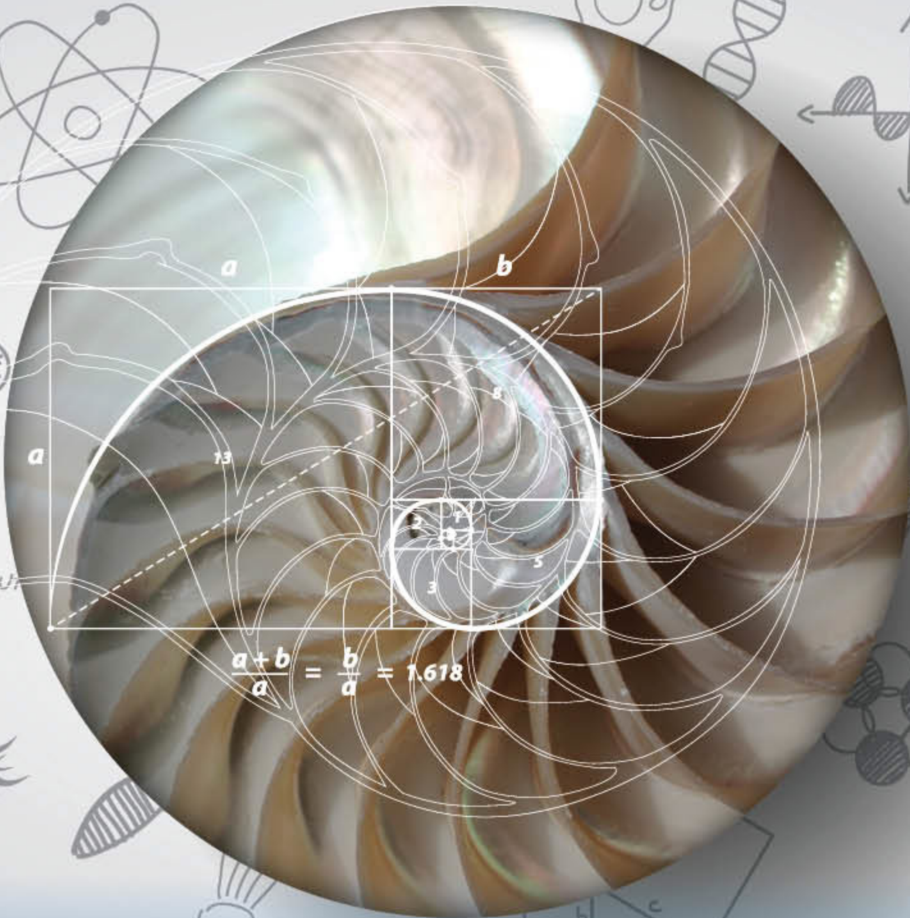
European Commission

Increasing achievement and motivation in mathematics and science learning in schools

Eurydice report



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CHAPTER 1: STUDENT ACHIEVEMENT IN MATHEMATICS AND SCIENCE

In our fast-changing and technology-driven societies, quality education and inclusion are essential to help establish a European Education Area by 2025 ([6]). The vision for quality in education includes the mastering of basic skills (in reading, mathematics and science), but also of transversal skills such as critical thinking, entrepreneurship, creativity and civic engagement. Mathematics and science education plays a crucial role in this regard, as these subject areas have great potential to equip young people with the necessary skills, knowledge and viewpoints to be responsible and active citizens who are able to think critically and creatively. As regards inclusive education, efforts should enable 'educational attainment and achievement to be decoupled from social, economic and cultural status' ([7]), thereby decreasing social inequalities, and should also challenge and dissolve gender stereotypes. An inclusive education system ensures 'a basic standard minimum education for all' (Field, Kuczera and Pont, 2007, p. 11).

There is a growing amount of evidence showing that the highest-performing education systems combine quality with equity (Checchi et al., 2014; European Commission, 2019; OECD, 2012; Parker et al., 2018). Consequently, 'education systems can pursue excellence and equity at the same time' (European Commission, 2019, p. 6). In order to reach this double goal of quality and inclusive education, the EU has set the following important objective: 'the share of low-achieving 15-year-olds in reading, mathematics and science should be less than 15%' ([8]). This objective is part of a set of targets the Commission proposes should be attained by 2030 within the framework of the European Education Area ([9]).

This chapter presents the main indicators of achievement levels in mathematics and science in European countries, focusing mainly on the percentage of low achievers according to the European Commission target. It builds on the extensive literature using the results of international assessment surveys such as the International Association for the Evaluation of Educational Achievement (IEA) Trends in International Mathematics and Science Study (TIMSS), and the Organisation for Economic Co-operation and Development (OECD) Programme for International Student Assessment (PISA).

After discussing the main data sources and their caveats, the chapter presents the percentage of low achievers among fourth graders – students in their fourth year of formal schooling – and among 15-year-old students. It then discusses quality and inclusion in European education systems, and the relationship between these education system characteristics and the percentage of low achievers. Finally, it examines some common determinants of success (or failure) in education, providing a snapshot of the percentage of low achievers by socioeconomic background and gender.

([6]) Commission communication – Achieving the European Education Area by 2025 (COM(2020) 625 final).
([7]) Commission communication – Achieving the European Education Area by 2025 (COM(2020) 625 final), p. 7.
([8]) Council Resolution on a strategic framework for European cooperation in education and training towards the European Education Area and beyond (2021–2030), OJ 2021/C 66/01.
([9]) Commission communication – Achieving the European Education Area by 2025 (COM(2020) 625 final), p. 27.

1.1. Main data sources and caveats

Relying on international assessment surveys has its advantages and disadvantages. Certainly, international assessment surveys can grasp only a fraction of educational outcomes. However, comparing education systems based on surveys that are designed to be comparable in terms of sampling design and content is the most reliable option for researchers. Given that international assessment surveys are conducted at regular intervals, they allow comparisons to be made not only across many countries but also over time.

Nevertheless, some issues related to the cross-national comparability of results might remain even after careful survey design, especially if social, cultural and economic differences between education systems are considerable (Schnepf, 2018). This can be true even for the measurement of skills, as students might not have the same attitudes towards performing well on tests in general and low-stakes tests – tests with little or no impact on students' grades or official results – in particular. In addition, international assessment surveys sample only students who are in school, leaving out those who have left education early. This affects education systems differently depending on the proportion of out-of-school children in the population (Schnepf, 2018). Keeping these caveats in mind, international assessment surveys are still the best available tools for computing comparable indicators related to achievement levels in education.

Given the utmost importance of early learning experiences in children's educational opportunities and trajectories at later educational stages (OECD, 2012, 2018), it is essential to start the analysis at the earliest available level in order to understand quality and inclusion in education. Therefore, this chapter presents indicators based on two surveys covering two important time points in a student's education: the fourth grade, which is typically part of primary education (through TIMSS) ([10]), and the age of 15 years (through PISA), when students are in lower or upper secondary education ([11]). These methodological differences have to be kept in mind when comparing performance data across surveys.

The TIMSS survey evaluates the mathematics and science performance of the same cohort of students ([12]). It is conducted every 4 years, with the latest available data being from 2019. Data are available for 29 European education systems participating in this report ([13]).

PISA measures 15-year-olds' ability to use their reading, mathematics and science knowledge and skills to meet real-life challenges ([14]). PISA was launched in 2000 and has been conducted every 3 years since then. The latest available PISA survey is from 2018, with data available for almost all the education systems participating in this report (the exception is Liechtenstein).

([10]) TIMSS assesses students in participating countries in their fourth year of formal schooling, provided the mean age at the time of testing is at least 9.5 years. Because education systems vary in structure and in policies and practices with regard to age of starting school and promotion and retention, there are differences across countries in how the target grades are labelled and in the average age of students. In addition, some countries choose to administer TIMSS to a different grade than the fourth year of formal schooling: Norway chose to assess fifth grade students to obtain better comparisons with Sweden and Finland; Turkey also chose to assess students in the fifth grade (see more at: https://timss2019.org/reports/about/).

([11]) The target population of the PISA surveys is an age-based population and not a grade-based population. This means that, depending on their structural features, education systems may differ in how 15-year-olds are distributed across different schools, pathways/tracks or grades. In participating countries, the majority of students may be enrolled at lower secondary level (ISCED level 2) or upper secondary level (ISCED level 3), or may be relatively evenly distributed across both levels (as in Czechia, Ireland, Luxembourg, Slovakia and Albania). See Table II.C.1 in OECD (2019b, pp. 365–366) for the list of dominant ISCED levels per country.

([12]) See the website of the IEA for more details (https://www.iea.nl/).

([13]) TIMSS 2019 data are not available for Belgium (French and German-speaking Communities), Estonia, Greece, Luxembourg, Romania, Slovenia, Switzerland, Iceland and Liechtenstein.

([14]) See the OECD website dedicated to PISA for more details (https://www.oecd.org/pisa/). This report focuses on achievement in mathematics and science.

