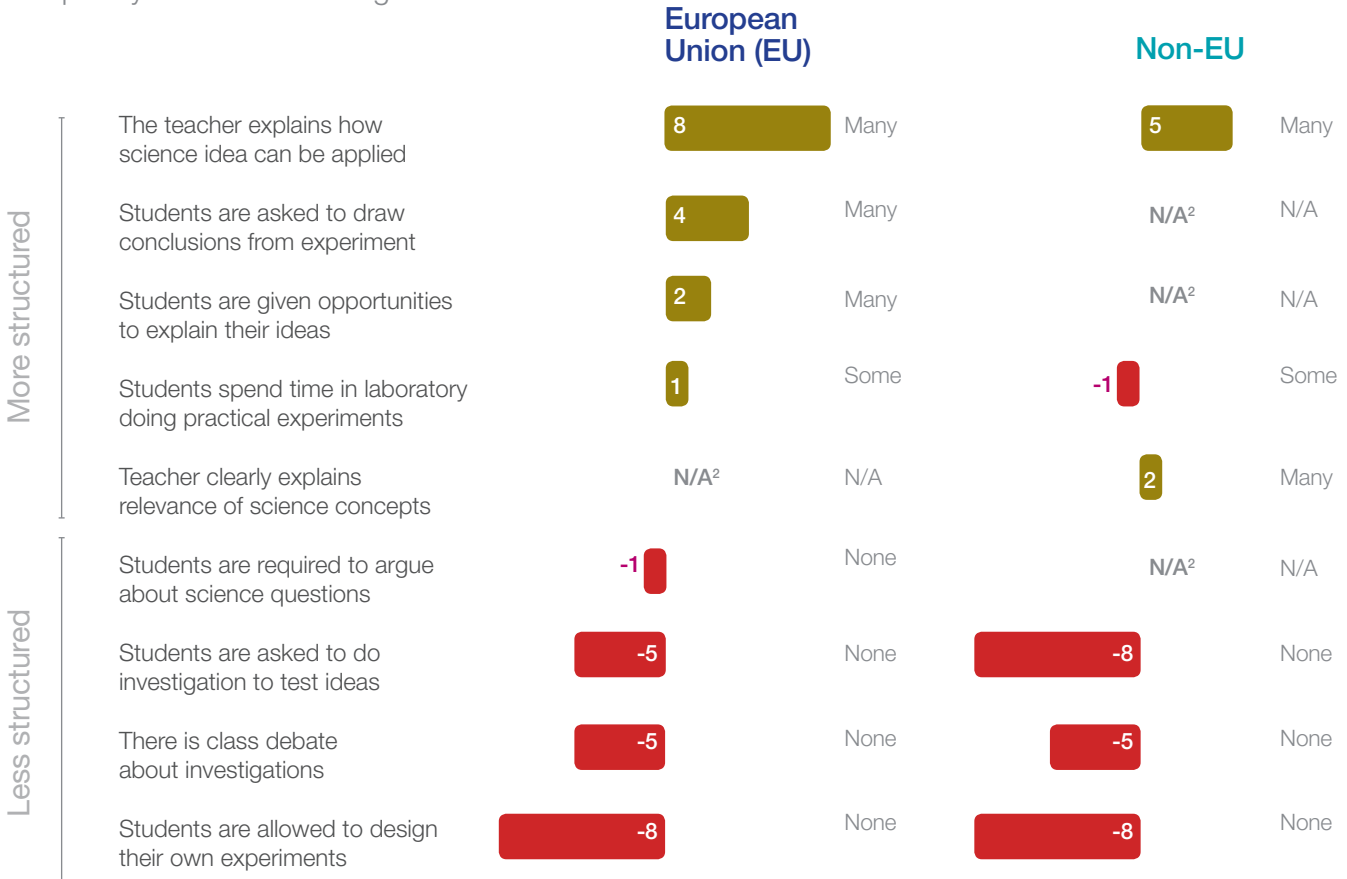


In Europe, most countries appear to be doing less teacher-directed instruction and more inquiry-based teaching than optimal. In fact, only 20 percent of EU students and 22 percent of non-EU students sit in the sweet spot, that is, teacher-directed instruction in most to all classes, supported by inquiry-based teaching in some of them. We estimate that moving the remaining students into the sweet spot could result in a 3.7 percent increase in PISA scores across the EU and a 4.2 percent increase in PISA scores across non-EU countries, equivalent to about half a school year of learning.

## EXHIBIT 20: STRUCTURED INQUIRY-BASED PRACTICES LEAD TO BETTER OUTCOMES; LESS STRUCTURED ACTIVITIES DO NOT.

### Impact of Inquiry-based practices

Expected % increase in PISA science score<sup>1</sup> between no use and use in many classes<sup>2</sup>;  
Frequency of lessons with highest score



<sup>1</sup>In a regression controlling for student socioeconomic status, school type, and location; normalized over regional average PISA score.

<sup>2</sup>No statistically significant relationship

SOURCE: OECD PISA 2015, McKinsey analysis

These results 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 and teacher-directed approaches are composed of specific practices, and these have discrete effects (Exhibit 20). Across Europe, inquiry-based activities that are more structured yield better student outcomes. In the EU, however, students appear to benefit from conducting practical experiments and drawing conclusions from them—substantially more so than in non-EU countries. Even in non-EU countries, though, students who spend time in the laboratory in some lessons score higher than those who never participate.





