

TIMSS 2023

Insights into mathematics
and science achievement
in Ireland



**Gráinne McHugh, Sylvia Denner, Aidan Clerkin,
George Piccio and Vasiliki Pitsia**



Educational Research Centre 2024

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Primary

Aedín Ní Thuathail (Irish Primary Principals' Network).
 Áine Lynch (National Parents Council – Primary).
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Acronyms and abbreviations

CI	Confidence Interval
DEIS	Delivering Equality of Opportunity in Schools
ERC	Educational Research Centre
EU	European Union
HER	Home Educational Resources
IEA	International Association for the Evaluation of Educational Achievement
NCCA	National Council for Curriculum and Assessment
PIRLS	Progress in International Reading Literacy Study
PISA	Programme for International Student Assessment
PSI	Problem Solving and Inquiry
SD	Standard Deviation
SE	Standard Error
SES	Socioeconomic Status
STEM	Science, Technology, Engineering and Mathematics
TCMA	Test-Curriculum Matching Analysis
TIMSS	Trends in International Mathematics and Science Study

Chapter 1:

Introduction

The Trends in International Mathematics and Science Study (TIMSS) is an international study that has been monitoring trends in educational achievement in mathematics and science since 1995. It assesses the mathematics and science skills of students in Fourth Grade and Eighth Grade (Fourth Class at primary level and Second Year at post-primary level in Ireland, respectively).

In this report, we use *Fourth Grade* and *Eighth Grade* to refer to the two internationally- defined grade levels that are assessed by TIMSS in all countries.

In Ireland, these grade levels are known as *Fourth Class* and *Second Year*. We use these terms when referring specifically to the results for Ireland.

About this report

The report focuses mainly on presenting new findings about the mathematics and science achievement of Fourth Class and Second Year students in Ireland.

Chapter 2 describes details of the administration of TIMSS 2023 in Ireland. Chapters 3 and 4 focus on the achievement of Fourth Class pupils in mathematics and science, respectively. Chapters 5 and 6 focus on the achievement of Second Year students in mathematics and science, respectively. For each of these chapters, mean scores are presented along with details on the distribution of achievement, performance at the International Benchmarks, achievement by content domain and cognitive domain, and curriculum coverage. Chapter 7 focuses on Ireland's transition from paper to digital administration in TIMSS 2023 and presents initial findings from the national mode effect study. Finally, Chapter 8 provides a summary and a discussion of the implications of the findings.

Overview of TIMSS

TIMSS is directed internationally by the TIMSS and PIRLS International Study Centre at Boston College, USA, and is managed by the International Association for the Evaluation of Education Achievement (IEA) headquartered in Amsterdam. The International Study Centre works collaboratively with participating countries, which each nominate a National Research Centre to manage TIMSS at the national level. In Ireland, the Educational Research Centre (ERC) takes on this role on behalf of the Department of Education.

TIMSS was first administered in 1995 with 56 countries, including Ireland, taking part. Since then, TIMSS has taken place every four years. TIMSS 2023 is the eighth cycle of TIMSS, with 65 participating countries. Ireland has participated in five cycles of TIMSS: in 1995, 2011 (at Fourth Grade only), 2015, 2019, and 2023.

TIMSS collects high-quality data on students' level of achievement in both mathematics and science at Fourth Grade and Eighth Grade. Contextual data are also collected from different sources including the students, their parent/guardians (at Fourth Grade only), their teachers, and their school principals.

Since 1995, TIMSS has provided invaluable information with which countries can make evidence-informed decisions about their education systems and policies. In Ireland, data from TIMSS has been used by the Department of Education to inform and monitor the outcomes of different national policies, including the *National Strategy: Literacy and Numeracy for Learning and Life 2011-2020* (Department of Education and Skills, 2011; 2017a), and may be used in future to evaluate policies such as Ireland's *Literacy, Numeracy and Digital Literacy Strategy 2024-2033* (Department of Education, 2024) and *STEM Education Policy Statement 2017-2026* (Department of Education and Skills, 2017b).

