Equations and Inequalities: Making Mathematics Accessible to All

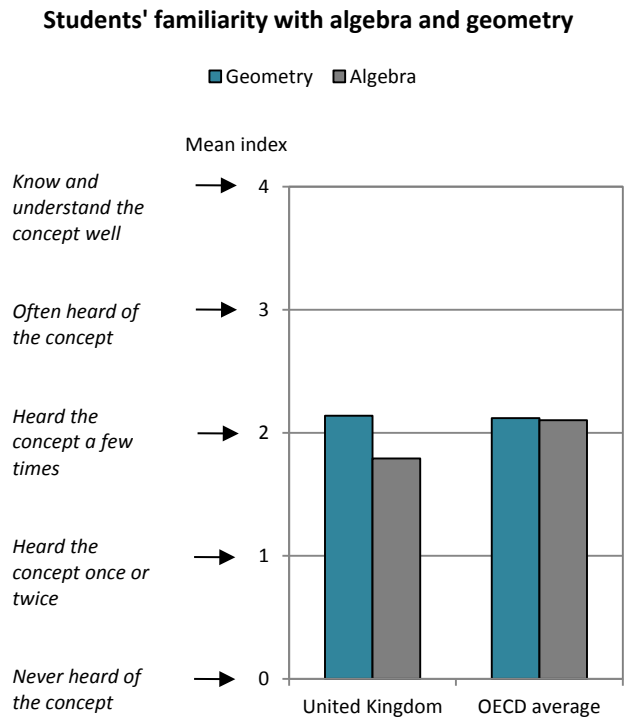
Country note United Kingdom

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 England and Northern Ireland (the only two UK nations to participate in the Survey of Adult Skills), more than 20% 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. 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 reported by students in the United Kingdom?

- By age 15, students in the United Kingdom have heard of algebra concepts (such as exponential function, quadratic function and linear equation) less frequently than the OECD average. They have heard of geometry concepts (such as vector, polygon, congruent figure and cosine) a few times, similar to the OECD average. For example, 38% of students reported they have never heard the concept of cosine (OECD average: 33%), and 32% reported they know well and understand the concept (OECD average: 34%). Overall familiarity with mathematics concepts is lower than the OECD average.
- Students in the United Kingdom reported exposure at school to pure mathematics (linear and quadratic equations) and to applied mathematics tasks (such as working out from a train timetable how long it would take to get from one place to another) as frequent as on average across OECD countries.



Source: Figure 1.7

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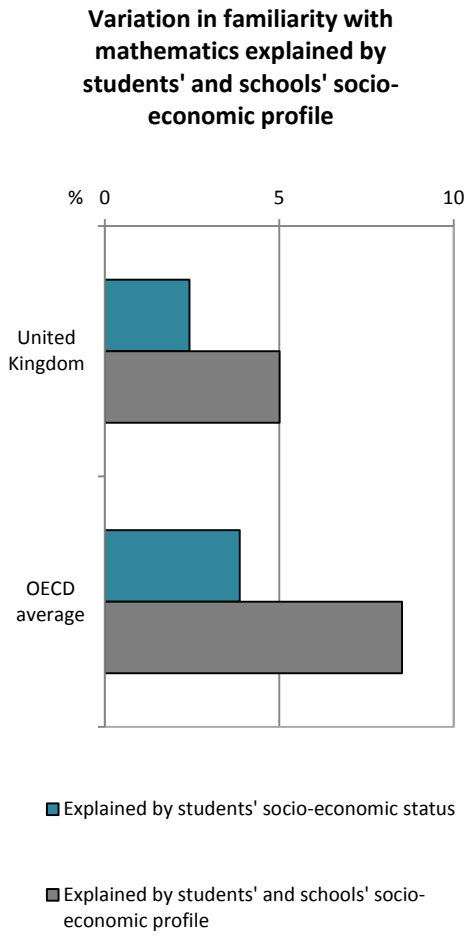
How does opportunity to learn mathematics vary across students, schools and school systems?

Lack of access to mathematics content at school can leave young people socially and economically disadvantaged for life. Education systems that provide inferior learning opportunities to disadvantaged 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 Kingdom?

In the United Kingdom, students' and schools' socio-economic profile is less strongly related to students' access to opportunities to learn mathematics than on average across OECD countries.



Source: Figure 2.2

- In the United Kingdom as on average across OECD countries, girls are more familiar with mathematics concepts than boys. 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).
- In the United Kingdom, 5% 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%). Some 68% of the students with tertiary-educated parents know well or have often heard the concept of linear equation, but only 47% of children of primary-educated parents reported so.
- Around 99% of students in the United Kingdom are in schools that practice ability grouping in some or all classes. This wide use of ability grouping might explain why few school principals reported that ability differences within classrooms hinder learning. Across OECD countries, ability grouping is not strongly associated with the average student's familiarity with mathematics.
- In the UK, most pupils are educated in general comprehensive schools until age 16 when different (academic and vocational) routes are available. On average across OECD countries, the younger the student at first tracking, the less equity in opportunity to learn mathematics in that country.
- Less than 30% of students in the United Kingdom attend schools where a student's academic performance and/or recommendations from feeder schools are always considered for admission. On average across OECD countries, the higher the percentage of students enrolled in selective schools in a country, the less equity in opportunity to learn mathematics in that country.