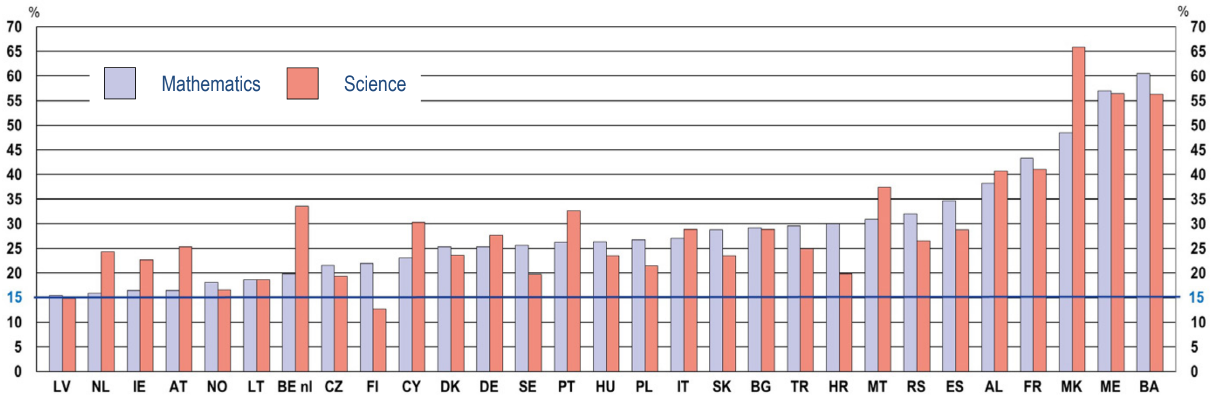
1.2. Percentage of low achievers

The European Commission target on low achievers provides a clear starting point for the discussion on quality and inclusive education in mathematics and science. As mentioned above, according to this target, the share of 15-year-olds who are low achievers in reading, mathematics and science should be less than 15%. In order to complete the picture on the percentage of low achievers among 15-year-olds in European countries, a similar share can be computed for fourth graders (i.e. primary school students) based on the TIMSS survey.

Low-achieving students in grade 4 are the ones who do not achieve the 'Intermediate International Benchmark'. In mathematics, this means that, although they might have some basic mathematical knowledge ([15]), they have difficulties applying their knowledge in simple situations or performing more complicated mathematical tasks such as computing with three- and four-digit whole numbers in a variety of situations, or reading, labelling and interpreting information in graphs and tables (Mullis et al., 2020, p. 36). In science, students who do not achieve the Intermediate International Benchmark show only a limited understanding of scientific concepts and have a limited knowledge of foundational science facts (Mullis et al., 2020, p. 107).

Figure 1.1 shows the percentage of low-achieving grade 4 students in mathematics and science in 29 European education systems. While the 15% European target concerns only 15-year-olds, this threshold is included in the figure for information (see blue line).

Figure 1.1: Percentage of low achievers in mathematics and science in the fourth grade, 2019



	LV	NL	IE	AT	NO	LT	BE nl	CZ	FI	CY	DK	DE	SE	PT	HU
Mathematics	15.5	15.9	16.4	16.5	18.1	18.6	19.9	21.6	22.0	23.1	25.3	25.4	25.6	26.2	26.4
Science	14.9	24.3	22.6	25.4	16.6	18.6	33.5	19.3	12.7	30.3	23.6	27.6	19.7	32.6	23.5
	PL	**IT**	**SK**	**BG**	**TR**	**HR**	**MT**	**RS**	**ES**	**AL**	**FR**	**MK**	**ME**	**BA**	
Mathematics	26.8	27.0	28.8	29.1	29.6	30.0	30.9	32.1	34.6	38.2	43.3	48.5	57.0	60.4	
Science	21.5	28.9	23.5	28.8	24.9	19.8	37.5	26.6	28.7	40.6	41.0	65.9	56.4	56.3	

Source: Eurydice, based on IEA, TIMSS 2019 database.

Explanatory notes

Education systems are depicted in ascending order based on the percentage of low achievers in mathematics.

The percentage of low-achieving students is defined as the percentage of students not achieving the Intermediate International Benchmark, which is set at a score of 475 points (for information on scoring, see the explanatory notes under Figure 1.3). Standard errors are available in Annex III.

([15]) 'They can add, subtract, multiply, and divide one- and two-digit whole numbers. They can solve simple word problems. They have some knowledge of simple fractions and common geometric shapes. Students can read and complete simple bar graphs and tables' (Mullis et al., 2020, p. 36).

As the figure depicts, in mathematics, the percentage of low achievers among fourth graders is above 15% in all education systems with available data. The percentages of low achievers are lowest in Latvia, the Netherlands, Ireland and Austria, followed by Norway, Lithuania and Belgium (Flemish Community). In these education systems, the percentage of students not achieving the Intermediate International Benchmark is below 20%. At the other end of the scale, the percentage of low achievers in mathematics is above 40% in France, North Macedonia, Montenegro, and Bosnia and Herzegovina. In Montenegro and Bosnia and Herzegovina, the majority of fourth graders (57% and over 60% respectively) are considered low achievers.

In science, the percentage of low achievers is below the 15% threshold only in Latvia (14.9%) and Finland (12.7%). Besides these two education systems, the percentage of low-achieving grade 4 students is below 20% in Norway, Lithuania, Czechia, Sweden and Croatia. The education systems registering the highest shares of low achievers are the same as in mathematics (France, North Macedonia, Montenegro, and Bosnia and Herzegovina), with the majority of students not achieving the Intermediate International Benchmark in North Macedonia, Montenegro, and Bosnia and Herzegovina (65.9%, 56.4% and 56.3% respectively).

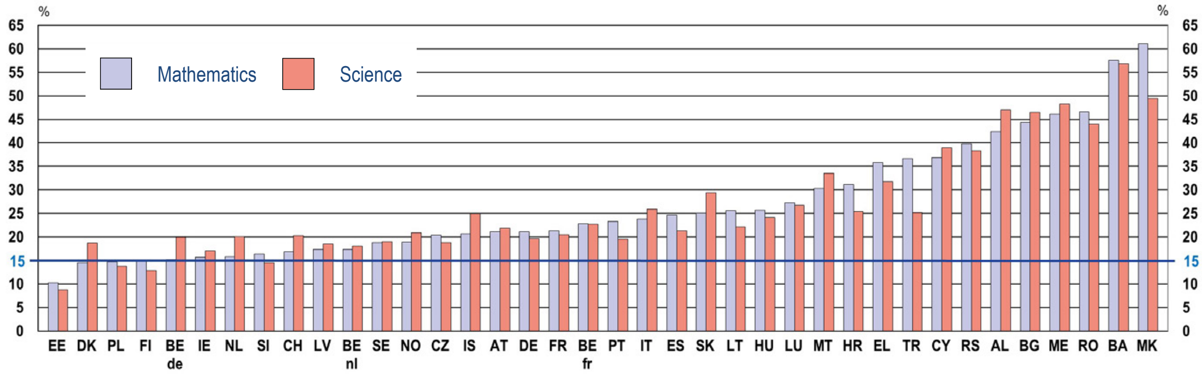
When it comes to 15-year-olds, the percentage of low achievers can be computed based on the PISA survey (Figure 1.2). The PISA survey examines 'how well students can extrapolate from what they have learned and apply their knowledge in unfamiliar settings, both in and outside of school' (OECD, 2019a, p. 26).

Low achievers with respect to the PISA survey are defined as students who do not reach 'level 2' proficiency. In mathematics, this means that these students can answer only those mathematics questions involving familiar contexts where all of the relevant information is present and the questions are clearly defined. They might be able to identify information and carry out routine procedures according to direct instructions, but can perform only those actions that are obvious and that immediately follow the given stimuli. However, interpreting and recognising situations poses problems for them, even if this requires no more than direct inference, extracting relevant information from a single source and making use of a single representational mode (such as a graph, table or equation) (OECD, 2019a, p. 105).

In science, students who do not achieve 'level 2' proficiency might be able to use basic or everyday content and procedural knowledge to recognise or identify explanations of simple scientific phenomena. However, they need support to undertake simple, structured scientific enquiries, and are able to identify only simple causal or correlational relationships and interpret only graphical and visual data that require a low level of cognitive demand (OECD, 2019a, p. 113).

In mathematics, as Figure 1.2 depicts, the percentage of low-achieving 15-year-olds is below the 15% target in only four education systems: those of Estonia (10.2%), Denmark (14.6%), Poland (14.7%) and Finland (15.0%). The percentages are lower than 20% in a further nine education systems. At the other end of the scale, the education systems with the highest percentages of low achievers (above 40%) are those of Albania, Bulgaria, Montenegro, Romania, Bosnia and Herzegovina, and North Macedonia. The majority of 15-year-old students are considered low achievers according to international standards in Bosnia and Herzegovina (57.6%) and North Macedonia (61.0%).