About TIMSS 2023

TIMSS 2019 was the last major international assessment administered prior to the onset of the COVID-19 pandemic which caused substantial disturbances to schooling and education systems worldwide.¹ In Ireland, the TIMSS 2023 main study administration took place after the main restrictions in schooling had been removed. In this sense the two cycles of TIMSS can be considered as 'bookending' the pandemic, although it should be acknowledged that schools were still returning to a new normal even during the latter end of this challenging period in education. The findings of TIMSS 2023, and comparisons back to previous TIMSS cycles, will therefore provide a valuable opportunity to examine any changes in student outcomes in mathematics and science from before to after the COVID-19 pandemic. TIMSS is not designed to provide estimates of the causal effects of the COVID-19 pandemic on student achievement (i.e., 'COVID learning loss') and did not administer the test to the same sample of students in both cycles (von Davier et al., 2024). Nonetheless, at a national level, the representative samples of students in TIMSS provide a basis for assessing population-level changes in achievement at Fourth Class and Second Year over the period in question.

TIMSS 2019 was the first cycle to introduce a digital version of the assessment, with half of TIMSS countries transitioning from the paper-based to digital assessment in that cycle. In TIMSS 2023, almost all participating countries and benchmarking participants completed the transition to digital testing. The digital assessment provides the opportunity to include more complex and innovative item types, including novel Problem Solving and Inquiry (PSI) tasks, as well as collecting information on how students interact with the assessment (often referred to as *process data*). PSI tasks are designed to enhance student motivation through scenarios and items that simulate real world contexts.

To provide a bridge between paper and digital testing and control for possible mode effects, countries that transitioned to digital testing in TIMSS 2019 administered the trend items from TIMSS 2015, on paper, to a separate sample of students. This was in addition to the main digital administration sample. Ireland transitioned to digital testing as part of TIMSS 2023 and, similarly to the approach used in TIMSS 2019 internationally, administered a national mode effect study which involved administering the trend items from TIMSS 2019, on paper, to a separate nationally representative sample of students. This allows for the examination of any differences related to the mode (digital or paper) of assessment.

¹ Fourth Class pupils in TIMSS 2023 would have been in First Class when school closures in response to the pandemic began in 2020; Second Year students in TIMSS 2023 would have been in Fifth Class at the time.

Who took part in TIMSS 2023?

The list of countries and benchmarking participants in TIMSS 2023 is presented in Table 1.1. As noted above, 65 countries participated in TIMSS 2023, including 59 at Fourth Grade and 44 at Eighth Grade. Of these, 38 countries (including Ireland) administered the test at both grade levels. In addition, there were five benchmarking participants, each of which administered the test at both grade levels. Benchmarking participants are sub-national regions or entities that follow the same procedures as participating countries and carry out the same procedures to the quality standards set out by the IEA. Internationally, as part of the main data collection, 656,360 students participated in TIMSS 2023 (359,098 at Fourth Grade and 297,262 at Eighth Grade) with an additional 63,521 students from benchmarking participants.

Almost all countries administered the test digitally in TIMSS 2023. A small group of countries, six in total, administered the trend assessment materials (those common to TIMSS 2019) on paper. These six countries are indicated with a ^P in Table 1.1.

As mentioned above, Ireland conducted a national mode effect study to account for the change in mode from paper to digital testing in this cycle (indicated by the letter ^M in Table 1.1). Three other countries – Azerbaijan, Bahrain, and Belgium (Flemish) – also completed national mode effect studies.