School systems need to tread carefully in selecting inquiry-based teaching practices. Our analysis shows that some less structured techniques actually hurt student outcomes across Europe, even when only used in some lessons. Among them are having students design their own experiments, asking them to do investigations to test ideas, having a class debate about investigations, and requiring students to argue about science questions.

Given that there is strong support for inquiry-based pedagogy among education professionals, these findings on instruction may seem counterintuitive. We offer two hypotheses for why inquiry-based teaching is not translating into better student outcomes. First, students cannot progress to inquiry-based methods without a strong foundational knowledge gained through teacher-directed instruction. Second, inquiry-based teaching is more challenging to deliver, and teachers who attempt it without sufficient training and support will struggle. Indeed, teacher training is required to help teachers not only identify when to use which approach but also to determine how to use each of the approaches most effectively.

We should emphasize that inquiry-based practices may bring benefits beyond improving student scores. Experiencing inquiry-based teaching increases European students' joy in science and belief that doing well in science will be worthwhile for their future careers. This matters, because passion for a topic is linked to perseverance. Although teacher-directed teaching is also positively correlated with joy in science, it does not have as strong an impact, especially in non-EU countries.

Knowing all this is only the start, and the results raise a slew of questions about how to find the right balance between teacher-directed and inquiry-based teaching, and how to improve the quality of each (see sidebar, "Teaching practices in English schools"). At a minimum, our research suggests that teachers need to understand fully the content they are teaching and be able to explain it before they jump into inquiry-based exercises □

## Teaching practices in English schools

A consistent trend in recent English education policy has been to grant more autonomy to schools over how they teach. Schools have been taken out of local-authority control through the academies program (in 2010), national assessment frameworks have been removed (2010), and the Office for Standards in Education, Children’s Services and Skills (Ofsted) abolished the notion of a preferred teaching style (2012). The PISA survey data allows us to explore what teaching styles are being employed, as well as the relationship between these teaching styles and PISA scores.

The results are consistent with our conclusions: teacher-led instructional practices are associated with higher PISA scores, while the efficacy of inquiry-based practices is mixed (Exhibit). At the most extreme ends of the spectrum, inquiry-based practices have a significant detrimental effect on PISA scores. For example, students who design their own experiments in many lessons score 7 percent worse than those who never do.

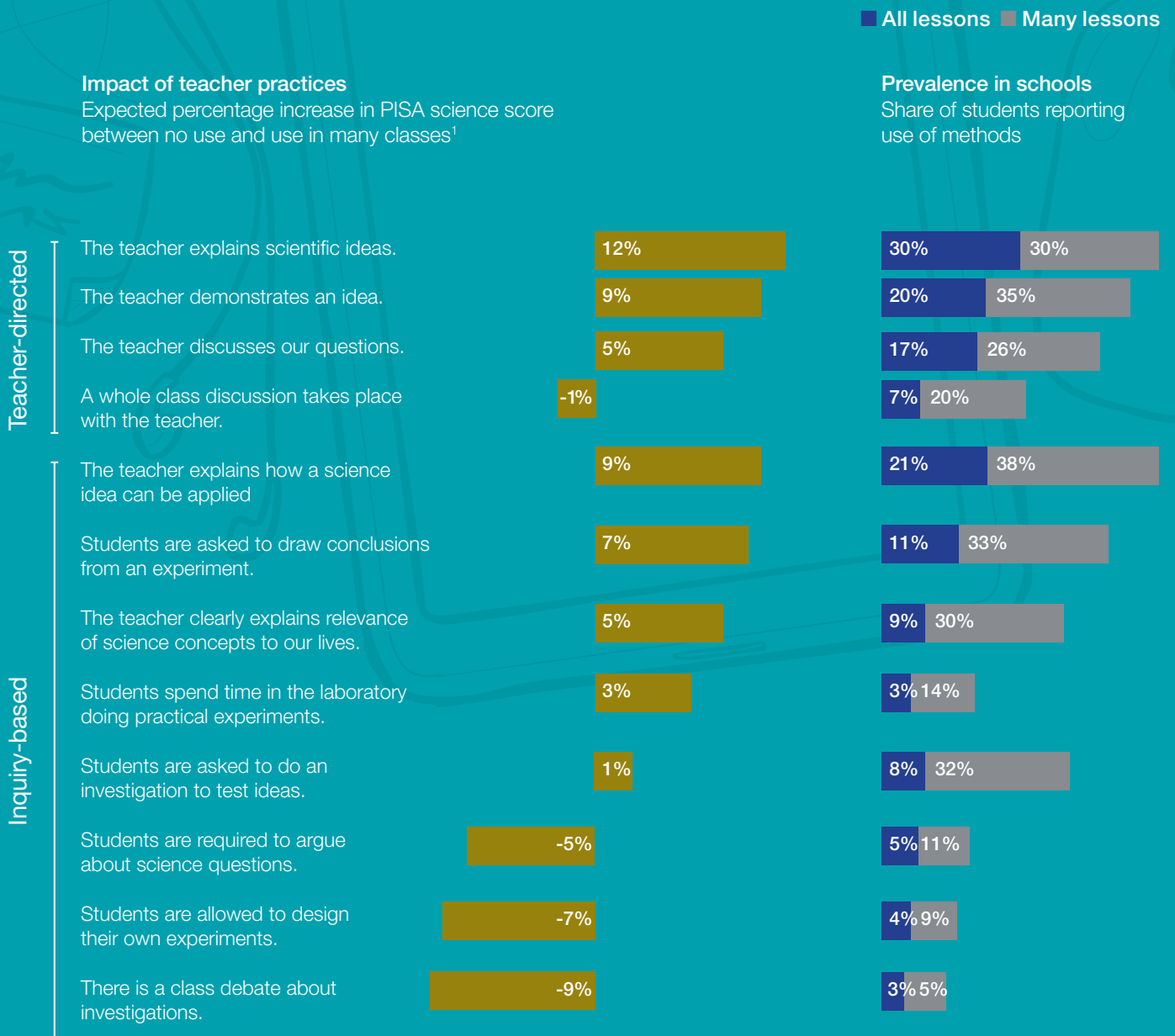
One common argument in favor of inquiry-based teaching methods is that they are more effective at fostering a love of science, which is important in nudging people toward a science-based career. In England, though, the PISA evidence for this is mixed. Looking across all nine inquiry-based practices, inquiry-based teaching is indeed more effective than teacher-directed methods at increasing students’ enjoyment of science. However, unpacking this tells a more nuanced story. Combining the four most extreme (and least effective) inquiry-based practices,<sup>1</sup> we find that students who regularly experience these practices actually enjoy science less.

