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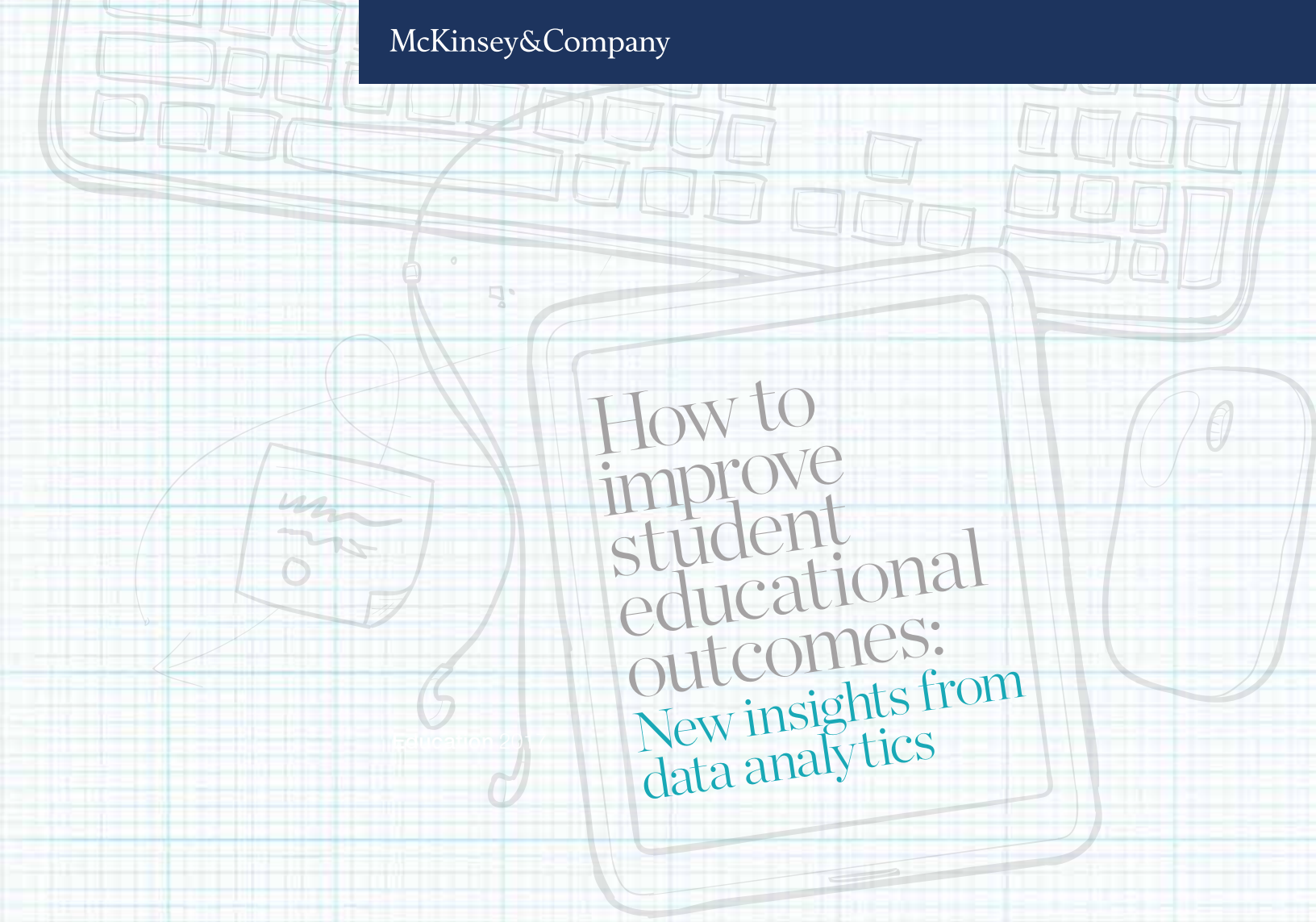

How to improve student educational outcomes:

New insights from data analytics

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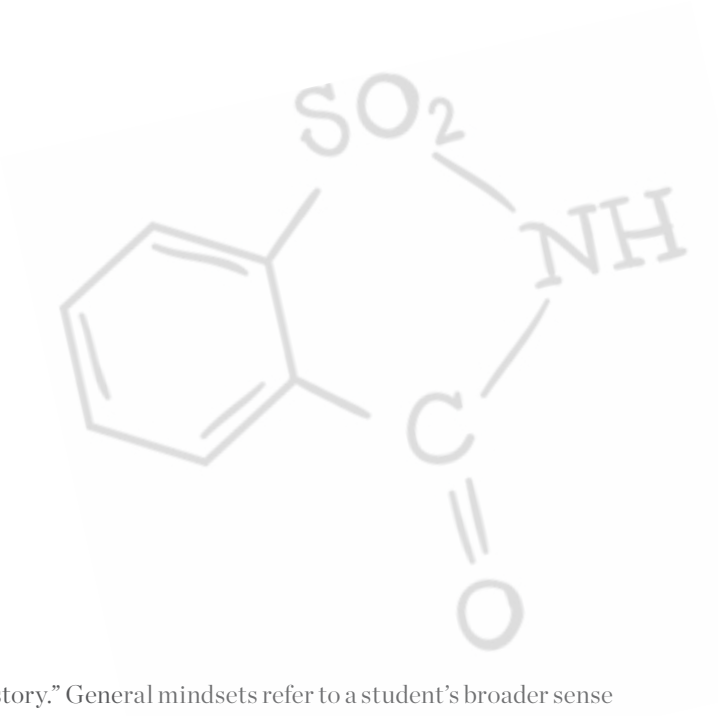
The success of societies depends, now more than ever, on the ability of young people to thrive amid relentless change. Policy makers, educators, and parents all over the world want students to understand and be able to apply their knowledge of mathematics, reading, and science. Yet improving educational outcomes has proved elusive. Some countries, states and municipalities have made great strides, but many continue to struggle. Educators continue to debate what matters and what works.

In this series of reports, we take a data-driven approach to consider a few of the most active debates: Do mindsets matter? If so, to what extent? What teaching practices work best? Does education technology help? Our data comes from the Program for International Student Assessment (PISA), administered by the Organisation for Economic Co-operation and Development (OECD). Since 2000, the OECD has regularly tested 15-year-olds around the world on mathematics, reading, and science. The most recent assessment in 2015 covered more than half a million students across 72 countries. This assessment concentrated on science outcomes—which are therefore also the focus of our analysis. What makes PISA so powerful is that it goes beyond the numbers, asking students, principals, teachers, and parents a series of questions about their attitudes, behaviors, and resources.

We applied machine learning and advanced analytics to identify factors that play a critical role in student achievement. We will be publishing five regional reports to share these findings: on Asia–Pacific; Europe; Latin America; the Middle East and North Africa (MENA); and North America. Here we summarize the two findings that were consistent across all five regions:

- Student mindsets, such as motivation and self-belief, have greater impact on student performance than any other factor—and double the effect of socioeconomic background.

- The students with the best outcomes receive teacher-directed instruction in most or all classes, together with inquiry-based teaching in some classes □



Finding 1: Students' mindsets matter much more than their socioeconomic background

It is hardly news that students' attitudes and beliefs—what we term their "mindsets"—influence their academic performance. But how much? To answer that question, we used a machine learning and feature discovery tool to identify the 100 most predictive variables—out of more than 1,000—from the PISA survey. We then sorted these into five categories: home environment, school resources and leadership, teachers and teaching, student behaviors, and student mindsets[1].