Table 1.1: Participating countries and benchmarking participants in TIMSS 2023

Country	Fourth Grade	Eighth Grade	Country	Fourth Grade	Eighth Grade
Albania	✓		Latvia	✓	
Armenia	✓		Lithuania	✓	✓
Australia	✓	✓	Macao SAR	✓	
Austria		✓	Malaysia		✓
Azerbaijan ^M	✓	✓	Malta		✓
Bahrain ^M	✓	✓	Montenegro	✓	
Belgium (Flemish) ^M	✓		Morocco ^P	✓	✓
Belgium (French)	✓		Netherlands	✓	
Bosnia and Herzegovina	✓		New Zealand	✓	✓
Brazil	✓	✓	North Macedonia	✓	
Bulgaria ^P	✓		Norway	✓	✓
Canada	✓		Oman	✓	✓
Chile	✓	✓	Palestinian Nat'l Auth.		✓
Chinese Taipei	✓	✓	Poland	✓	
Côte d'Ivoire, Rep. of ^P		✓	Portugal	✓	✓
Cyprus ^P	✓	✓	Qatar	✓	✓
Czech Republic	✓	✓	Romania	✓	✓
Denmark	✓		Saudi Arabia	✓	✓
England	✓	✓	Serbia	✓	
Finland	✓	✓	Singapore	✓	✓
France	✓	✓	Slovak Republic	✓	
Georgia	✓	✓	Slovenia	✓	
Germany	✓		South Africa ^P	✓	✓
Hong Kong SAR	✓	✓	Spain	✓	
Hungary	✓	✓	Sweden	✓	✓
Iran, Islamic Rep. of ^P	✓	✓	Türkiye	✓	✓
Iraq ^P	✓		United Arab Emirates	✓	✓
Ireland ^M	✓	✓	United States	✓	✓
Israel		✓	Uzbekistan	✓	✓
Italy	✓	✓	Benchmarking participants		
Japan	✓	✓	Ontario (Canada)	✓	✓
Jordan	✓	✓	Quebec (Canada)	✓	✓
Kazakhstan	✓	✓	Kurdistan (Iraq) ^P	✓	
Korea, Rep. of	✓	✓	Abu Dhabi (UAE)	✓	✓
Kosovo	✓		Dubai (UAE)	✓	✓
Kuwait	✓	✓	Sharjah (UAE)	✓	✓

Note. ^P indicates that the country completed paper-based assessment comprised of TIMSS 2019 trend items only.

^M indicates countries which completed a national mode effect study.

Selected comparison countries

Comparison with the circumstances and outcomes of other education systems can often provide useful points of reference to assist readers when interpreting the findings of studies such as TIMSS. In this report, a subset of participating countries has been selected as being of particular interest to readers in Ireland (Table 1.2). These countries have been selected because they participated at both grade levels, have relatively high performance in TIMSS 2023, share some linguistic or cultural similarities with Ireland or, like Ireland, they transitioned from paper to digital testing in TIMSS 2023.

Table 1.2: Selected comparison countries

Country	Reason for selection
Australia	Linguistic and some cultural similarity; Transitioned to digital in 2023
Chinese Taipei	High performance
England	Linguistic and some cultural similarity
Finland	High performance
Ireland	N/A
Japan	High performance; Transitioned to digital in 2023
Korea, Rep. of	High performance
Singapore	High performance
Sweden	High performance
United States	Linguistic and some cultural similarity

Note. Countries are sorted alphabetically.

What does TIMSS assess?

TIMSS assesses student achievement in the domains of mathematics and science based on assessment frameworks (Mullis et al., 2021). The TIMSS 2023 frameworks for Fourth and Eighth Grades were updated from those used in the previous cycle, TIMSS 2019, through an iterative review process with individuals at the TIMSS and PIRLS International Study Center, the IEA, subject experts on the TIMSS 2023 Science and Mathematics Item Review Committee, and the TIMSS 2023 National Research Coordinators.

Innovations in TIMSS 2023

Given that the vast majority of TIMSS countries and benchmarking participants administered the assessment digitally, one objective for TIMSS 2023 was to take advantage of the benefits of computer-based assessments. This included using a fully digital item development system to incorporate new and better assessment items with various digital tools for students to use in their responses. As noted above, PSIs – interactive scenarios that allow students to follow a series of steps toward a solution or goal – were first introduced in TIMSS 2019. The idea of PSIs was developed further for TIMSS 2023 and were integrated more completely into the mathematics and science assessments.

While new test items are developed for each cycle, the stability of the assessment from cycle to cycle – a crucial aspect for the estimation of robust trends over time – is safeguarded by carrying about two-thirds of the items from one assessment to the next on a rolling basis. Half of the PSI item blocks (one per subject and per grade) were also carried forward as trend blocks from TIMSS 2019 for use in TIMSS 2023.