How then are these different practices being adopted by teachers across the heterogeneous English system? Even the most common method—the teacher explaining scientific ideas to students—occurs most or all of the time in only 60 percent of classes. On the other end of the spectrum, a small but committed core of teachers use the four least effective inquiry-based practices in all or most of their lessons; most use these more extreme practices in few to some lessons only.

Taken together, these findings suggest that there are potential gains to be made in England from reinforcing the most common teacher-led practices and paring back the use of the less successful inquiry-based ones.

<sup>1</sup> Students are allowed to design their own experiments; there is a class debate about investigations; students are required to argue about science questions; students are asked to do an investigation to test ideas.

## TEACHER-DIRECTED PRACTICES HAVE LARGELY POSITIVE IMPACT, WHILE THE EFFICACY OF INDIVIDUAL INQUIRY-BASED PRACTICES IS MIXED.



<sup>1</sup> Based on a regression of expected PISA science scores when controlling for socio-economic status  
SOURCE: OECD PISA 2015 (English students only), McKinsey analysis



## Finding 3: While technology can support student learning outside of school, its record in school is mixed, with the best results from technology in the hands of teachers.

**The potential of technology in education is obvious.** It can individualize learning, assist teachers with curriculum 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; so are the hopes that ICT can help to improve performance.

In response, European countries are equipping schools with hardware and integrating computing into school curricula. Russia, as part of its modernization of regional schools, has connected more than 13,000 schools to the Internet and purchased more than 240,000 computers.<sup>12</sup> France plans to equip primary and secondary schools with digital tablets.<sup>13</sup> The German government is planning to invest €5 billion to equip 40,000 schools with broadband Internet and tablet computers.<sup>14</sup> Sixteen European countries have begun to integrate coding into their curricula.<sup>15</sup>

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 concluded that the evidence that it does is “mixed at best.”<sup>16</sup> Among countries that had invested heavily in ICT, the report concluded, there were “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 early exposure—digital exposure before age six—perform 13 percent better than those exposed at age 13 or later in non-EU countries, and 23 percent better in EU countries (Exhibit 21).<sup>17</sup>

Even controlling for socioeconomic status, school type, and location, students who start using digital devices early score 9 to 16 percent higher than those who do not. The effect is most pronounced for the more privileged. For example in non-EU countries, high-socioeconomic-status students get double the benefit of low-socioeconomic-status students from early exposure (in a regression controlling for socioeconomic status, school type, and location). Not only do higher-status students get greater lift from early use of digital devices, they are also more likely to have started young. The implication is that ICT may actually be widening the equity gap.

It should be noted that 15-year-olds today reporting on their technology exposure before the age of six are referring to technology that is a decade old. The dynamic nature of the field means research like this is dated the moment it is

