Equations and Inequalities: Making Mathematics Accessible to All

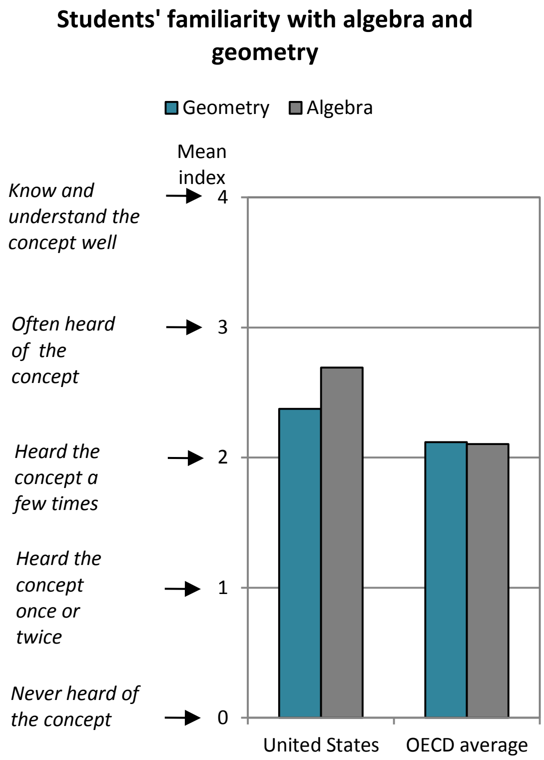
Country note United States

Numeracy skills are used daily in many jobs, and proficiency in numeracy is important for a wide range of outcomes in adult life, from employment to health and civic participation. In the United States, almost 30% of employees use algebra at work, and people with high numeracy skills are more than twice as likely to earn high wages as the average worker (Table 1.2). Proficiency in numeracy involves more than the ability to make simple calculations; people also need to be able to reason mathematically. Given the importance of mathematics reasoning in everything from preparing a meal to exploring space, mathematics curricula and teaching practices need to give all students the opportunity to develop higher-order thinking and reasoning skills.

Opportunity to learn (OTL) refers to the content taught in the classroom and the time a student spends learning this content. Not all students, not even those in the same school, have equal opportunities to learn. Opportunity to learn can be affected not only by the content of the curriculum and how that content is taught, but also by how students from different socio-economic backgrounds progress through the system, how well learning materials match students' skills, and how well teachers understand and manage the diverse learning needs of their students.

What opportunities to learn mathematics are offered to students in the United States?

- In 2012, on average, 15-year-old students in the United States spent 4 hours and 14 minutes per week in regular mathematics lessons at school (OECD average: 3 hours and 32 minutes), 33 minutes more per week than students spent on average in 2003 (OECD average: 13 minutes more).
- Students in the United States have heard of algebra concepts (such as exponential function, quadratic function and linear equation) and of geometry concepts (such as vector, polygon, congruent figure and cosine) more than a few times.
- Students in the United States perform relatively worse in PISA tasks requiring knowledge of the geometric concepts of space and shape, than their performance in mathematics overall.
- Students in the United States reported more frequent exposure at school to pure mathematics (linear and quadratic equations) than to applied mathematics tasks (such as working out from a train timetable how long it would take to get from one place to another).



Source: Figure 1.7

Contacts:

Andreas Schleicher
Advisor to the Secretary-General on Education Policy, Director for Education and Skills
Andreas.SCHLEICHER@oecd.org
Telephone: +33 1 45 24 93 66

Mario Piacentini
Analyst
Directorate for Education and Skills
Mario.PIACENTINI@oecd.org
Telephone: +33 1 45 24 17 76

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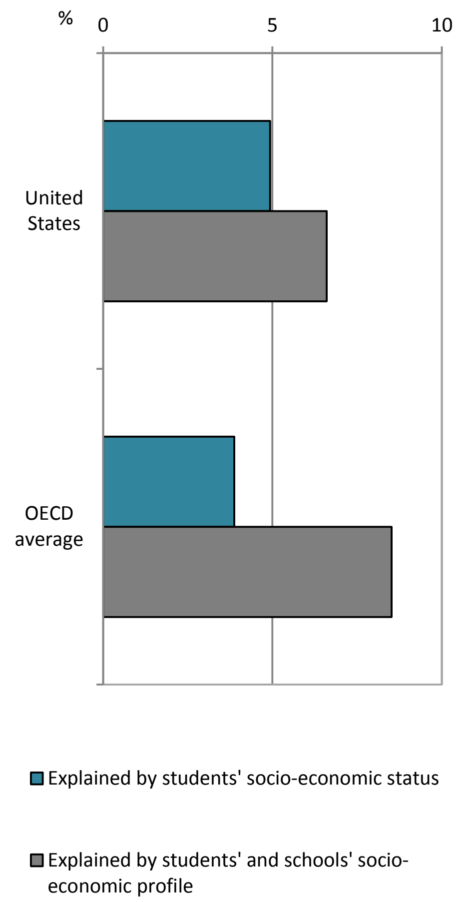
How does access to mathematics vary across students, schools and school systems?