TIMSS uses a matrix sampling approach where a pool of mathematics and science items² are arranged into 14 mathematics and 14 science item blocks at each grade level. These item blocks are then arranged into 14 overlapping ‘booklets’, such that each item and item block appear in two booklets and the item blocks are paired with different item blocks each time. Each student was then randomly assigned a test booklet.

A new addition to TIMSS 2023 was the introduction of a group adaptive assessment design to allow for more accurate targeting of student ability internationally due to a growing need for a broader range of assessment difficulty (Yin & Foy, 2021). The group adaptive design was first introduced by the IEA in PIRLS 2021. As part of the TIMSS 2023 group adaptive design, item blocks were classified by three levels of difficulty—easy, medium, and difficult—that were combined into two levels of booklet difficulty (less difficult and more difficult). The main aim of the group adaptive design was to improve the match between the difficulty of the assessment and student ability in each country based on the country’s achievement in the previous cycle. Countries with relatively high achievement (defined as those with average achievement above 550 on the TIMSS mathematics and science scales) received a greater proportion of more difficult booklets, and countries with relatively low achievement (average achievement below 450 on the TIMSS mathematics and science scales) received a greater proportion of less difficult booklets. Countries with average achievement between 450 and 550 administered equal proportions of more difficult and less difficult booklets. Based on student performance in TIMSS 2019, Ireland was included in the latter category. With this adaptive design only at the country level, any two students had the same chance of receiving a given booklet, regardless of their proficiency.

Assessment frameworks

The assessment frameworks for both grades in TIMSS are organised around two dimensions. The first is the *content domain*, which specifies the subject matter of the item, and the second is the *cognitive domain*, specifying the thinking processes to be assessed. The target percentage allocated to each content and cognitive domain in TIMSS 2023 are presented in Table 1.3 (for Fourth Grade) and Table 1.4 (for Eighth Grade). Every item in the assessment is developed to align with one content domain and one cognitive domain.

Table 1.3: TIMSS 2023 target and final distribution of items across content and cognitive domains – Fourth Grade

Subject	Content	Target %	Final %	Cognitive	Target %	Final %
Mathematics	Number	50	51	Knowing	40	30
	Measurement & Geometry	30	27	Applying	40	47
	Data	20	22	Reasoning	20	23
Science	Life Science	45	45	Knowing	40	40
	Physical Science	35	36	Applying	40	40
	Earth Science	20	19	Reasoning	20	19

Source: Mullis et al. (2021) and von Davier et al. (2024).

² In total: 183 items (Fourth Grade mathematics); 173 items (Fourth Grade science); 200 items (Eighth Grade mathematics); and 212 items (Eighth Grade science).

Table 1.4: TIMSS 2023 target and final distribution of items across content and cognitive domains – Eighth Grade

Subject	Content	Target %	Final %	Cognitive	Target %	Final %
Mathematics	Number	30	31	Knowing	35	29
	Algebra	30	28	Applying	40	44
	Geometry & Measurement	20	22	Reasoning	25	27
	Data & Probability	20	20			
Science	Biology	35	37	Knowing	35	33
	Chemistry	20	20	Applying	35	43
	Physics	25	24	Reasoning	30	24
	Earth Science	20	20			

Source: Mullis et al. (2021) and von Davier et al. (2024).

The content areas for mathematics differ across grades to reflect the mathematics taught at each grade level. Number accounts for half of the assessment at Fourth Grade, whereas the equivalent percentage at Eighth Grade is 30%. Algebra is a separate content domain at Eighth Grade (allocated 30%), while pre-algebra items are included in the Number content domain at Fourth Grade. Data (or Data & Probability at Eighth Grade) is allocated one-fifth of the assessment. At Fourth Grade, the Data domain focuses more on representing and interpreting data, while at the Eighth Grade it puts more weight on drawing conclusions from data, basic statistics, and the fundamentals of probability. Measurement & Geometry accounts for the remainder of the assessment at Fourth Grade (30%) while, at Eighth Grade, the final content area is Geometry & Measurement (20%). As shown in Tables 1.3 and 1.4, the final distribution of the items was broadly similar to the target proportion outlined in the Assessment Framework.