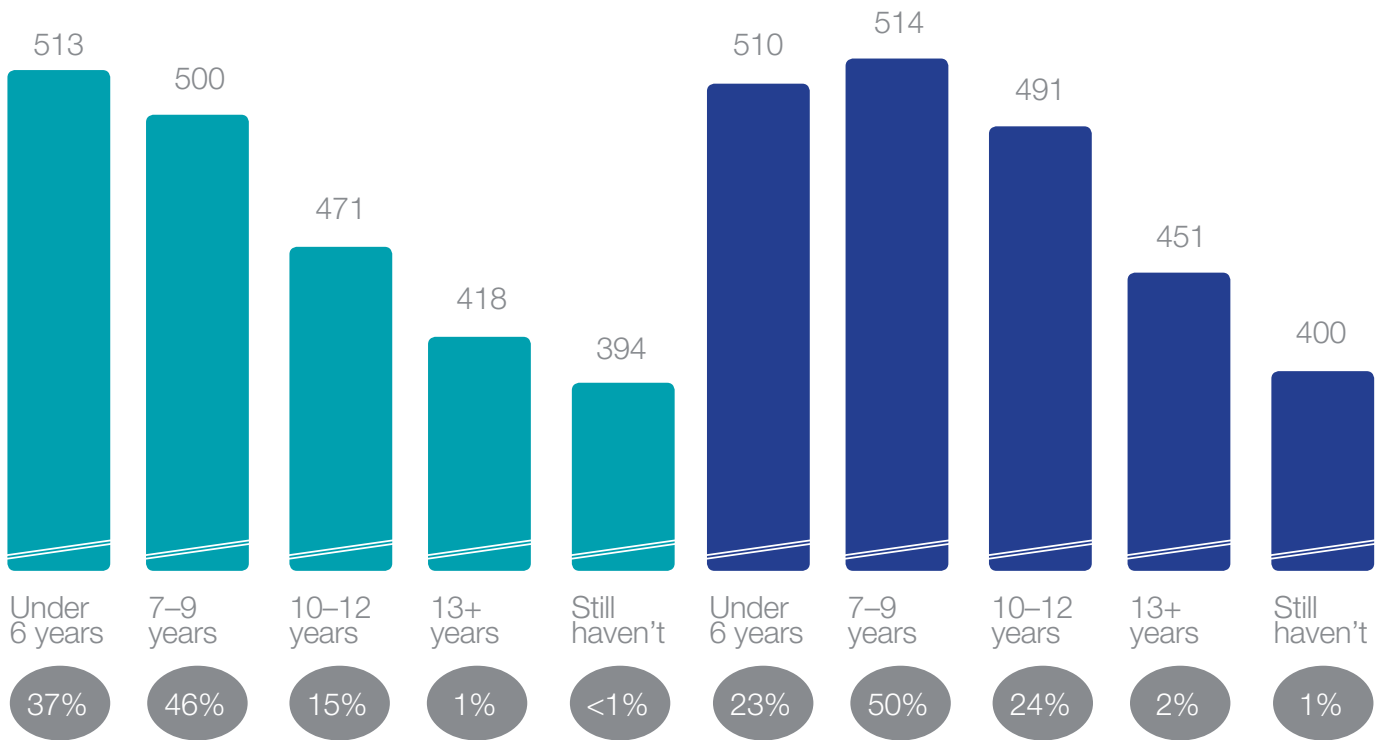
**EXHIBIT 21:** EARLY EXPOSURE TO ICT IS ASSOCIATED WITH HIGHER SCIENCE SCORES LATER.

**Age of first exposure to digital devices**

Europe average PISA Science Score by age<sup>1</sup>

**European Union (EU)**

**Non-EU**



<sup>1</sup> Statistically significant in regression controlling for student socioeconomic status, school type, and school location  
Source: OECD PISA 2015, McKinsey analysis



published. Constant updates on the effects of technology are required to gain a more accurate picture.

### ICT at home.

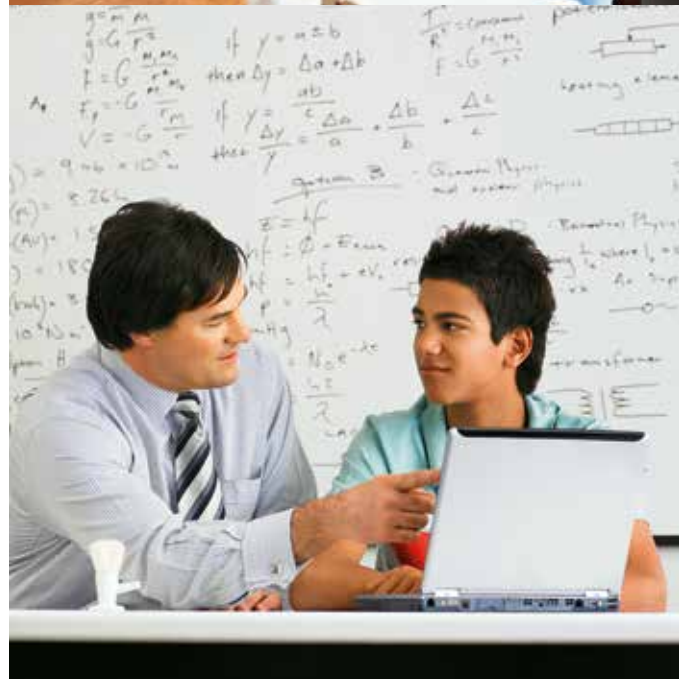
Across Europe, ICT use at home has a positive relationship with PISA science scores, up to a point. Controlling for socioeconomic status, school type, and location, EU students using the Internet from one to two hours per day score highest: 61 PISA points higher than those with no use. Among non-EU students, those who spend two to four hours per day online score highest: 45 PISA points higher than those with no use, with more than 75 percent of the benefit captured with just one to two hours. Beyond four hours, the positive effects tend to decline, and use for six hours or more is associated with negative behaviors, such as missing school.