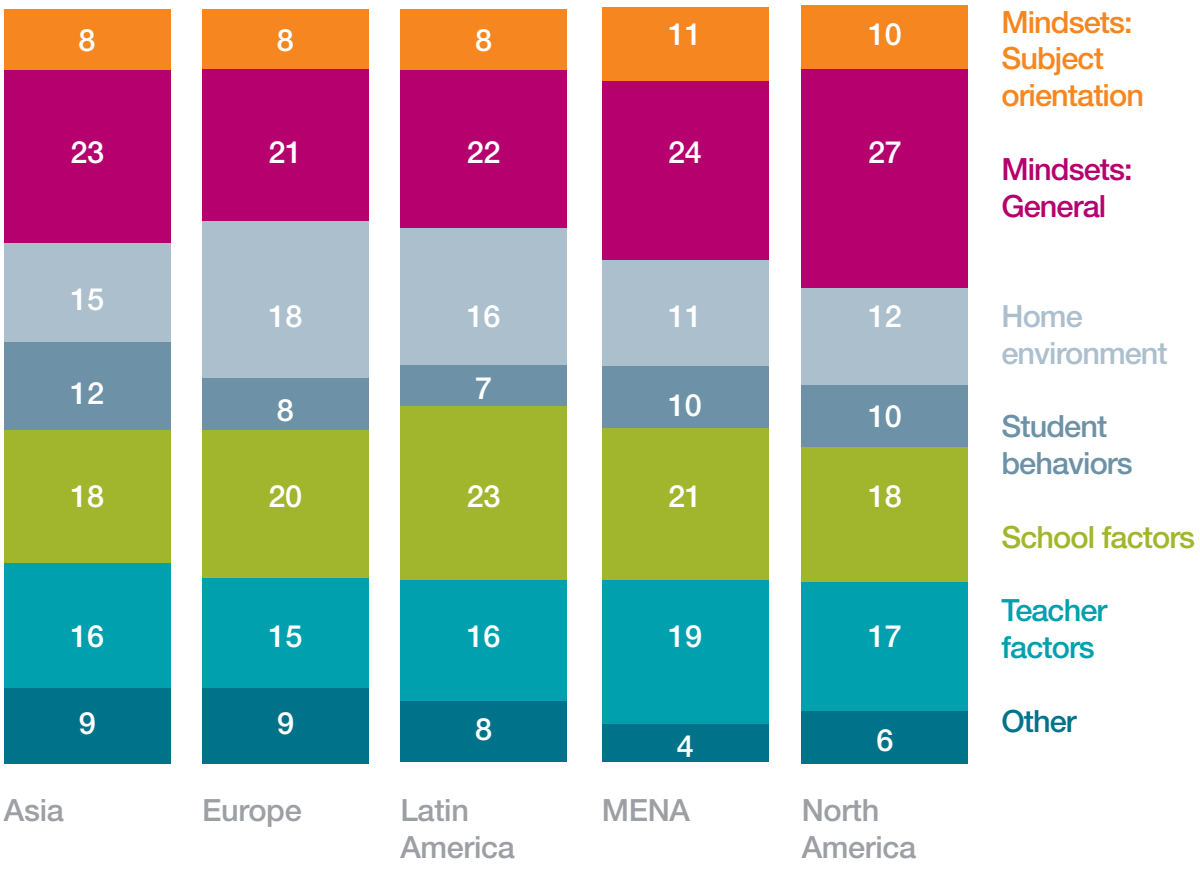
We separated mindsets into two types: "subject orientation" and "general mindsets." Subject orientation refers to students' attitudes about science as a discipline (because that was the focus of the 2015 PISA); it is measured by the degree to which they agree with statements such as "I have fun learning science" and "I am interested in the universe and its history." General mindsets refer to a student's broader sense of belonging, motivation, and expectations—as measured by their agreement with statements such as "I feel like I belong at school," "I see myself as an ambitious person," and "If I put in enough effort I can succeed."

We then determined how influential each category was in terms of predicting student performance. Our conclusion: after controlling for all other factors, student mindsets are twice as predictive of students' PISA scores than even their home environment (Exhibit 1). This finding and its magnitude are consistent across all five regions—which amplifies its importance.

Several mindsets emerged as highly predictive of performance in 2015. Top of the list was the ability to identify what motivation looks like in day-to-day life—including preparing for class, doing more than expected, and working to perfection. We call this "motivation calibration." Students who scored high in this mindset outperformed others by between 12 and 15 percent in PISA science tests, depending on their region. Students with high self-identified motivation ("wanting to be the best," and "wanting to get top grades") also scored higher than those without—but by a lower margin of between one and eight percent. Other mindsets that were predictive of performance in 2015 PISA included instrumental motivation (believing that school science will be useful for future career and life); a sense of belonging; and having low test anxiety. All of these mindsets had a statistically significant impact on score, even controlling for socioeconomic status, school type and location.

EXHIBIT 01: MINDSETS ECLIPSE EVEN HOME ENVIRONMENT IN PREDICTING STUDENT ACHIEVEMENT

Percent of predictive power by category of variable



Numbers may not sum to 100% due to rounding
Source: OECD PISA 2015, McKinsey analysis

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 9 to 17 percent, depending on their region.