Similar to mathematics, the content areas for science at both grades are related, though the proportions of the assessment allocated to covering each content domain differs between the grades. There is more emphasis on Life Science at Fourth Grade than its equivalent, Biology, at the Eighth Grade (45% and 35%, respectively). At Eighth Grade, Physics and Chemistry are assessed as separate content domains; at Fourth Grade, they are assessed as one domain (Physical Science). The Earth Science content domain has been allocated the same proportions at both grades, although the objectives at Eighth Grade are more advanced than at Fourth Grade. Similar to mathematics, the final distribution of the items was broadly similar to the target proportion outlined in the Assessment Framework.

For both science and mathematics, at both levels, there are three cognitive domains – Knowing, Applying, and Reasoning. Items assessing Knowing are relatively more common at Fourth Grade, and items assessing Reasoning at Eighth Grade. The Assessment Framework for mathematics at Fourth Grade specifies that 40% of the items are dedicated to Knowing, 40% to Applying, and 20% to Reasoning. The corresponding proportions at Eighth Grade are 35%, 40%, and 25%, respectively. Reasoning skills, which require students to analyse information, draw conclusions, and widen their understandings to new situations are more frequently used at Eighth Grade (25% and 30% for mathematics and science, respectively) compared to Fourth Grade (20% for both mathematics and science). The final distribution of the three cognitive domains in the TIMSS 2023 assessment were broadly similar to the target proportions. Some small differences were observed (e.g., with relatively fewer Knowing items in mathematics at both grade levels, and relatively more Applying items in Fourth Grade mathematics and Eighth Grade science).

What contextual information is collected?

As well as collecting data on student achievement in mathematics and science, TIMSS gathers a range of information about the contexts for student learning. These contextual data can provide important insights into factors associated with mathematics and science achievement, as well as other outcomes (such as students' sense of school belonging). TIMSS collects information about students' demographic characteristics, opinions, and experiences, and about the home, classroom, school, and national contexts in which they learn. The collection of contextual information is guided by the TIMSS 2023 Context Questionnaire Framework (Mullis et al., 2021). Like the development of the mathematics and science framework, the framework was updated and developed from the previous cycle by the TIMSS and PIRLS International Study Center, the IEA, the TIMSS 2023 Questionnaire Item Review Committee, and the TIMSS 2023 National Research Coordinators in participating countries.

In Ireland, all questionnaires were made available in paper and online formats to ensure the highest possible response rates. Table 1.5 provides a summary of the types and sources of contextual data gathered in TIMSS 2023. The various instruments include:

Student Questionnaire

Participating students completed a questionnaire directly after the mathematics and science assessment. This questionnaire collected information about students' home environment, such as resources for learning, as well as students' experiences in school (e.g., sense of school belonging, bullying) and attitudes towards mathematics and science.

Test-taking Questionnaire

As mentioned, Ireland transitioned to digital testing in 2023. For this reason, students in Ireland were also presented with an additional short paper questionnaire which collected information on students' attitudes to the test, the types of questions they were asked, and if they had completed a test on computer before.

School Questionnaire

Principals of participating schools were asked to complete a questionnaire which included questions about school characteristics (e.g., school location, school size, socioeconomic profile), principals' qualifications and experience, and school resources. For TIMSS 2023, new questions were added about the length of time for which schools were closed during the COVID-19 pandemic.

Teacher Questionnaire

The Teacher Questionnaire was completed by students' mathematics and science teachers. In general, there was one classroom teacher for each Fourth Class group and separate mathematics and science teachers for Second Year students. Teachers were asked to complete a questionnaire about classroom contexts (e.g., instructional practices, availability and use of technology) and teacher characteristics (e.g., teacher qualifications, experience, job satisfaction).

Home Questionnaire (*Fourth Grade only*)

Parents/guardians of participating pupils were asked to complete a questionnaire (known as the Early Learning Survey). This questionnaire collected information related to the home environment, including participation in early childhood education, early literacy and numeracy activities, and parents'/guardians' educational and professional backgrounds.