How students spend their time also matters. External research has demonstrated that going online for educational purposes and interactive game-based learning has positive effects, while participation in social media appears to be negative not only for student scores, but also for student well-being.<sup>18</sup>

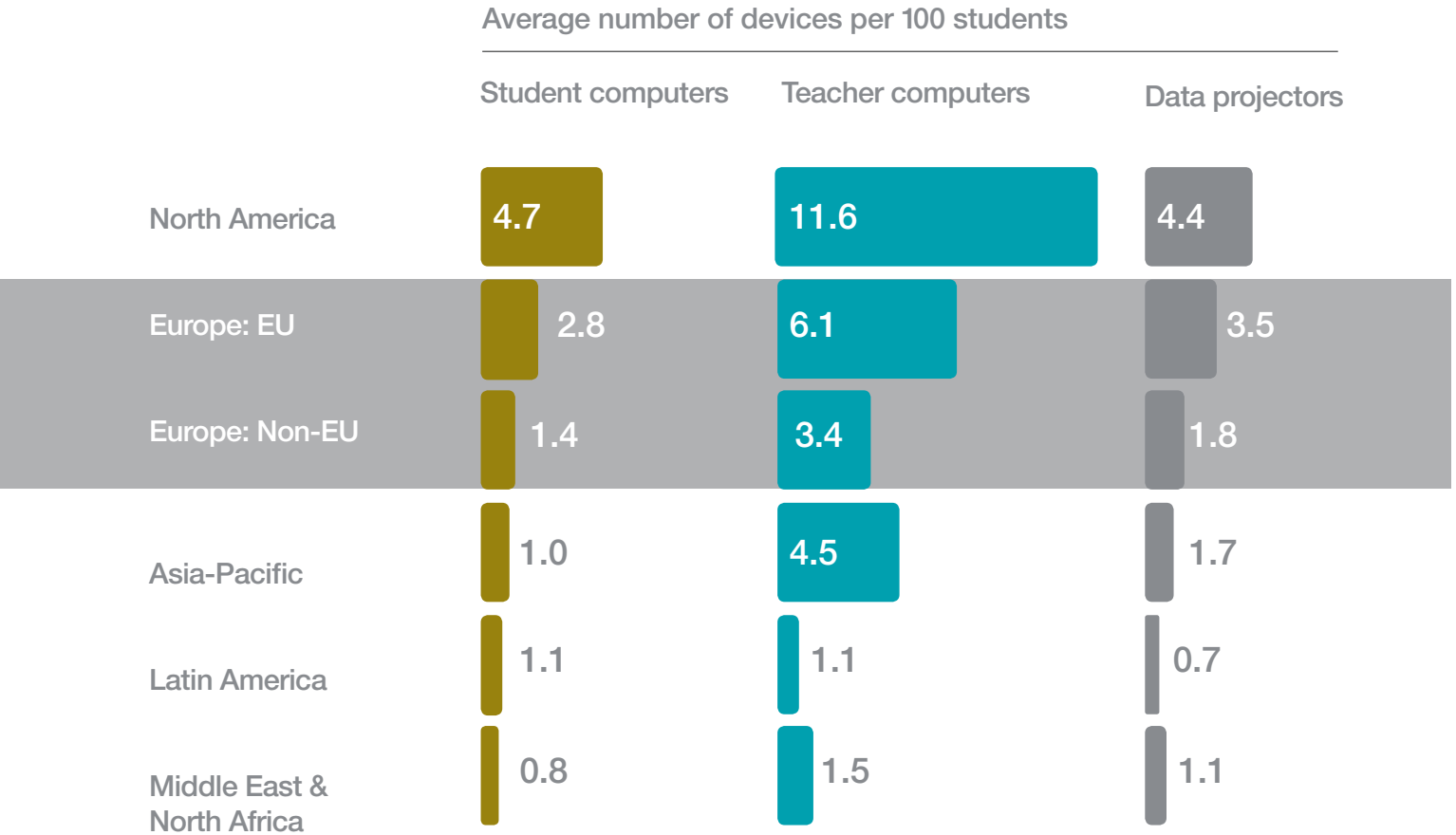
### ICT at school.

PISA data enables us to understand both the penetration of ICT devices in European schools, and the impact of those devices on student outcomes. Penetration of ICT is significantly lower than in North America but still among the highest globally. EU countries on average have 2.8 student computers, 6.1 teacher computers, and 3.5 data projectors per 100 students (Exhibit 22). Non-EU countries have about half the prevalence as the EU but more than Latin America or the Middle East and North Africa.

The impact of these devices on student performance is mixed. Regardless of the type of school or student, we found that ICT