Lack of access to mathematics content at school can leave young people socially and economically disadvantaged for life. Education systems that fail to provide the same learning opportunities to all students can end up reinforcing, rather than beginning to dismantle, the inequalities already present in society. How are opportunities to learn mathematics distributed in the United States?

Variation in familiarity with mathematics explained by students' and schools' socio-economic profile



Source: Figure 2.2

- 15-year-old girls in the United States are more familiar with mathematics concepts than boys of the same age, as on average across OECD countries. Immigrant students are as familiar with mathematics as students without an immigrant background (while on average across OECD countries, students without an immigrant background are more familiar with mathematics than immigrant students – Table 2.10).
- In the United States, around 7% of the variation in familiarity with mathematics is explained by students' socio-economic status and by the concentration of socio-economically disadvantaged students in certain schools (OECD average: 9%).
- The relationship between US students' socio-economic status and their familiarity with mathematics is stronger among students attending upper secondary school than among students attending lower secondary school, as is the case on average across OECD countries.
- In the United States about 94% of 15-year-old students attend schools that practice ability grouping for some or all mathematics classes. Across OECD countries, ability grouping has a weak negative association with the average student's familiarity with mathematics, and might reduce disadvantaged students' access to advanced mathematics.
- Over 70% of 15-year-old students in the United States attend schools that always consider residence for admission. On average across OECD countries, the higher the percentage of students enrolled in schools that consider residence for admission in a country, the weaker the relationship between socio-economic status and familiarity with mathematics. Admission requirements based on residence make school choice less dependent on families' socio-economic status, particularly so in the countries where residential segregation is not pervasive.
- In the United States, students in disadvantaged schools (that is, schools whose average socio-economic profile is lower than the country average) reported less exposure to problems that require thinking for an extended time, that have no immediate solution or that are presented in different contexts than students in advantaged schools (Table 2.25a).

What is the relationship between exposure to mathematics in school and performance in PISA?

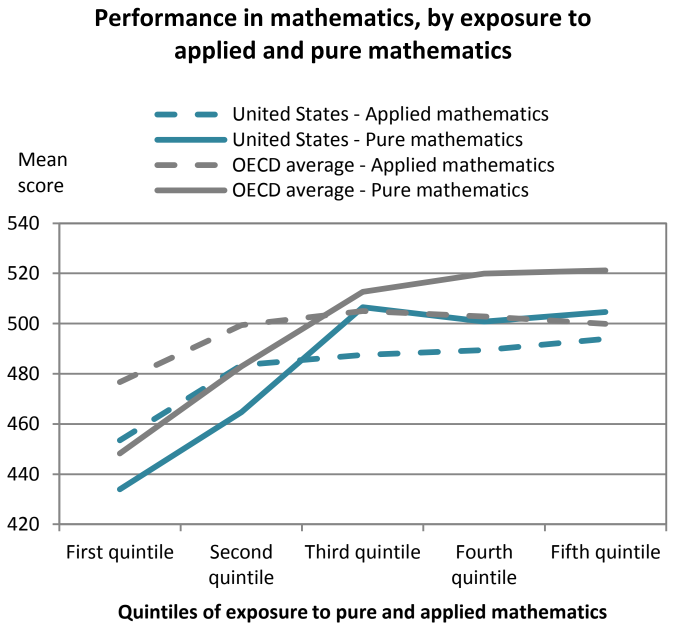
How is opportunity to learn mathematics related to students' performance in PISA? PISA challenges students to solve problems that might be encountered in real life and that do not necessarily look like the problems presented in mathematics classes at school. Even though PISA data cannot establish cause and effect, by analysing students'

exposure to mathematics and how those students perform on different PISA tasks, PISA can provide evidence of whether students can apply the mathematics they learn at school to novel problems.