Test-Curriculum Matching Analysis (TCMA)

The TIMSS assessments are designed to ensure the widest possible coverage of mathematics and science curricula in each participating country. Given the variation in these curricular areas across countries, it is inevitable that the assessments will not reflect the relevant curriculum in each participating country perfectly. For this reason, each country conducts a TCMA. Subject experts (in Ireland, Professional Learning Leaders in Oide) conducted a review of all items included in the TIMSS assessment for each subject, at both primary and post-primary levels. They estimated whether each item would have been covered, as part of the curriculum, by the majority of students at the target grade level by the time of TIMSS testing (in Ireland, March/April). The following curricula were used as reference points for students who participated in TIMSS 2023:

- › *Fourth Grade mathematics*: 1999 Primary Mathematics Curriculum – Fourth Class.
- › *Fourth Grade science*: 1999 Primary Science Curriculum – Third/Fourth Class.
- › *Eighth Grade mathematics*: Junior Cycle mathematics.
- › *Eighth Grade science*: Junior Cycle science.

Curriculum Questionnaire and TIMSS Encyclopaedia

Information about national education systems at a high level is captured through the Curriculum Questionnaire and the TIMSS Encyclopaedia, which includes chapters describing national policies on early childhood education, age of school entry, teacher education and principal professional development, and mathematics and science curricula at each target grade level for each country (<https://timss2023.org/encyclopedia>). In Ireland, this was completed by the ERC in conjunction with colleagues with curriculum and education experience at the Department of Education and the National Council for Curriculum and Assessment (NCCA).

Table 1.5: Summary of data gathered and data sources for TIMSS 2023

Type of data	Source	Instrument
Mathematics achievement	Student	Test
Science achievement	Student	Test
Student background and attitudes	Student	Student Questionnaire
Test-taking attitudes and behaviours (<i>Ireland only</i>)	Student	Test-Taking questionnaire
School environment and resources	Principals	School Questionnaire
Classroom environment and teaching practices	Teachers	Teacher Questionnaire
Home background (<i>Fourth Class only</i>)	Parents	Early Learning Survey (Home Questionnaire)
Overlap between national curriculum and TIMSS assessment	Subject experts	Test-Curriculum Matching Analysis
Structure and policies of the national education system	Department of Education / NCCA / ERC	Curriculum Questionnaire and Encyclopaedia country chapter

How to interpret the analyses in this report

The following notes can be used to interpret the results reported in the following chapters:

Achievement scores

Estimates of student achievement are reported on a scale that was set to a centrepoint of 500 in 1995 (reflecting average achievement internationally during the first TIMSS cycle). The scale's standard deviation (SD) was set to 100. This means that, in 1995, approximately 68% of students' scores fell between 400 and 600 on the scale (i.e., 500 ± 1 SD), and 95% of scores fell between 300 and 700 (i.e., 500 ± 2 SD).

Subsequent iterations of the study have retained this marker as the scale centrepoint (i.e., as a constant point of reference between assessments). This means that it is no longer considered an international average, which varies across cycles depending on which countries participate. However, countries that take part in multiple cycles of TIMSS can use this marker to monitor how their national performance changes over time with reference to this constant.

Both domains (mathematics and science) are reported on scales that are set to a centrepoint of 500 in the same way, but they are constructed independently and should be considered as separate measures. For example, it would not be correct to say that a student who achieves a mathematics score of 520 and a science score of 520 is equally proficient at mathematics and science. Performance should be interpreted relative to other students within a domain, but not across domains.

Similarly, the subscales calculated for each cognitive and content domain are created independently of the main scales by using only the subset of items that belong to that content or cognitive domain, and were also originally set, in 1995, to a centrepoint of 500.

Measures of uncertainty

When a subgroup within a country comprises less than 2.5% of the population, their estimated mean achievement is not reported here as the uncertainty of the estimate increases when small numbers are involved.

Standard errors (SEs)

Estimates of achievement are prone to uncertainty arising from sampling and measurement error. To quantify this error, when a mean achievement score or percentage is estimated for a group (e.g., for all students in Ireland), this value is accompanied by a standard error (SE). The SE is a gauge of the level of uncertainty around the mean estimate. The smaller the SE, the more confident we can be that the observed value is likely to reflect that of the population. Conversely, larger SEs indicate more uncertainty around the mean estimate.