**EXHIBIT 22:** PENETRATION OF ICT IN EUROPE LAGS NORTH AMERICA, BUT IS HIGHER THAN IN MOST OTHER REGIONS.



SOURCE: OECD PISA 2015, McKinsey analysis

... 8 ~~~~~>

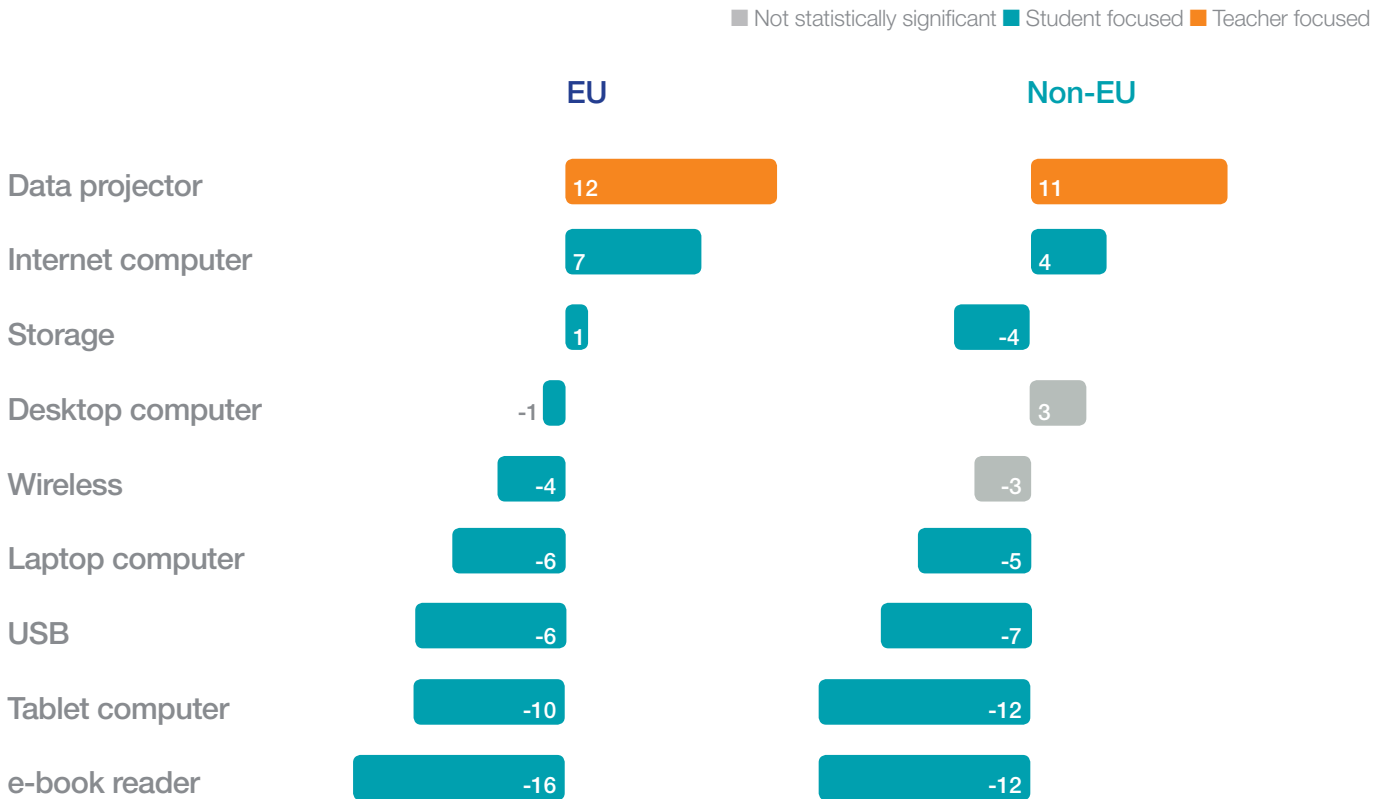
$$\det \left| (E_i^{(2)} - E) \delta_{ij} + V_{ij} \right| = 0; \quad i, j = 1, 2$$

$$V_{12} \frac{1}{E^{(-)} - H_2} V_{12}^+ \rightarrow V_{12}$$

## EXHIBIT 23: TECHNOLOGY DIRECTED TO TEACHERS IS THE MOST EFFECTIVE AT IMPROVING LEARNING.

### Impact of student use of specific technologies at school

Europe percent change in PISA science score when technology is used in school<sup>1</sup>



<sup>1</sup> Statistically significant in regression controlling for student socioeconomic status, school type, and school location, except for non-EU desktop and wireless. Interactive whiteboard not shown, as there was no significant result in non-EU; a descriptively small positive impact in EU, and a small statistically significant negative impact in regression.

SOURCE: OECD PISA 2015, McKinsey analysis

deployed to teachers and in support of teaching is more beneficial than ICT provided directly to students. For example, based upon the PISA principal survey in non-EU countries, adding one teacher computer per classroom leads to a nine-point increase in PISA science scores (controlling for student socioeconomic status, school type, and location). By contrast, adding one student computer per classroom has little to no effect.

The student survey reinforced these results (Exhibit 23). The greatest positive impact comes from using a data projector in the classroom. Internet-connected desktop computers (usually found in computer labs) do appear to be improving student outcomes. But the use of some student-based technologies, such as laptops, tablets, and e-book readers, as currently deployed, actually seem to hurt learning.



Given the evidence of the negligible or even negative impact of much 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 long-term potential. First, the results tell us only about hardware, not software or specific interventions like well-executed personalized learning. Second, education technology is evolving rapidly, and it is possible that specific interventions, including software and implementation strategies, can raise achievement at the system level.

Nevertheless, European school-system leaders should be careful not to assume that all technology is beneficial or even neutral to student achievement. They should be especially cautious with mobile devices, such as laptops and tablets, to ensure that these are integrated with instruction and that teachers are supported to use them well □





# Conclusion

Our research has mapped some areas previously blank and also identified new territories worthy of further exploration. For each of the three findings, there is a clear need for additional research.

Within mindsets, the priority is to determine what system-level 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 combine teacher-directed and inquiry-based teaching effectively. 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.