Figure 1.2: Percentage of low achievers among 15-year-old students in mathematics and science, 2018



	EE	DK	PL	FI	BE de	IE	NL	SI	CH	LV	BE nl	SE	NO	CZ	IS	AT	DE	FR	BE fr
Mathematics	10.2	14.6	14.7	15.0	15.1	15.7	15.8	16.4	16.8	17.3	17.3	18.8	18.9	20.4	20.7	21.1	21.1	21.3	22.8
Science	8.8	18.7	13.8	12.9	20.0	17.0	20.0	14.6	20.2	18.5	18.0	19.0	20.8	18.8	25.0	21.9	19.6	20.5	22.6
	PT	**IT**	**ES**	**SK**	**LT**	**HU**	**LU**	**MT**	**HR**	**EL**	**TR**	**CY**	**RS**	**AL**	**BG**	**ME**	**RO**	**BA**	**MK**
Mathematics	23.3	23.8	24.7	25.1	25.6	25.6	27.2	30.2	31.2	35.8	36.7	36.9	39.7	42.4	44.4	46.2	46.6	57.6	61.0
Science	19.6	25.9	21.3	29.3	22.2	24.1	26.8	33.5	25.4	31.7	25.2	39.0	38.3	47.0	46.5	48.2	43.9	56.8	49.5

Source: Eurydice, based on OECD, PISA 2018 database.

Explanatory notes

Education systems are depicted in ascending order based on the percentage of low achievers in mathematics.

The percentage of low-achieving students is defined as the percentage of students who score below the baseline level of proficiency (level 2) on the PISA mathematics and/or science scales. This corresponds to not achieving 420.07 points in mathematics, and 409.54 points in science (for information on scoring, see the explanatory notes under Figure 1.4). Standard errors are available in Annex III.

Similarly to mathematics, in science the percentage of low achievers among 15-year-olds is below 15% in four education systems: those of Estonia (8.8%), Finland (12.9%), Poland (13.8%) and Slovenia (14.6%). Estonia, Poland and Finland have therefore reached the European target in both subject areas. In nine education systems, the percentage of low achievers in science is between 15% and 20%. The education systems with a percentage of low achievers higher than 40% in science are the same as in the case of mathematics: those of Albania, Bulgaria, Montenegro, Romania, Bosnia and Herzegovina, and North Macedonia. The share in Bosnia and Herzegovina is above 50%.

As these comparisons illustrate, percentages of low achievers tend to correlate across subject areas ([16]). In other words, if an education system has a relatively high/low percentage of low achievers in one subject area, it tends to also have relatively high/low percentages of low achievers in other areas. Most education systems also tend to perform similarly across education levels (i.e. in primary and secondary education) ([17]). This suggests that certain education systems can tackle low achievement in general – across subjects and educational levels – better than others. So the question arises: what are the characteristics of education systems that have lower shares of low achievers? The next section starts this analysis by addressing quality and inclusion in education.

([16]) The Spearman correlation coefficient between percentages of low achievers in mathematics and science is 0.67 in TIMSS 2019 and 0.93 in PISA 2018, both significant at the 5% level.

([17]) The Spearman correlation coefficient between percentages of low achievers in primary and secondary education is 0.73 in mathematics and 0.61 in science, both significant at the 5% level.

1.3. Quality and inclusive education

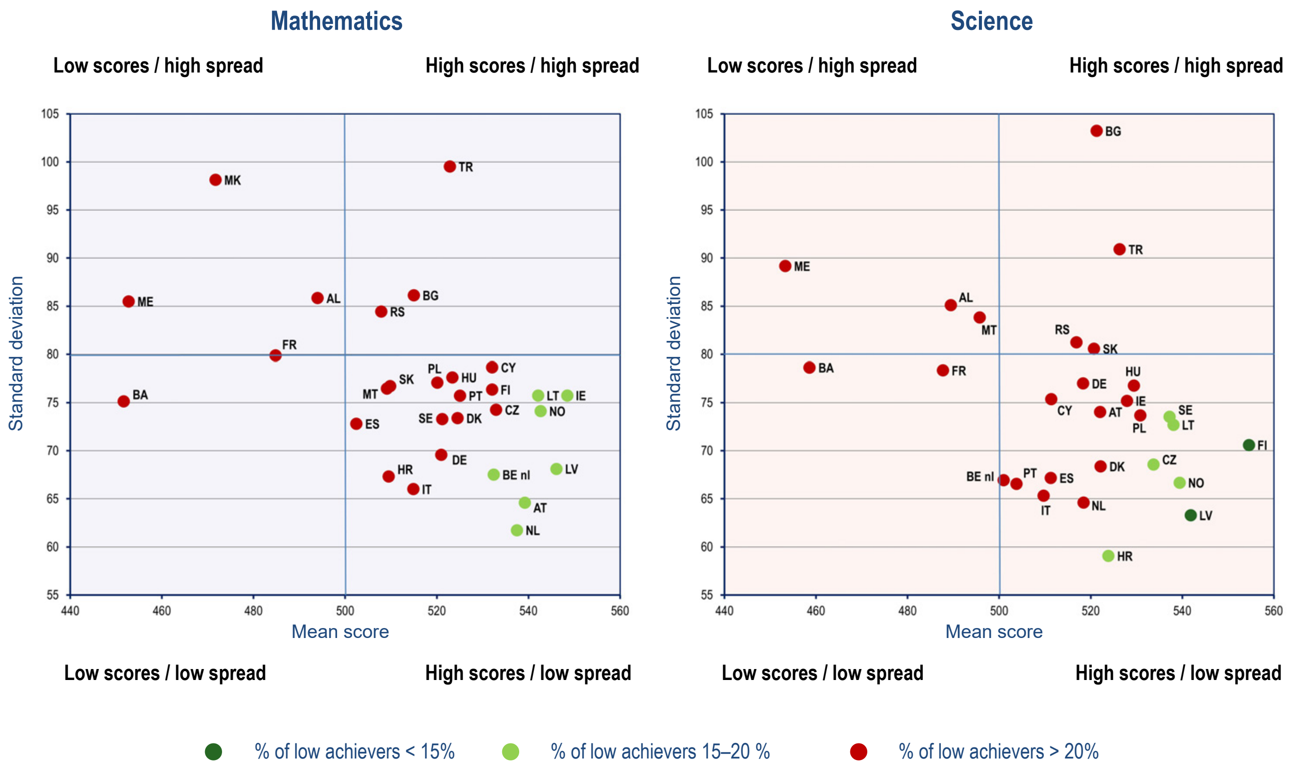
Assessing quality and inclusion in education systems is a complex task. Nevertheless, international student assessment surveys allow indicators to be defined and computed that enable international comparisons along given dimensions.

When it comes to quality, average achievement within education systems is the most commonly used indicator. Average achievement refers to the weighted mean score of all students participating in a given survey within an education system.

Inclusive education means, on the one hand, that most students can reach a minimum basic achievement level (i.e. the share of underachieving students is as small as possible), and, on the other hand, that differences between students' achievement levels are not too wide. Therefore, this chapter relies on the standard deviation of achievement scores within education systems as the main indicator for inclusion. Nevertheless, several other indicators can also capture such differences between students, including the achievement gap between the lowest percentile or quartile and the highest percentile or quartile of students (see, for example, European Commission / EACEA / Eurydice, 2020).

Figure 1.3 shows education systems along the quality and inclusion dimensions in both mathematics and science based on the TIMSS 2019 survey, while Figure 1.4 does the same based on the PISA 2018 survey. As the figures illustrate, education systems with similar levels of average performance can have different ranges of student scores and vice versa.

Figure 1.3: Mean score and standard deviation in mathematics and science for fourth grade students, 2019



		BE nl	BG	CZ	DK	DE	IE	ES	FR	HR	IT	CY	LV	LT	HU	MT
Mathematics	Mean score	532	515	533	525	521	549	503	485	510	515	532	546	542	523	509
	Standard deviation	67.5	86.1	74.3	73.4	69.6	75.8	72.8	79.9	67.3	66.0	78.7	68.1	75.7	77.6	76.5
Science	Mean score	501	521	534	522	518	528	511	488	524	510	511	542	538	529	496
	Standard deviation	66.9	103.2	68.6	68.4	77.0	75.2	67.2	78.3	59.1	65.3	75.4	63.3	72.7	76.8	83.8
		NL	**AT**	**PL**	**PT**	**SK**	**FI**	**SE**		**AL**	**BA**	**ME**	**MK**	**NO**	**RS**	**TR**
Mathematics	Mean score	538	539	520	525	510	532	521		494	452	453	472	543	508	523
	Standard deviation	61.7	64.6	77.1	75.7	76.7	76.3	73.3		85.8	75.1	85.5	98.1	74.1	84.4	99.5
Science	Mean score	519	522	531	504	521	555	537		490	459	453	426	539	517	526
	Standard deviation	64.6	74.0	73.7	66.5	80.6	70.6	73.5		85.1	78.6	89.2	102.8	66.7	81.2	90.9

Source: Eurydice, based on IEA, TIMSS 2019 database.