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

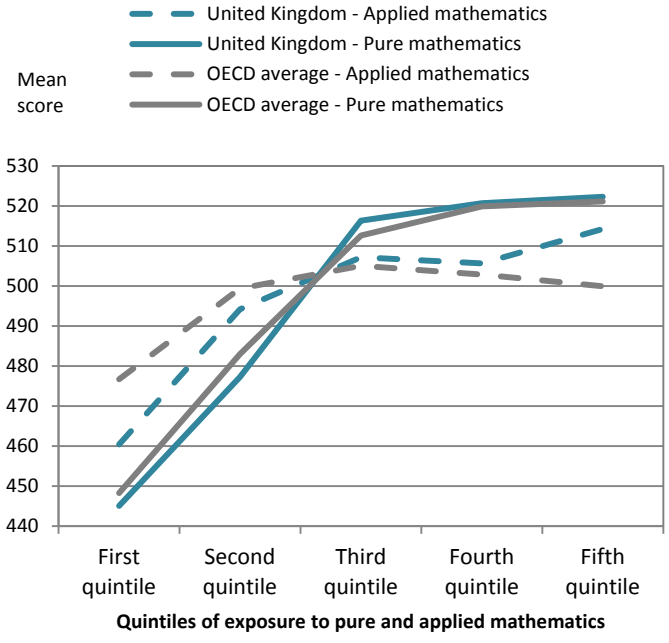
How is opportunity to learn mathematics related to students' performance in PISA? PISA challenges students to solve problems that might be encountered in real life and that do not necessarily look like the problems presented in mathematics classes at school. Even though PISA data cannot establish cause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

- In the United Kingdom, students who spend between 2 and 4 hours in mathematics classes per week perform better than students who spend less than 2 hours and those who spend more than 4 hours. After accounting for the fact that better-performing students may be sorted into schools and grades that provide longer instruction time in mathematics, the analysis shows that a linear increase in instruction time has no statistically significant impact on performance.

- In the United Kingdom, exposure to pure mathematics is more strongly related to higher performance than exposure to applied mathematics, as is the case on average across OECD countries. The relationship is particularly strong at low levels of exposure to pure mathematics. Even after accounting for the fact that better-performing students may attend schools that offer more mathematics instruction, exposure to pure mathematics is related to higher performance, both in the United Kingdom and on average across OECD countries.

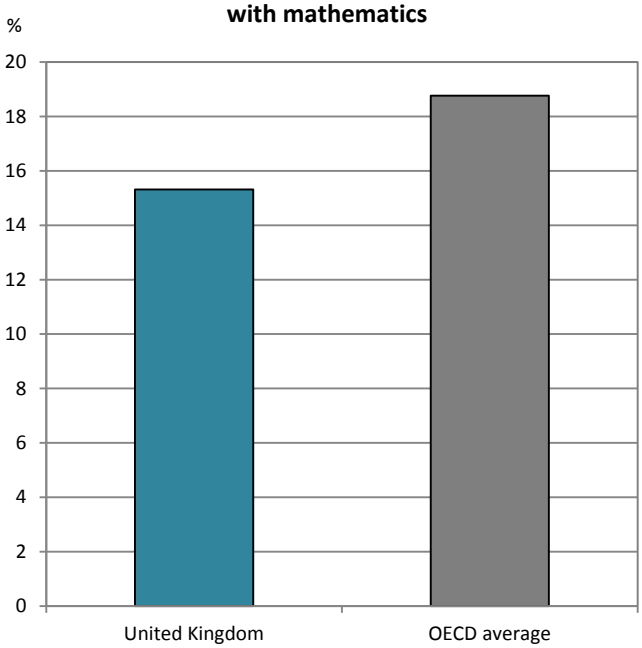
- In the United Kingdom, around 15% of the performance difference between socio-economically advantaged and disadvantaged students can be attributed to disadvantaged students' relative lack of familiarity with mathematics concepts (OECD average: 19%).

Performance in mathematics, by exposure to applied and pure mathematics



Source: Figure 3.9

Percentage of the performance difference between advantaged and disadvantaged students explained by differences in familiarity with mathematics



Source: Figure 3.15

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

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.

- In the United Kingdom, 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 more mathematics anxiety, after accounting for students' mathematics performance. By contrast, greater exposure to contextualised mathematics problems is positively associated with students' self-confidence, after accounting for their performance in mathematics.

- In the United Kingdom, 17% of students reported that they are more frequently exposed to pure mathematics problems in tests than in lessons. Students who are more frequently exposed to mathematics problems – including algebraic word problems, contextualised mathematic problems, procedural tasks, pure mathematics problems – more often during tests than during lessons feel more anxious than students of similar ability who are less or equally exposed to these problems in tests and in lessons.

- Students in the United Kingdom whose parents do not like mathematics are 43% more likely to feel helpless when doing a mathematics problem than students whose parents like mathematics.

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. The following policy suggestions are meant to be general and are not specific to any one country in particular.

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