With its emphasis on data and analysis, this research aims to help European 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 three findings outlined here, combined with the conclusions of our 2010 report on the world's most improved school systems, provide useful insights to guide European policy makers as they make their way to their ultimate destination—improving the education and thus the lives of the region's students ■

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# 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
Non-EU	35	21	29	13	3
EU	18	20	28	20	14
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.	<input type="checkbox"/> _1	<input type="checkbox"/> _2	<input type="checkbox"/> _3	<input type="checkbox"/> _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.	<input type="checkbox"/> _1	<input type="checkbox"/> _2	<input type="checkbox"/> _3	<input type="checkbox"/> _4
ST121Q03NA	<NAME 3> wants to get top grades at school and continues working on tasks until everything is perfect. <Name 3> is motivated.	<input type="checkbox"/> _1	<input type="checkbox"/> _2	<input type="checkbox"/> _3	<input type="checkbox"/> _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.	<input type="checkbox"/> _1	<input type="checkbox"/> _2	<input type="checkbox"/> _3	<input type="checkbox"/> _4
ST034Q02TA	I make friends easily at school.	<input type="checkbox"/> _1	<input type="checkbox"/> _2	<input type="checkbox"/> _3	<input type="checkbox"/> _4
ST034Q03TA	I feel like I belong at school.	<input type="checkbox"/> _1	<input type="checkbox"/> _2	<input type="checkbox"/> _3	<input type="checkbox"/> _4
ST034Q04TA	I feel awkward and out of place in my school.	<input type="checkbox"/> _1	<input type="checkbox"/> _2	<input type="checkbox"/> _3	<input type="checkbox"/> _4
ST034Q05TA	Other students seem to like me.	<input type="checkbox"/> _1	<input type="checkbox"/> _2	<input type="checkbox"/> _3	<input type="checkbox"/> _4
ST034Q06TA	I feel lonely at school.	<input type="checkbox"/> _1	<input type="checkbox"/> _2	<input type="checkbox"/> _3	<input type="checkbox"/> _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.	<input type="checkbox"/> _1	<input type="checkbox"/> _2	<input type="checkbox"/> _3	<input type="checkbox"/> _4
ST119Q02NA	I want to be able to select from among the best opportunities available when I graduate.	<input type="checkbox"/> _1	<input type="checkbox"/> _2	<input type="checkbox"/> _3	<input type="checkbox"/> _4
ST119Q03NA	I want to be the best, whatever I do.	<input type="checkbox"/> _1	<input type="checkbox"/> _2	<input type="checkbox"/> _3	<input type="checkbox"/> _4
ST119Q04NA	I see myself as an ambitious person.	<input type="checkbox"/> _1	<input type="checkbox"/> _2	<input type="checkbox"/> _3	<input type="checkbox"/> _4
ST119Q05NA	I want to be one of the best students in my class.	<input type="checkbox"/> _1	<input type="checkbox"/> _2	<input type="checkbox"/> _3	<input type="checkbox"/> _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.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
ST118Q02NA	I worry that I will get poor <grades> at school.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
ST118Q03NA	Even if I am well prepared for a test I feel very anxious.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
ST118Q04NA	I get very tense when I study for a test.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
ST118Q05NA	I get nervous when I don't know how to solve a task at school.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

## 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.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
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.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
ST113Q03TA	Studying my <school science> subject(s) is worthwhile for me because what I learn will improve my career prospects.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
ST113Q04TA	Many things I learn in my <school science> subject(s) will help me to get a job.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

## 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	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
(b)	Whether or not I do well in maths is up to me	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
(c)	If I wanted to, I could do well in mathematics	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
(d)	I do badly in mathematics whether or not I study for my exams	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

## 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 available assessments like PISA, TIMSS, TERCE, or local tests. We normalized the data, creating new units that are equivalent to 2000 PISA scores, and then broke down the results into five categories: poor, fair, good, great, and excellent. For more detail, see the analytical appendix, as well as Michael Barber, Chinezi Chijioke, and Mona Mourshed, "How the world's most improved school systems keep getting better," November 2010, McKinsey.com. <<http://www.mckinsey.com/industries/social-sector/our-insights/how-the-worlds-most-improved-school-systems-keep-getting-better>>
- 2 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.
- 3 Argentina, Kazakhstan, and Malaysia were excluded from the PISA 2015 report but are included in our analyses. The PISA 2015 sample for Malaysia did not meet PISA response-rate standards, the PISA 2015 sample from Argentina did not cover the full target population, and the results from Kazakhstan are based only on multiple-choice items. Because our report analyzes achievement drivers at the student level based on examining individual items, and reports are generated on a regional basis rather than comparing the performance of individual countries, we have included these countries in our analysis. Albania was excluded from our analysis, because the ways in which the data were captured made it impossible to match the data in the test with the data from the student questionnaire. As our report is entirely based on the drivers from the student questionnaire, we could not include Albania.
- 4 This section discusses absolute changes in PISA scores, rather than changes in rank or in scores relative to other countries.
- 5 Duckworth, Angela (2016) *Grit: The Power of Passion and Perseverance*.
- 6 Dweck, Carol (2006) *Mindset: The New Psychology of Success*; and Claro, S., Paunesku, D., & Dweck, C. S. (2016). "Growth mind-set tempers the effects of poverty on academic achievement." *Proceedings of the National Academy of Sciences*, 113(31), 8664-8668. doi:10.1073/pnas.1608207113
- 7 Credé, M., Tynan, M. C., & Harms, P. D. (2016). "Much Ado About Grit: A Meta-Analytic Synthesis of the Grit Literature." *Journal of Personality and Social Psychology*. doi:10.1037/pspp0000102 and Education Endowment Foundation (2013) *The impact of noncognitive skills on outcomes for young people*: [https://educationendowmentfoundation.org.uk/public/files/Publications/EEF\\_Lit\\_Review\\_Non-CognitiveSkills.pdf](https://educationendowmentfoundation.org.uk/public/files/Publications/EEF_Lit_Review_Non-CognitiveSkills.pdf).
- 8 Each category was composed of several sub-variables. For example, the category home environment was composed of variables for parent education and occupation, possessions, and language spoken at home; student behaviors consisted of skipping school, activities before school, ICT use out of school; school factors were class size, school size, school resource level and funding, and school autonomy; and teacher factors were teacher qualifications, teacher professional development, and teaching practices.