Explanatory notes

The TIMSS achievement scale was established in TIMSS 1995 based on the achievement of all participating countries, treating each country equally. The TIMSS scales have a typical range of achievement between 300 and 700 in both mathematics and science. A centre point of 500 points was set to correspond to the mean of overall achievement at the first data collection, with 100 points set to correspond to the standard deviation. Achievement data from each subsequent TIMSS assessment have been reported on these scales, so that increases or decreases in achievement may be monitored across assessments. TIMSS uses the scale centre point as a point of reference that remains constant from assessment to assessment.

TIMSS describes achievement at four points along the scale as international benchmarks: Advanced International Benchmark (625), High International Benchmark (550), Intermediate International Benchmark (475) and Low International Benchmark (400). The score gaps between the benchmarks correspond to 75 points on the achievement scale.

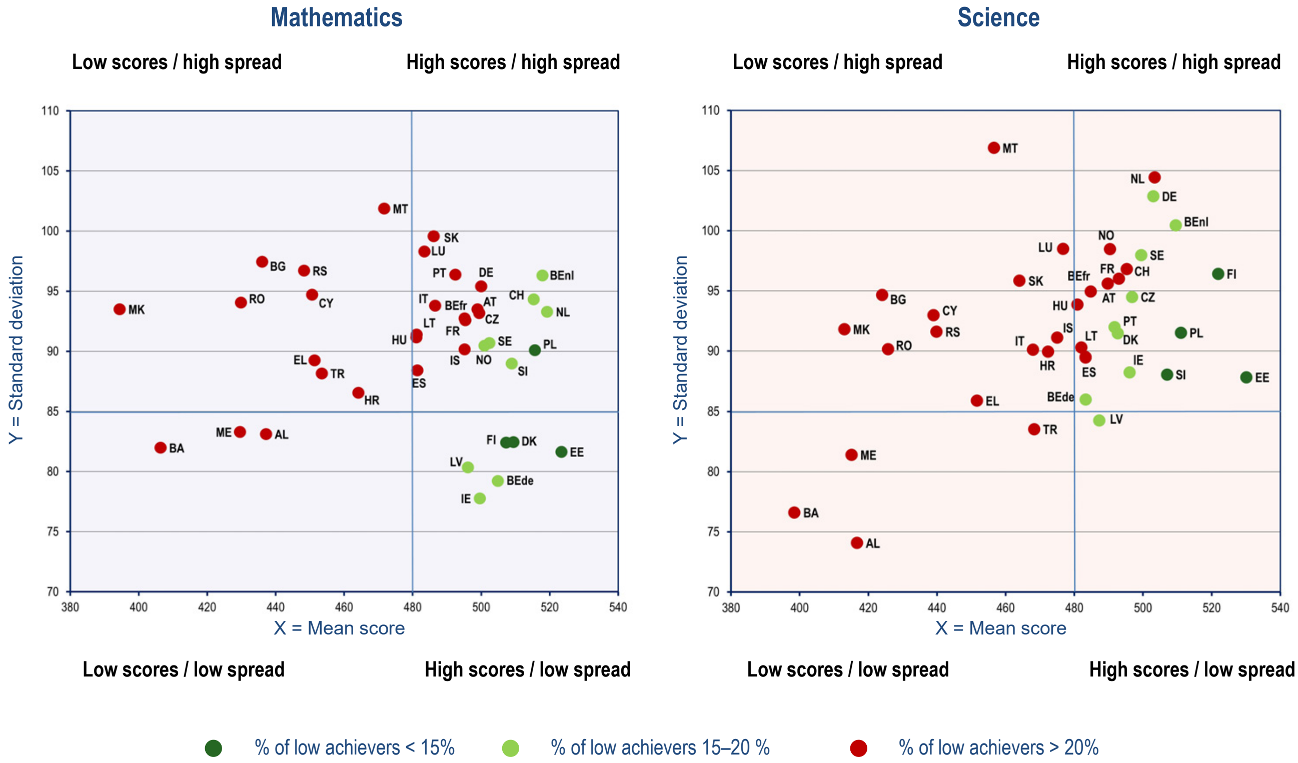
Standard errors are available in Annex III.

In primary education, differences between countries are relatively small. Most countries crowd relatively close to the bottom right corner in Figure 1.3 in both mathematics and science. This means that, in grade 4, most education systems are relatively close to the desired combination of high quality (mean scores higher than 500) and a high level of inclusion (measured as low spread, e.g. standard deviation below 80).

In Figure 1.3, education systems with the lowest shares of underachieving students (see Figure 1.1) are marked in dark green (below 15%) and light green (above 15% but below 20%). As is clearly visible in the figures, these are the education systems closest to the bottom right corner, with the highest mean scores (over 520 points) and lowest standard deviations (around or below 75 points). Given that score gaps between adjacent benchmarks correspond to 75 points in the TIMSS survey – for example, the difference between the low and intermediate benchmarks as defined by the TIMSS survey is 75 points – having a standard deviation around or below 75 points means that differences between low- and high-achieving students do not exceed one benchmark. In other words, education systems with low percentages of low achievers in primary education are visibly characterised by high levels of both quality and inclusion according to the TIMSS survey.

The picture changes slightly when examining quality and inclusion in secondary education, through the achievement levels of 15-year-old students (Figure 1.4). In the PISA 2018 survey, mean scores of European countries are situated between 390 and 530 points. Although the majority of education systems have mean scores higher than 480 points, 12 countries have lower averages in mathematics, and an even greater number of countries, 16, have lower averages in science. Differences between high- and low-achieving students are also more pronounced, with the overwhelming majority of countries having ranges above 80 points. In the PISA survey, a difference of 80 points is interpreted as the difference in described skills and knowledge between successive proficiency levels (i.e. between proficiency levels 1 and 2, between levels 2 and 3, etc.). Thus, education systems are more spread out along both the quality dimension and the inclusion dimension. This means that differences both within and between countries are bigger in secondary education than in primary education.

Figure 1.4: Mean score and standard deviation in mathematics and science for 15 year-old students, 2018



		BE fr	BE de	BE nl	BG	CZ	DK	DE	EE	IE	EL	ES	FR	HR	IT	CY	LV	LT	LU	HU
Mathematics	Mean score	495	505	518	436	500	510	500	523	500	451	481	495	464	487	451	496	481	483	481
	Standard deviation	92.7	79.2	96.3	97.4	93.2	82.4	95.4	81.6	77.8	89.2	88.4	92.6	86.5	93.8	94.7	80.3	91.4	98.3	91.1
Science	Mean score	485	483	510	424	497	493	503	530	496	452	483	493	472	468	439	487	482	477	481
	Standard deviation	94.9	86.0	100.5	94.6	94.5	91.5	102.9	87.8	88.3	85.9	89.5	96.0	89.9	90.1	93.0	84.3	90.3	98.5	93.9
		MT	NL	AT	PL	PT	RO	SI	SK	FI	SE	AL	BA	CH	IS	ME	MK	NO	RS	TR
Mathematics	Mean score	472	519	499	516	493	430	509	486	507	502	437	406	515	495	430	394	501	448	454
	Standard deviation	101.9	93.3	93.5	90.1	96.4	94.0	89.0	99.6	82.4	90.7	83.1	82.0	94.3	90.2	83.3	93.5	90.5	96.7	88.2
Science	Mean score	457	503	490	511	492	426	507	464	522	499	417	399	495	475	415	413	490	440	468
	Standard deviation	106.9	104.4	95.6	91.5	92.0	90.1	88.1	95.8	96.4	98.0	74.1	76.6	96.8	91.1	81.4	91.8	98.4	91.6	83.5

Source: Eurydice, based on OECD, PISA 2018 database.

Explanatory notes

PISA scores are set in relation to the variation in results observed across all test participants. There is theoretically no minimum or maximum score in PISA; rather, the results are scaled to fit approximately normal distributions, with means around 500 points and standard deviations around 100 points. PISA scales are divided into proficiency levels (1–6) corresponding to increasingly difficult tasks. For each proficiency level identified, descriptions were generated to define the kinds of knowledge and skills needed to complete those tasks successfully. Each proficiency level corresponds to a range of about 80 points. Hence, differences in scores of 80 points can be interpreted as the difference in described skills and knowledge between successive proficiency levels.

Because the PISA sample is defined by a particular age group, rather than a particular grade, in many countries, students who participate in the PISA assessment are distributed across two or more grades. Based on this variation, past reports have estimated the average difference in scores across adjacent grades for countries in which a sizeable number of 15-year-olds are enrolled in at least two different grades. These estimates take into account some socioeconomic and demographic differences that are also observed across grades. On average across countries, the difference between adjacent grades is about 40 points (see more in OECD, 2019a).

Standard errors are available in Annex III.