It was particularly striking that several of the mindsets we analyzed made the most difference for students either in low-performing schools or in lower socioeconomic quartiles. For students in schools with low average test scores, a well-calibrated motivation mindset is equivalent to vaulting into a higher socioeconomic quartile. In low-performing schools, students in the lowest socioeconomic quartile who are well-calibrated perform better than those in the highest quartile who are poorly calibrated (Exhibit 2). This result was consistent across all regions.

EXHIBIT 02: HAVING A WELL-CALIBRATED MOTIVATION MINDSET IS EQUIVALENT TO LEAPFROGGING INTO A HIGHER SOCIOECONOMIC QUARTILE (NORTH AMERICAN EXAMPLE).

1 Schools with average PISA score of less than 480 (serving 37% of North American students). Statistically significant controlling for socioeconomic status, school type and location
Source: OECD PISA 2015, McKinsey analysis

Mindsets, of course, are not everything. They cannot compensate for all economic and social disparities; in general, being richer rather than poorer remains a great educational advantage. But the PISA evidence shows that mindsets matter a great deal, particularly for those living in the most challenging circumstances.

So far, the academic research on this subject is both nascent and predominantly US-based. Considering its importance, establishing how mindsets can be shifted in a positive direction to improve student performance should be a priority globally □

Girls and science

Why don't more girls embrace careers in science, technology, engineering, and mathematics (STEM)? That is a question that educators, policy makers, and business leaders around the world are asking—and the PISA data can help answer.

Overall, there is not a meaningful achievement gap between girls and boys, who score similarly on the PISA science assessment. On average, boys score four PISA points (0.8 percent) higher, but girls outperform boys in science in 22 of the 72 countries where the PISA assessment was conducted. There are some more subtle differences however. For example, girls and boys have very different expectations about future careers in science. Boys are more than twice as likely as girls to expect to work as engineers, scientists or architects; and girls are more than three times as likely to work in health professions.[2]

Looking specifically at the predictive mindsets highlighted in this paper, we find that girls are slightly more likely than boys to have strong motivation calibration and to believe that their school science work will be useful in the future. But girls are also more likely to have high levels of test anxiety and are less likely to say they find a sense of joy in studying science. Our analysis suggests that girls' higher anxiety, in effect, cancels out their higher motivation calibration and goes on to affect the choices they make later in life. There are distinct regional differences. In MENA for example, girls have more positive mindsets on several dimensions, including various aspects of motivation as well as a sense of belonging and joy in science[3]. In North America, girls are much more likely to show schoolwork-and test-related anxiety than boys: while 45 percent of boys say they experience test-related anxiety, 69 percent of girls do. This is a bigger difference than in any other region.

Girls have the building blocks, in terms of academic outcomes and positive motivation mindsets, for STEM careers. If interventions were made to decrease their sense of anxiety and increase their enjoyment of science, the outcome might well be more female STEM professionals □

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

There are two dominant types of teaching practices. The first is "teacher-directed instruction," in which the teacher explains and demonstrates ideas, considers questions, and leads classroom discussions. The second is "inquiry-based teaching," in which students are given a more prominent role in their own learning—for example, by developing their own hypotheses and experiments.