For example, while the SE around the estimate of achievement for all Fourth Class pupils in Ireland is relatively small, the SE around the estimate of achievement for Fourth Class pupils in DEIS Urban Band 1 schools is larger, reflecting the fact that our sample of the pupils in this subset of schools is smaller and less representative of the overall population.

Confidence intervals (CIs)

A 95% confidence interval (CI) is a range of values such that there is a 95% probability that the true population score lies within this interval. We can create 95% CI around a mean achievement score by (i) multiplying our estimated SE by 1.96, and (ii) adding this amount to, and subtracting it from, the mean score. Often – although not always – if the CIs around two sets of means scores overlap, it indicates that the difference between the

two means is not statistically significant. Conversely, if two CIs do not overlap, that indicates a statistically significant difference in means.

For a quick approximation, the SE can be multiplied by 2 instead of 1.96. For example, the confidence interval around a mean achievement score of 520 (SE = 3) is roughly 514-526. This means that there is a 95% chance that the true population mean falls within this range.

Statistical significance

A difference between groups is considered statistically significant if we can be confident that it is unlikely to have occurred by chance. In this report, statistical significance tests are reported at the 95% confidence level and measurement and sampling error are accounted for in the statistical comparisons. For example, as noted above, if the confidence intervals around two mean achievement scores do not overlap (e.g., 514-525 vs 527-531), the difference between them can be considered statistically significant. Where reference is made to a *significant difference* (i.e., *significantly lower* or *significantly higher*) in this report, a test of statistical significance has been conducted.³

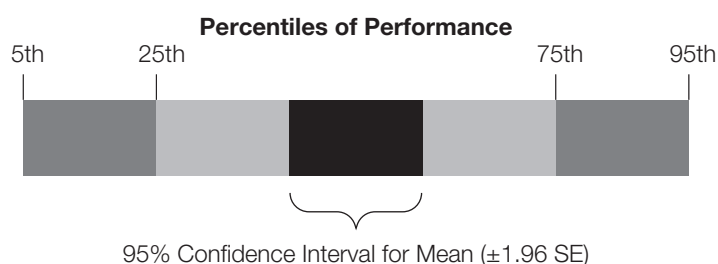
Readers should note that a statistically significant difference does not necessarily imply that a difference is substantive or meaningful in terms of its implications for policy or practice.

Percentiles of performance

Student performance can also be examined using percentiles, which can be interpreted as indicating that a *student at the xth percentile of a given group performed as well as or better than x% of the students in that group*. For example, a student at the 20th percentile achieved a mean score at least as high or higher than 20% of their peers. Students at the 5th percentile of a group are among the lowest-achieving students in that group, while those at the 95th percentile are among the highest-achieving students.

In this report, the distributions of performance are presented graphically (see Figure 1.1). The black band in the middle of each distribution represents the 95% CI around the mean achievement score, taking into account sampling and measurement error. The light grey bands on the left represents the range of achievement from the 25th percentile to the lower limit of the CI, while the light grey band on the right represents the range from the upper limit of the CI to the 75th percentile. The dark grey bands at either end of the distribution represent the range from the 5th to the 25th percentile (left) and from the 75th to the 95th percentile (right).

Figure 1.1: Percentiles of performance



³ Statistical significance testing in this report was conducted in line with the approaches used by the IEA for the international TIMSS reports. Specifically, the z-distribution was utilised for all tests of statistical significance.

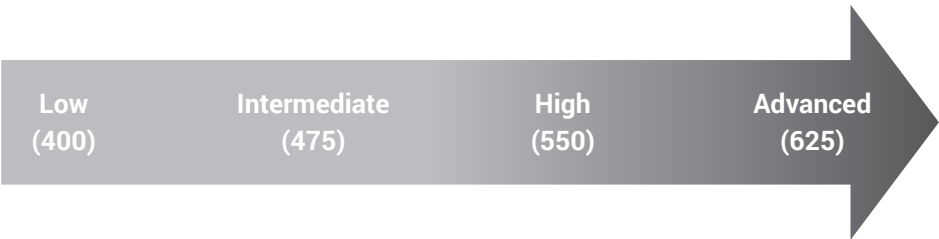
Benchmarks

The TIMSS International Benchmarks are used to describe the specific skills and knowledge that students can demonstrate at various levels of mathematics and science achievement. Each participating student is categorised as reaching one of four benchmarks for each domain. Specific descriptors for the mathematics and science benchmarks for Fourth and Eighth Grade students are provided in the relevant chapters (Chapters 3-6).