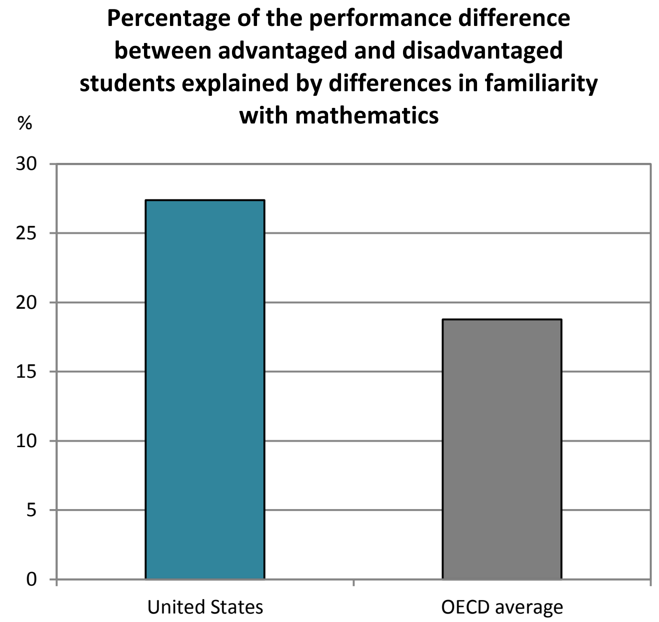
- In the United States, 15-year-old students who attend between 4 and 6 hours of mathematics instruction per week score the equivalent of two school years ahead of students who attend less than 2 hours of instruction (Table 3.4a). But after accounting for the fact that better-performing students may be sorted into schools and grades that provide longer instruction time in mathematics, an increase in instruction time has no statistically significant impact on performance .

- Exposure to pure mathematics (linear and quadratic equations) is more strongly related to higher performance than exposure to applied mathematics (such as calculating how much more expensive a computer would be after adding a tax), in the United States as on average across OECD countries (Table 3.4a). Even after accounting for the fact that better-performing students may attend schools that offer them more mathematics instruction, exposure to pure mathematics is related to higher performance, both in the United States and on average across OECD countries.

- In the United States, around 27% of the performance difference between socio-economically advantaged and disadvantaged students (that is, students in the top and bottom quarters of the distribution of socio-economic status) can be attributed to disadvantaged students' relative lack of familiarity with mathematics concepts (OECD average: 19%). After accounting for student and school characteristics (gender, migrant status, public/private ownership and selectivity of the school…), 31% of the performance difference is explained by familiarity with mathematics (OECD average: 16%).



Source: Figure 3.9



Source: Figure 3.15

How are opportunity to learn, students' attitudes towards mathematics and mathematics performance related?

If not everyone is born to become a mathematician, everyone needs to be able to reason mathematically. Positive feelings towards mathematics and the ability to solve mathematics problems are closely interconnected. That is why it is important to nurture positive attitudes towards mathematics among students of all ages.

- Some 37% of 15-year-old US students reported that they enjoy studying mathematics, and 51% are interested in the things they learn in mathematics (Table 4.1). These percentages have not changed since 2003 and are similar to the OECD average. Students in the United States have more confidence in their mathematics abilities and are less anxious towards mathematics than the average student in OECD countries.

- In the United States, greater exposure to complex mathematics concepts, as measured by the *index of familiarity with mathematics*, is associated with less self-confidence (lower self-concept) in mathematics and with more mathematics anxiety, after accounting for students' mathematics performance (Table 4.9). By contrast, greater exposure to contextualised mathematics problems is positively associated with students' self-confidence, after accounting for their performance in mathematics (Table 4.7c).

- In the United States, as on average across OECD countries, students who reported less familiarity with mathematics than the average student in their school have lower mathematics self-concept. The analysis suggests that the self-concept of these students is undermined by social comparisons with peers who have a greater familiarity with mathematics.

- Students in the United States whose parents do not like mathematics are 40% more likely to feel helpless when doing a mathematics problem than students whose parents like mathematics (Table 4.14b).

Giving all students similar opportunities to learn mathematics

How can all students be helped to understand mathematical ideas, compute fluently, engage in logical reasoning and communicate using mathematics? One way is to ensure that all students learn core mathematics concepts and learn how to solve challenging mathematics tasks at school.

A policy strategy centred on giving all students similar opportunities to learn mathematics can reduce the number of students who lack the knowledge and understanding of mathematics expected of 15-year-olds and could ultimately result in greater social mobility. A general strategy for the countries participating in PISA would include:

- **Developing coherent standards, frameworks and instruction material for all students**, to increase focus and connections between topics in the curriculum and to set the same expectations for all students.

- **Helping students acquire mathematical skills beyond content knowledge**, by supporting teachers in including problem solving in mathematics classes.

- **Reducing the impact of tracking and ability grouping on equity in exposure to mathematics**, by postponing the age at which students are first tracked, allowing students to change tracks and courses, and increasing the quantity and improving the quality of the mathematics taught in vocational tracks.

- **Addressing heterogeneity in the classroom**, by offering individualised support to struggling students and by providing pedagogical training to teachers on how to handle students with different abilities in the same class.

- **Promoting positive attitudes towards mathematics through innovations in the curriculum and teaching**, by creating and using engaging tasks and giving feedback to struggling students.

- **Monitoring and analysing opportunity to learn**, by collecting and analysing data on the mathematics content and the teaching methods to which students are exposed.

To learn more, see…

OECD (2016), *Equations and Inequalities: Making Mathematics Accessible to All*, PISA, OECD Publishing, Paris, http://dx.doi.org/10.1787/9789264258495-en