Similarly to primary education, systems with the lowest percentages of underachieving students (marked in dark green (below 15%) and light green (above 15% but below 20%); see Figure 1.2) have relatively high mean scores. However, patterns are different between mathematics and science for 15-year-old students. In mathematics, similarly to what Figure 1.3 showed in primary education, a group of six education systems with low percentages of low achievers (those of Belgium (German-speaking Community), Denmark, Estonia, Ireland, Latvia and Finland) are situated in the bottom right corner in Figure 1.4, with high mean scores and low standard deviations. These are the systems where the survey points towards quality meeting equity in education. However, these education systems are not the only ones with a share of underachievers below 15% or 20%. Another group of countries with high mean scores can be distinguished: those with a standard deviation of scores above 85 (Belgium (Flemish Community), the Netherlands, Poland, Slovenia, Sweden, Switzerland and Norway). These education systems achieve similar quality levels to the first group, but have lower levels of inclusion.

In science, however, even education systems with low shares of underachieving students have a standard deviation of scores larger than 85 points, and in some cases even around or exceeding 100 points. Moreover, the relationship between the mean and the spread of scores seems much stronger – and goes in the opposite direction – than in mathematics and in both fields in primary education: the higher the mean scores, the larger the differences between students ([18]). As a result, the bottom right corner of the figure for achievement in science is left largely unpopulated.

These differences between mathematics and science are linked to the fact that the range of scores tends to be narrower in science than in mathematics in education systems with a high percentage of low achievers, while tending to be wider in systems with a relatively low share of underachieving students. In other words, in countries with large shares of low achievers, differences between students tend to be bigger in mathematics than in science. Conversely, countries with lower percentages of low achievers have a relatively narrow achievement gap in mathematics, but less so in science. Education systems that achieve the EU target despite a wider spread of scores (most notably those of Estonia and Finland) can do so because, in these cases, the differences lie not in the achievement levels of low achievers but in those of high achievers: high-achieving students achieve higher scores in science than in mathematics ([19]). In Belgium (German-speaking Community), Denmark, Ireland and Latvia, on the other hand, low-achieving students in science have lower scores than low-achieving students in mathematics ([20]).

Following this general discussion on achievement levels and differences, in light of the European Commission's definition of inclusive education ([21]), the final section of this chapter looks into how achievement might be linked to the socioeconomic background or gender of students.

([18]) The Spearman correlation coefficient between the mean scores and the standard deviations in science is 0.37, significant at the 5% level.
([19]) See the P90 values in Annex III, Table 1.4.
([20]) See the P10 values in Annex III, Table 1.4.
([21]) Commission communication – Achieving the European Education Area by 2025, COM(2020) 625 final, p. 7.

1.4. Determinants of student achievement

Equity in education implies that personal and social circumstances should not be an obstacle to educational success. It is commonly measured by analysing the school achievement differences between, for example, those students who are born in rich and poor households, boys and girls, those who have highly educated parents and those who do not, and those who speak the main national language at home and those who do not. This section is devoted to examining the common determinants of success (or failure) in education, providing a snapshot of the percentage of low achievers by socioeconomic background and gender in order to gain an initial insight into the extent of differences between students from various backgrounds.

Socioeconomic status

Socioeconomic background is the most common individual characteristic determining achievement in education. Students from families of low socioeconomic status are more likely to have lower levels of literacy and numeracy, to leave school early or to have negative attitudes towards school (Considine and Zappala, 2002a). Research confirms that socioeconomic background variables such as parental education, ethnicity, the number of books at home and housing type are among the strongest predictors of academic performance (Considine and Zappala, 2002b; European Commission / EACEA / Eurydice, 2020; Jerrim et al., 2019; OECD, 2012). Nevertheless, socioeconomic background does not have the same impact on achievement in all education systems. As the Eurydice report *Equity in School Education in Europe* demonstrated, the correlation between socioeconomic background and student achievement largely depends on how education systems are structured and organised (European Commission / EACEA / Eurydice, 2020).

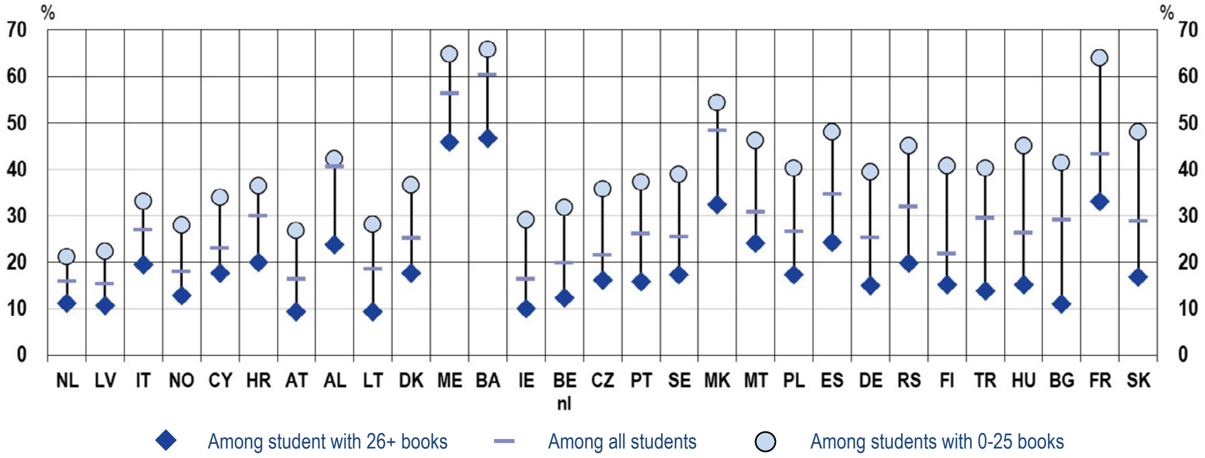
A common proxy used for socioeconomic status is the number of books at home, as reported by students. Researchers argue that the number of books at home provides a good theoretical proxy for the educational, cultural and economic background of families (see, for example, Schütz, Ursprung and Wößmann, 2008; Wößmann, 2003, 2004). Empirically, the number of books at home is found to be a more important predictor of student performance than parental education (Schütz, Ursprung and Wößmann, 2008) ([22]). In addition, this variable is available in both surveys analysed. This section examines differences in the percentages of low achievers among students from lower (maximum of 25 books at home) and higher (26 books or more at home) socioeconomic backgrounds.

Figure 1.5 shows these differences based on the TIMSS survey (i.e. between different groups of students in the fourth grade of primary education). In all European education systems, children from households with a maximum of 25 books tend to have lower results in mathematics and science than those with 26 or more books at home. As the charts and tables in Figure 1.5 show, gaps between shares of low achievers among students from lower and higher socioeconomic backgrounds are between 10 and 31 percentage points in mathematics, and between 10 and 34 percentage points in science. The smallest differences, of around 10–12 percentage points, can be found in Latvia in both subject areas, in the Netherlands in mathematics and in Croatia in science, while the differences are largest (above 30 percentage points) in Bulgaria, France and Slovakia in both subject areas.

([22]) Certainly, having books at home can have different cultural connotations in different education systems (i.e. having many books may signal high educational, social and cultural status in some education systems more than in others), which might limit the comparability of results to some extent.

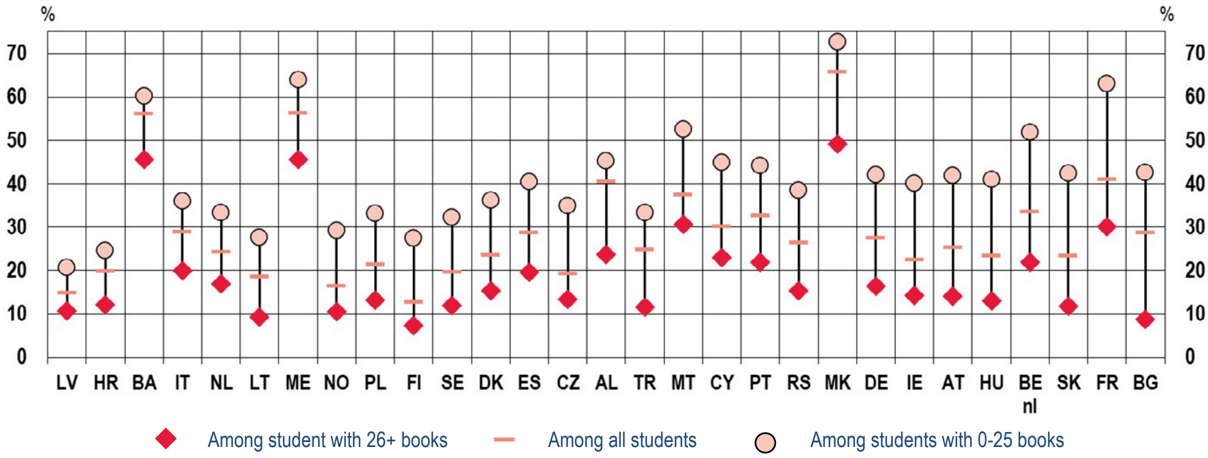
Figure 1.5: Percentage of low achievers in mathematics and science in the fourth grade, by the number of books at home, 2019