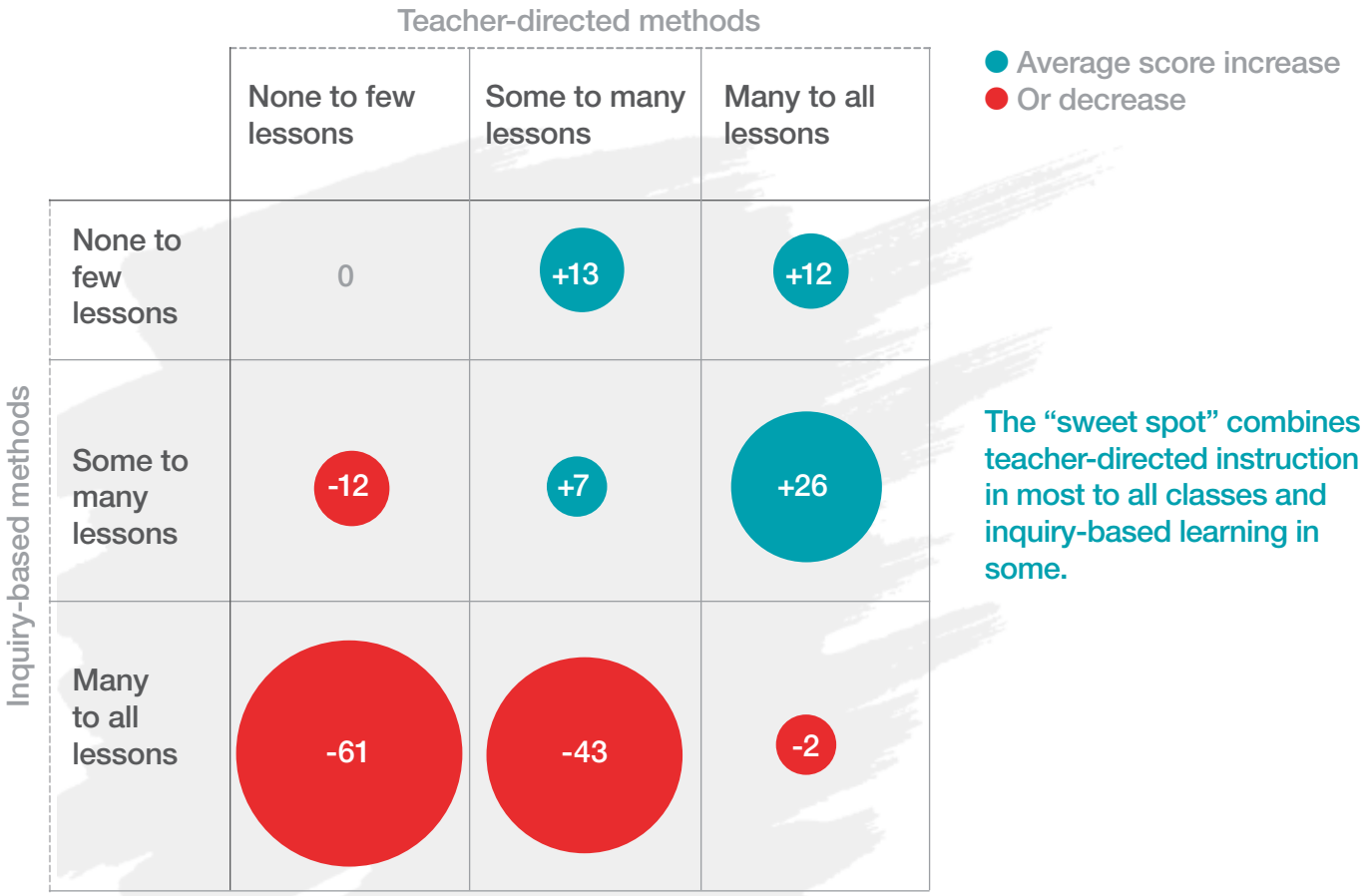
We analyzed the PISA results to understand the relative impact of each of these practices. In all five regions, scores were generally higher when teachers took the lead. The more inquiry-based teaching was used, however, the lower the average PISA scores were. At first glance that looks like a damning verdict on inquiry-based teaching. When we dig deeper into the data, however, a more interesting story is revealed: the best results are achieved when the two styles work together. The "sweet spot" is to use teacher-directed instruction in most or almost all lessons, and inquiry-based teaching in some lessons. This pattern holds true across all five regions.

Across all regions, high levels of inquiry-based teaching without a sufficient foundation of teacher-direction result in lower student outcomes. What differs across regions is the expected benefit from moving to the sweet spot from a purely teacher-directed approach with little inquiry-based teaching. In developed school systems with strong performance on PISA overall, there is substantial benefit—for example, an increase of 14 PISA points in the European Union (Exhibit 3). In developing school systems with weaker performance the benefit is much smaller—just one PISA point in MENA and two points in Latin America.