- 9 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 colinearity across variables, we mitigated that problem by placing variables very likely to be colinear in the same category. We cannot control for colinearity between categories.
- 10 David Paunesku Gregory M. Walton, Carissa Romero, et al., "Mindset interventions are a scalable treatment for academic underachievement," *Psychological Science*, 2015, Volume 26, Number 6, pp. 784–93.
- 11 "Meta-cognition and self-regulation," Teaching and Learning Toolkit, Education Endowment Foundation, August 2017, [educationendowmentfoundation.org.uk](https://educationendowmentfoundation.org.uk). <[https://educationendowmentfoundation.org.uk/pdf/generate/?u=https://educationendowmentfoundation.org.uk/pdf/toolkit/?id=138&t=Teaching% percent20and% percent20Learning% percent20Toolkit&e=138&s=>](https://educationendowmentfoundation.org.uk/pdf/generate/?u=https://educationendowmentfoundation.org.uk/pdf/toolkit/?id=138&t=Teaching%20and%20Learning%20Toolkit&e=138&s=>)>
- 12 More than 240 thousand new computers purchased in schools as part of the project to modernize general education in 2012 Russia News: <http://xn--80abucjiibhv9a.xn--plai/special/news/2979>.
- 13 To learn more, see Emilie Blanchard, "Les tablettes à l'école: Où en est-on?", *Les Echos*, May 5, 2017, [lesechos.fr](https://www.lesechos.fr). <<https://www.lesechos.fr/idees-debats/cercle/cercle-169705-les-tablettes-a-lecole-ou-en-est-on-2084818.php#wqL6hKkCSRQbQfrK.99>> <<https://www.lesechos.fr/idees-debats/cercle/cercle-169705-les-tablettes-a-lecole-ou-en-est-on-2084818.php>>
- 14 "Germany to spend 5 billion euros on digital infrastructure for schools," Reuters, October 12, 2016, [reuters.com](http://reuters.com). <<http://in.reuters.com/article/germany-education/germany-to-spend-5-billion-euros-on-digital-infrastructure-for-schools-idINKCN12C1AO>>
- 15 Anja Balanskat and Katja Engelhardt, Computing our future: Computer programming and coding—priorities, school curricula and initiatives across Europe, European Schoolnet, October 2014, [europeanschoolnet.org](http://europeanschoolnet.org).
- 16 Organisation for Economic Co-operation and Development, *Students, Computers and Learning: Making the Connection*, Paris: OECD Publishing, 2015, doi:<http://dx.doi.org/10.1787/9789264239555-en>.
- 17 Note that PISA is silent on the impact of technology on younger children; other literature does suggest limiting use for infants and toddlers, due to negative impact on sleep, body mass index, and cognitive, language, and emotional processing, coupled with limited positive benefits.

- 18 See, for example, Paul A. Kirschner and Aryn C. Karpinski, "Facebook and academic performance," *Computers in Human Behavior*, 2010, Volume 26, Number 6, digitalcommons.kent.edu <<http://digitalcommons.kent.edu/flapubs/72/>>; Jeffrey Mingle and Musah Adams, "Social media network participation and academic performance in senior high schools in Ghana," *Library Philosophy and Practice*, 2015, digitalcommons.unl.edu <<http://digitalcommons.unl.edu/cgi/viewcontent.cgi?article=3446&context=libphilprac>>; 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*, 2012, Volume 10, pp. 96–105, doi:10.4018/jdet.2012100108 <[https://www.researchgate.net/publication/262156457\\_The\\_Effects\\_of\\_Online\\_Interactive\\_Games\\_on\\_High\\_School\\_Students'\\_Achievement\\_and\\_Motivation\\_in\\_History\\_Learning](https://www.researchgate.net/publication/262156457_The_Effects_of_Online_Interactive_Games_on_High_School_Students'_Achievement_and_Motivation_in_History_Learning)>; 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*, 2011, Paper 62, surface.syr.edu <[http://surface.syr.edu/cgi/viewcontent.cgi?article=1061&context=cfs\\_etd](http://surface.syr.edu/cgi/viewcontent.cgi?article=1061&context=cfs_etd)>; 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, doi:10.1007/s11423-012-9274-1 <<http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.902.5638&rep=rep1&type=pdf>>; Alberto Posso, "Internet usage and educational outcomes among 15-year-old Australian students," *International Journal of Communication*, 2016, Volume 10, pp. 3851–76, ijoc.org. <<http://ijoc.org/index.php/ijoc/article/view/5586/1742>

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