Mathematics



		NL	LV	IT	NO	CY	HR	AT	AL	LT	DK	ME	BA	IE	BE nl	CZ
Mathematics	26+ books	11.2	10.7	19.4	12.8	17.7	20.0	9.3	23.8	9.3	17.7	46.0	46.7	10.0	12.3	16.2
	0-25 books	21.2	22.2	33.1	27.9	33.9	36.5	26.8	42.3	28.1	36.5	64.9	65.9	29.2	31.9	35.8
	Percentage point difference	9.9	11.5	13.7	15.1	16.2	16.5	17.5	18.6	18.8	18.8	19.0	19.2	19.2	19.6	19.6
		PT	SE	MK	MT	PL	ES	DE	RS	FI	TR	HU	BG	FR	SK	
	26+ books	15.9	17.3	32.4	24.1	17.4	24.3	14.9	19.8	15.2	13.9	15.2	11.0	33.1	16.9	
	0-25 books	37.2	38.9	54.3	46.3	40.3	48.0	39.4	45.1	40.7	40.2	45.0	41.5	63.9	48.1	
	Percentage point difference	21.4	21.6	21.9	22.1	22.9	23.8	24.5	25.3	25.6	26.3	29.8	30.4	30.8	31.2	

Science



		LV	HR	BA	IT	NL	LT	ME	NO	PL	FI	SE	DK	ES	CZ	AL
Science	26+ books	10.7	12.1	45.7	20.0	16.9	9.4	45.6	10.6	13.2	7.3	11.9	15.4	19.6	13.4	23.7
	0-25 books	20.8	24.5	60.2	36.1	33.4	27.7	64.0	29.2	33.2	27.5	32.3	36.1	40.5	34.9	45.3
	Percentage point difference	10.1	12.4	14.5	16.0	16.5	18.3	18.4	18.5	20.0	20.3	20.4	20.7	20.9	21.6	18.4
		TR	MT	CY	PT	RS	MK	DE	IE	AT	HU	BE nl	SK	FR	BG	
	26+ books	11.5	30.8	23.0	21.9	15.4	49.1	16.5	14.3	14.2	13.1	22.0	11.8	30.2	8.7	
	0-25 books	33.4	52.6	44.9	44.3	38.4	72.7	42.1	40.1	42.0	41.0	51.8	42.4	63.0	42.6	
	Percentage point difference	21.8	21.9	21.9	22.3	23.0	23.6	25.6	25.8	27.8	27.9	29.7	30.5	32.8	33.8	

Source: Eurydice based on IEA, TIMSS 2019 database.

Explanatory notes

Education systems are depicted in ascending order based on the percentage point differences between low achievement rates among students with 0–25 and 26+ books in mathematics/science.

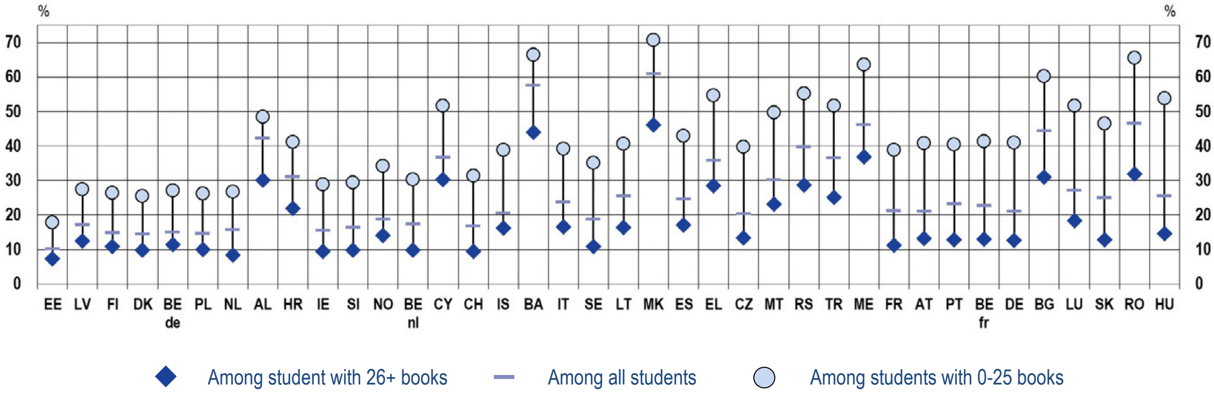
The original categories of the number of books at home variable (ASBG04) were transformed so that there were two values only: (1) 0–25 books and (2) 26+ books. Please consult Annex III, Table 1.5 for the relative size of the two subgroups and for the standard errors.

Differences in the percentages of low achievers between the two subgroups of students are statistically significant ($p < 0.05$) in all education systems. Percentage point differences were calculated before rounding.

Similar differences can be computed for 15-year-old students based on the PISA survey. Figure 1.6 shows the percentage of low achievers among 15-year-olds, by the number of books at home (0–25 books or 26 or more books). Differences between the percentages of low achievers among students from lower and higher socioeconomic backgrounds in the PISA survey lie between 10 and 39 percentage points in mathematics, and between 9 and 38 percentage points in science.

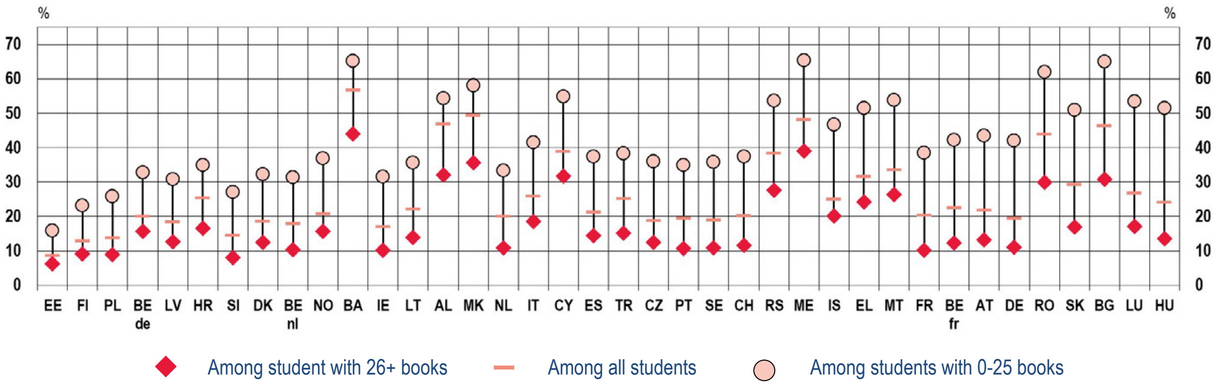
Figure 1.6: Percentage of low achievers in mathematics and science among 15-year-olds, by the number of books at home, 2018

Mathematics



		EE	LV	FI	DK	BE de	PL	NL	AL	HR	IE	SI	NO	BE nl	CY	CH	IS	BA	IT	SE
Mathematics	26+ books	7.4	12.4	11.0	9.9	11.4	10.0	8.4	30.1	22.0	9.5	9.8	14.2	9.9	30.2	9.6	16.3	44.0	16.5	11.0
	0-25 books	17.8	27.5	26.4	25.4	27.0	26.1	26.7	48.4	41.3	28.9	29.4	34.3	30.3	51.7	31.4	38.8	66.5	39.2	35.1
	Percentage point difference	10.4	15.0	15.4	15.6	15.7	16.1	18.3	18.3	19.3	19.4	19.7	20.1	20.3	21.5	21.8	22.5	22.5	22.7	24.1
		LT	MK	ES	EL	CZ	MT	RS	TR	ME	FR	AT	PT	BE fr	DE	BG	LU	SK	RO	HU
	26+ books	16.4	46.2	17.1	28.6	13.5	23.3	28.8	25.2	36.9	11.2	13.3	12.8	13.0	12.7	31.1	18.4	12.9	31.9	14.7
	0-25 books	40.7	70.8	42.9	54.7	39.7	49.7	55.3	51.8	63.5	38.8	40.9	40.5	41.3	41.1	60.2	51.8	46.5	65.6	53.8
	Percentage point difference	24.2	24.5	25.8	26.1	26.2	26.4	26.5	26.5	26.7	27.6	27.6	27.7	28.3	28.4	29.1	33.3	33.5	33.7	39.1

Science



Source: Eurydice based on OECD, PISA 2018 database.