The benefits of teacher-direction were also seen in our analysis on the role of information and communication technology (ICT) in the classroom. Here we found that deploying ICT to teachers, rather than to students, works best. For example, adding a data projector to a classroom in Latin America has 30 times the impact on student score as adding a student computer to that same classroom. Across all the regions that undertook the PISA student ICT survey,

EXHIBIT 03: STUDENTS WHO RECEIVE A BLEND OF TEACHER-DIRECTED AND INQUIRY-BASED INSTRUCTION HAVE THE BEST OUTCOMES (EUROPEAN UNION EXAMPLE)

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



1 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 all classes (–2), which was not significant at 95% confidence level.
Source: OECD PISA 2015, McKinsey analysis

providing students with e-book readers, tablet computers and laptops had a negative impact on test scores. These results evaluate only hardware, not software, and do not account for ongoing rapid evolution in technology. Even so, they support the finding that effective teacher direction is critical—both in technology and learning.

Given the strong support in educational circles for inquiry-based pedagogy, these results seem counterintuitive. We offer two hypotheses. First, students cannot progress to inquiry-based methods

without a strong foundation of knowledge, gained through teacher-directed learning. 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.

It is also important to note that some kinds of inquiry-based teaching appear better than others in improving student outcomes, and that different practices work best at different frequencies. In almost all regions, explaining how a science idea can be applied has a positive impact on scores when done in some, most or even all lessons (between 20 and 30 PISA points for most lessons across regions). In developed regions, having students spend time in the laboratory doing practical experiments and drawing conclusions from these experiments has an important positive impact when done in some lessons (30 PISA points in North America and Oceania, for example). But this has a negative impact when done too often, likely due to crowding out of other activities.

In developing regions, however, these laboratory-based practicums have either no significant impact or a small negative one. We hypothesize that this is likely because developing regions may lack the equipment and teaching supervision to benefit from these practices. These school systems may be better off initially focusing on consistent quality teacher-directed instruction supported by lesson plans and teacher coaching. With that in place, systems can introduce targeted inquiry-based teaching, helping students to excel by giving them the experience of conducting and drawing conclusions from experiments.

School systems need to tread carefully in selecting inquiry-based teaching practices, however. Our analysis shows that there is a set of practices that have a negative impact on average student scores across almost all regions—even when applied in only some lessons. These practices include 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.

We should emphasize that inquiry-based practices may bring benefits beyond improving student scores. Experiencing inquiry-based teaching increases students' joy in science significantly more than teacher-directed learning does (although it is important to note that teacher-directed

instruction also has a positive correlation with more joy in science, just not as strong an impact). This matters because passion for a topic is linked to increased perseverance in studying. Inquiry-based teaching has a similar positive impact on students' belief that science is worthwhile for their future careers.

Overall, our analysis suggests that systems should aim to balance inquiry-based methods with sufficient teacher-directed instruction to ensure that teachers are able to explain scientific concepts clearly, and that students have sufficient content mastery to fully benefit from inquiry-based teaching. In school systems whose outcomes are currently poor, an even more directive approach may be appropriate as they drive improvement.

Previous McKinsey research pinpointed what school systems need to do to progress from one performance level to the next—from poor to fair, from fair to good, from good to great, and from great to excellent.[4] Our newest findings deepen those insights, highlighting the pedagogical choices that can best improve student outcomes—and shedding new light on the impact of mindsets on those outcomes.

Even a survey as large and rigorous as the PISA assessment provides only some of the answers. Nevertheless, we believe that our findings provide useful insights to guide policy makers as they pursue their ultimate goal—improving the education and thus the lives of students all over the world ■

1 Each category was composed of several sub-variables. For example, home environment included parent education and occupation, home and cultural possessions, language at home, and immigration status. Student behaviors included skipping school, activities before school, and ICT use out of school. School factors included class size, school size, school resource level and funding, and school autonomy. Teacher factors included teacher qualifications, teacher professional development, and teaching practices.

2 OECD PISA (2015). EXCELLENCE AND EQUITY IN EDUCATION. VOLUME I; PISA results in focus #69: What kind of careers in science do 15-year-old boys and girls expect for themselves?

3 In MENA, girls had higher levels of several positive mindsets. Motivation calibration: 58% of girls vs 44% of boys were well calibrated. Self-identified motivation: 79% of girls and 69% of boys had high self-identified motivation. Instrumental motivation: 36% of girls and 29% of boys had high instrumental motivation. Sense of belonging: 42% of girls and 38% of boys had a strong sense of belonging. Joy in science: 68% of girls and 63% of boys had high joy in science

4 See How the world's most improved school systems keep getting better, McKinsey & Company, 2010