Data (Figure 1.6)

		EE	FI	PL	BE de	LV	HR	SI	DK	BE nl	NO	BA	IE	LT	AL	MK	NL	IT	CY	ES
Science	26+ books	6.2	9.2	8.9	15.7	12.7	16.6	8.1	12.5	10.3	15.7	44.0	10.2	14.0	32.0	35.7	10.9	18.6	31.8	14.5
	0-25 books	15.9	23.2	25.9	32.8	30.9	34.9	27.0	32.3	31.4	36.9	65.2	31.6	35.6	54.3	58.1	33.4	41.6	54.8	37.5
	Percentage point difference	9.6	14.0	17.0	17.0	18.2	18.3	19.0	19.8	21.0	21.2	21.2	21.3	21.6	22.3	22.4	22.5	23.0	23.0	23.1
		TR	CZ	PT	SE	CH	RS	ME	IS	EL	MT	FR	BE fr	AT	DE	RO	SK	BG	LU	HU
	26+ books	15.2	12.5	10.7	10.9	11.6	27.6	39.1	20.1	24.2	26.4	10.1	12.4	13.2	11.0	29.9	17.0	30.8	17.2	13.6
	0-25 books	38.3	36.0	34.9	35.9	37.5	53.6	65.5	46.7	51.4	53.7	38.4	42.3	43.5	42.0	62.0	50.9	65.1	53.5	51.5
	Percentage point difference	23.1	23.5	24.1	25.0	25.9	26.0	26.4	26.5	27.2	27.3	28.3	30.0	30.2	31.0	32.1	33.9	34.3	36.3	37.9

Source: Eurydice based on OECD, PISA 2018 database.

Explanatory notes

Education systems are depicted in ascending order based on the percentage point differences between low achievement rates among students with 0–25 and 26+ books in mathematics/science.

The original categories of the number of books at home variable (ST013Q01TA) were transformed so that there were two values only: (1) 0–25 books and (2) 26+ books. Please consult Annex III, Table 1.6 for the relative size of the two subgroups and for the standard errors.

Differences in the percentages of low achievers between the two subgroups of students are statistically significant ($p < 0.05$) in all education systems. Percentage point differences were calculated before rounding.

In both subject areas, differences between the two groups of students are smallest in Estonia, at around 10 percentage points, followed by Latvia, Finland, Denmark, Belgium (German-speaking Community) and Poland in mathematics, and Finland, Poland and Belgium (German-speaking Community) in science. Similarly to the findings based on the TIMSS survey, the education systems in Bulgaria and Slovakia are among those with the largest differences between students by socioeconomic background in both subject areas, together with Romania, Luxembourg, and Hungary. The biggest differences in the shares of low achievers by socioeconomic background can be found in Hungary, reaching more than 39 percentage points in mathematics, and almost 38 percentage points in science.

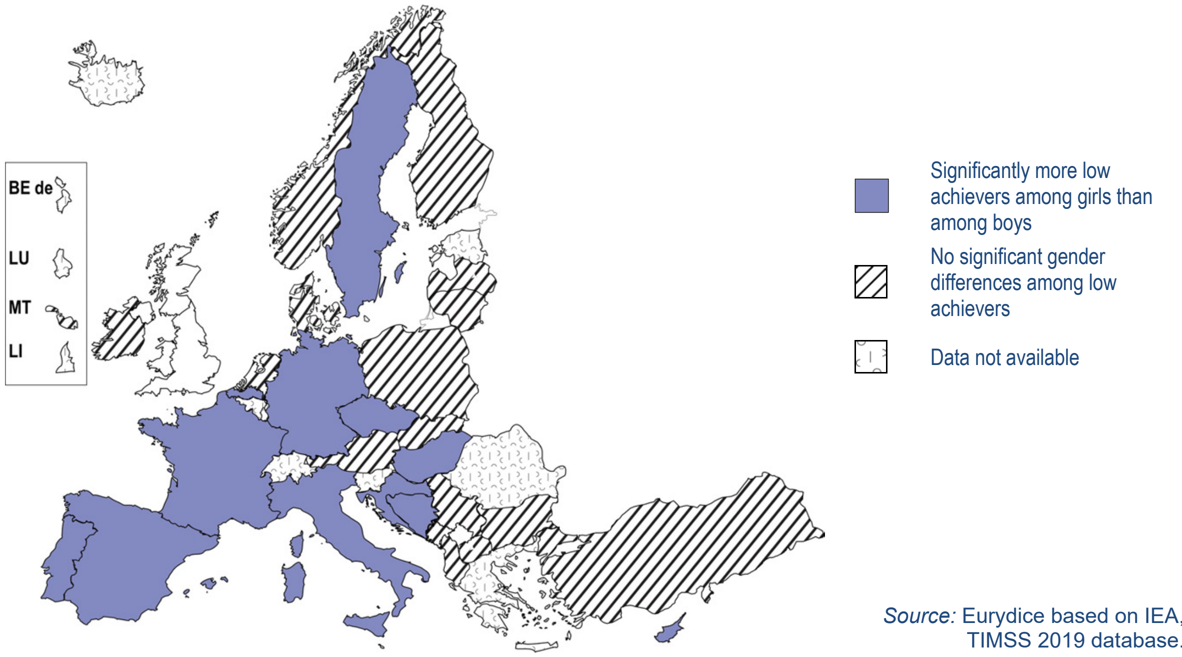
Thus, socioeconomic background influences the chances of becoming a low achiever across all education systems and subject areas. Nevertheless, differences between countries suggest that achievement gaps between students can be reduced by developing appropriate policies that decrease socioeconomic inequalities.

Gender

When it comes to mathematics and science education, gender differences are often highlighted, drawing attention to existing gender stereotypes related to science, technology, engineering and mathematics (STEM) subjects. However, the impact of gender on student achievement is less straightforward than that of socioeconomic status. While students from low socioeconomic backgrounds are clearly over-represented among low achievers in all education systems, there is no such overarching pattern in relation to the gender of students. Firstly, in most countries, gender differences in low achievement are not significant at all, especially in primary education. Secondly, gender patterns differ across educational levels. In primary education, girls struggle with basic mathematics more than boys, at least in some European countries with available data. Among 15-year-olds, boys do not grasp elementary science in more than half of European countries, and in a few countries this is also the case in mathematics.

Looking first at low achievers in primary education, data show virtually no gender differences in science achievement. The only education system with significant gender differences in this subject area is that of North Macedonia, where the percentage of low achievers is higher among boys than among girls in science ([23]). In contrast, in mathematics, as Figure 1.7 shows, achievement differences between boys and girls might require targeted policies in some European countries.

Figure 1.7: Gender differences in the percentage of low achievers among fourth grade students in mathematics, 2019



Source: Eurydice based on IEA, TIMSS 2019 database.

% of low achievers	BE nl	BG	CZ	DK	DE	IE	ES	FR	HR	IT	CY	LV	LT	HU	MT
Girls	22.0	29.4	23.5	25.6	26.5	17.2	37.4	45.8	32.6	29.4	26.3	16.0	19.3	28.3	32.0
Boys	17.6	28.9	19.8	24.5	21.6	15.6	31.9	40.7	27.3	24.7	19.6	14.9	18.1	24.5	29.9
Percentage point difference	4.3 (*)	0.5	3.8 (*)	1.1	4.8 (*)	1.6	5.5 (*)	5.2 (*)	5.3 (*)	4.8 (*)	6.7 (*)	1.1	1.2	3.8 (*)	2.0
	NL	AT	PL	PT	SK	FI	SE		AL	BA	ME	MK	NO	RS	TR
Girls	16.9	16.8	27.5	29.4	30.7	22.1	27.3		39.5	63.5	58.2	46.9	17.4	31.0	29.6
Boys	14.7	16.1	26.2	23.1	27.0	21.7	23.6		37.1	57.4	55.7	49.7	17.6	33.0	29.4
Percentage point difference	2.2	0.7	1.3	6.3 (*)	3.7	0.4	3.7 (*)		2.3	6.1 (*)	2.8	-2.7	-0.1	-2.0	0.3

Explanatory note

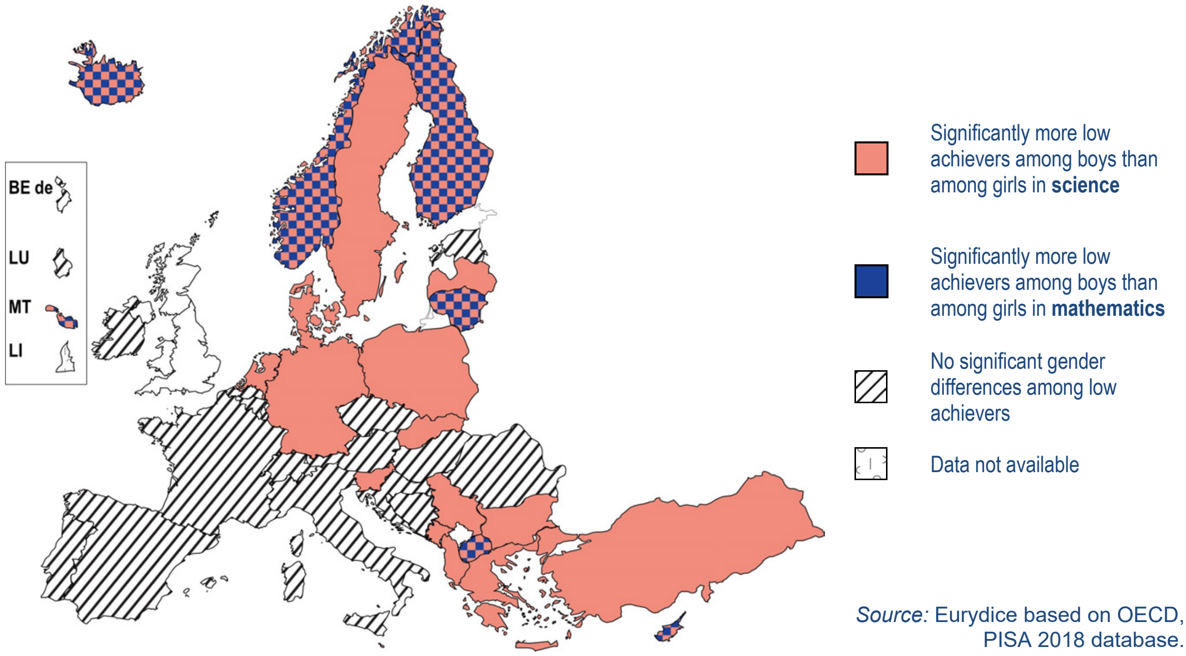
Statistically significant differences ($p < 0.05$) are marked with a (*). Percentage point differences were calculated before rounding. Standard errors are available in Annex III.

As the figure reveals, gender differences are not significant in the majority of education systems with available data. However, in 12 education systems ([24]), these differences are significant and they point in the same direction: there is a higher share of low achievers among girls than among boys, with differences of between 3 and 7 percentage points. This might suggest that girls can have a slight disadvantage in mathematics in primary education ([25]). Interestingly, when looking back at Figure 1.1, it becomes clear that almost all education systems with significant gender differences also have relatively high overall levels of low achievement, above 20% (the only exception is Belgium (Flemish Community)).

([23]) In North Macedonia, the percentage of low achievers is 62.2% among girls and 69.1% among boys. For data on other education systems, please consult the statistical annex (Annex III, Table 1.7).
([24]) These are Belgium (Flemish Community), Czechia, Germany, Spain, France, Croatia, Italy, Cyprus, Hungary, Portugal, Sweden, and Bosnia and Herzegovina.
([25]) While this report does not address the issue of high achievement, the share of high achievers is smaller among girls than among boys in the majority of countries with available data (source: IEA, TIMSS 2019 database).

However, this slight female disadvantage concerning low achievement in mathematics completely disappears in secondary education. As Figure 1.8 illustrates, among 15-year-olds, percentages of low achievers in mathematics are largely similar among girls and boys, with significant differences between the genders in only seven education systems: those of Cyprus, Lithuania, Malta, Finland, Iceland, North Macedonia and Norway. Moreover, in these seven systems, the percentage of low achievers is higher among boys than among girls, with differences of between 3 and 8 percentage points.

Figure 1.8: Gender differences in the percentage of low achievers among 15-year-old students in mathematics and science, 2018



Source: Eurydice based on OECD, PISA 2018 database.

		BE fr	BE de	BE nl	BG	CZ	DK	DE	EE	IE	EL	ES	FR	HR	IT	CY	LV	LT	LU	HU
Maths	Girls	23.8	15.6	19.0	43.6	20.0	14.3	21.0	10.3	15.7	34.6	24.8	21.3	31.9	25.1	33.8	17.4	23.8	28.2	26.5
	Boys	21.8	14.6	15.7	45.2	20.8	14.9	21.2	10.1	15.7	37.0	24.6	21.2	30.4	22.6	39.8	17.3	27.4	26.3	24.8
	Difference	2.0	1.0	3.2	-1.6	-0.9	-0.6	-0.2	0.2	0.0	-2.4	0.3	0.1	1.4	2.4	-6.0 (*)	0.1	-3.6 (*)	1.9	1.7
Science	Girls	22.6	18.3	18.3	42.4	18.1	17.1	18.2	8.0	16.0	28.5	20.8	19.4	24.0	25.9	33.5	16.0	19.7	25.7	24.6
	Boys	22.6	21.8	17.8	50.2	19.4	20.2	20.8	9.5	18.1	34.9	21.8	21.6	26.8	25.8	44.2	21.1	24.6	27.8	23.6
	Difference	0.1	-3.5	0.6	-7.8 (*)	-1.2	-3.1 (*)	-2.6 (*)	-1.5	-2.1	-6.3 (*)	-1.0	-2.1	-2.8	0.1	-10.7 (*)	-5.1 (*)	-5.0 (*)	-2.2	1.0
		MT	**NL**	**AT**	**PL**	**PT**	**RO**	**SI**	**SK**	**FI**	**SE**	**AL**	**BA**	**CH**	**IS**	**ME**	**MK**	**NO**	**RS**	**TR**
Maths	Girls	26.0	15.1	21.7	14.1	23.2	47.1	15.8	24.8	13.1	18.1	40.6	57.4	17.5	18.0	47.9	59.2	16.6	39.3	37.6
	Boys	34.2	16.4	20.5	15.4	23.3	46.0	17.0	25.4	16.8	19.5	44.1	57.7	16.3	23.4	44.6	62.7	21.1	40.2	35.7
	Difference	-8.8 (*)	-1.3	1.2	-1.3	-0.1	1.1	-1.2	-0.6	-3.8 (*)	-1.4	-3.5	-0.3	1.2	-5.4 (*)	3.3	-3.6 (*)	-4.5 (*)	-0.9	1.9
Science	Girls	28.2	18.5	20.6	12.7	19.0	43.1	12.3	27.5	8.9	17.3	41.6	56.1	19.2	22.2	46.6	45.0	17.9	36.5	22.9
	Boys	38.4	21.6	23.1	15.0	20.1	44.8	16.7	31.1	16.7	20.8	52.2	57.4	21.1	27.8	49.7	53.5	23.7	40.1	27.4
	Difference	-10.2 (*)	-3.2 (*)	-2.5	-2.2 (*)	-1.0	-1.7	-4.4 (*)	-3.5 (*)	-7.7 (*)	-3.5 (*)	-10.7 (*)	-1.3	-1.9	-5.6 (*)	-3.0 (*)	-8.6 (*)	-5.8 (*)	-3.7 (*)	-4.6 (*)

Explanatory note

The table includes only countries with available data (in protocol order). Statistically significant differences ($p < 0.05$) are marked with a (*). Percentage point differences were calculated before rounding. Standard errors are available in Annex III.

This female advantage is even stronger in science, where gender differences in the shares of low achievers are significant in the majority of education systems covered in this report. The share of low achievers in science among 15-year-old boys is 2–11 percentage points higher than among 15-year-old girls in 21 education systems, with differences of over 10 percentage points in Cyprus, Malta and Albania ([26]).

Interestingly – although certainly not without exceptions – education systems with a slight female disadvantage in mathematics in primary education tend to have non-significant gender differences in secondary education, while the gender disparity with a male disadvantage tends to appear in education systems with no significant gender differences in primary education. Nevertheless, as the report will show, education systems do not act upon this male disadvantage when designing targeted policies for low achievers in mathematics or science.

Summary

This chapter analysed the percentage of low achievers in mathematics and science in European education systems, linking such percentages to quality and inclusion in education. As the chapter showed, only a handful of European countries have managed to reach the European target of having no more than 15% of 15-year-old students underachieving in the different subject areas representing basic skills. Most European education systems still need to find ways to lower the proportion of students who are not able to solve more complex mathematical or scientific problems.

Percentages of low achievers tend to correlate across subject areas and education levels. Thus, within an education system, they are likely to be at similar levels in mathematics and science, as well as in primary and secondary education. The analysis has shown that education systems with relatively low percentages of underachieving students tend to combine quality and inclusion in education: they have higher average scores and smaller differences between the high- and low-achieving students.

At the same time, there are consistent differences in the likelihood of becoming a low achiever between students from more or less affluent families in all education systems. Differences between the percentages of low achievers among students from higher and lower socioeconomic backgrounds are significant everywhere, with students from low socioeconomic backgrounds being over-represented among low achievers. Nevertheless, the gaps between the two groups differ across education systems, which demonstrates that the impact of socioeconomic background on achievement can potentially be reduced if appropriate policies and structures are put in place.

The impact of gender on student achievement is less straightforward than that of socioeconomic status. In most countries, gender differences in low achievement are not significant at all, especially in primary education. Furthermore, gender patterns differ across educational levels. In primary education, girls struggle with basic mathematics more than boys, at least in some of the European countries with available data. Among 15-year-olds, boys are more likely to become low achievers in science in the majority of education systems, and in a few countries this is also the case in mathematics.

([26]) Although this report does not address the issue of high achievement, it has to be noted that, while boys are the majority of low achievers in the PISA survey, they form the majority of high achievers as well. In mathematics and to a lesser extent in science, the percentage of high achievers – students scoring higher than level 5 in PISA – is larger among boys than among girls in the majority of education systems (source: OECD, PISA 2018 database).