The TIMSS International Benchmarks are defined relative to specified thresholds on the continuous TIMSS achievement scale (see Figure 1.2) and are described in terms of specific skills and knowledge that students meeting these thresholds can reliably and successfully apply. For example, a student achieving 460 points on the mathematics assessment can be said to have reached the *Low International Benchmark* of mathematics performance. Another student scoring 549 points will have reached the *Intermediate International Benchmark*. A student scoring below 400 (i.e., more than one standard deviation below the scale centrepont of 500) is described as not reaching the *Low International Benchmark*. The skills and knowledge of students below the Low Benchmark cannot be reliably assessed by the items in the TIMSS assessments.⁴

The thresholds that are used to differentiate between the benchmarks were determined internationally by drawing on detailed analyses of students' performance and particular items that are used to anchor each benchmark. Anchoring items are items that can consistently be completed successfully by students reaching a given benchmark, but not by students reaching lower benchmarks. The particular characteristics of these anchoring items – the required content and cognitive demands – define the types of skills that students at a higher benchmark can consistently demonstrate. As a result of this design, students' categorisation at the International Benchmarks is cumulative. That is, a student who reaches the *High International Benchmark* can, by definition, demonstrate the skills expected at the *Low* and *Intermediate International Benchmarks* as well as the additional skills that are specific to the *High International Benchmark*.

Figure 1.2: TIMSS International Benchmarks reached by students scoring at or above each scale score thresholds



For further details on the construction of the International Benchmarks, anchoring items and the specified thresholds, please see von Davier et al. (2024).

⁴ Countries with large proportions of students in this category can opt to participate in 'less difficult' TIMSS, which is linked to the same scale but has items at a lower level of difficulty to enable information about which items are answered correctly to be gathered.

Chapter 2: TIMSS in Ireland

In Ireland, Fourth Class and Second Year students participated in the TIMSS main study in March and April 2023. Despite some ongoing adjustments to school life following the COVID-19 pandemic, TIMSS 2023 data offer a valuable opportunity to compare student achievement before and after COVID-19. Prior to the main study, a field trial was conducted in spring 2022 to test the study materials and procedures in a smaller sample of schools. The implementation of TIMSS in Ireland was overseen by a National Advisory Committee at each grade level, including representatives from the NCCA, the State Examinations Commission (SEC), and academics with expertise in mathematics and science education.

Who took part in TIMSS 2023 in Ireland?

The Fourth Class and Second Year samples for TIMSS 2023 were drawn by the international TIMSS consortium, led by RTI International with the support of the IEA Hamburg sampling team, and in consultation with the ERC. Sampling at each grade level took place in two stages.

First, 154 primary and 154 post-primary schools were selected from lists of all primary and post-primary schools in Ireland. To ensure representative samples, all schools were stratified by various characteristics and then randomly selected from each stratum. At primary level, schools were stratified by DEIS status (*DEIS Urban Band 1*, *DEIS Urban Band 2*, *DEIS Rural*, or *non-DEIS*); school gender (*all girls*, *all boys*, or *mixed*); language of instruction (*ordinary school* [medium of instruction is English], *Gaeltacht school* [in Irish-speaking area], or *all Irish school* [all Irish school in English-speaking area]); and school location (*Dublin and cities* or *towns and rural areas*). At post-primary level, schools were stratified by school sector (*secondary*, *vocational*, or *community/comprehensive*); school gender (*all girls*, *all boys*, or *mixed*); and school socioeconomic status (*low*, *medium*, or *high*) based on the percentage of students in a school eligible for the Junior Certificate fee waiver.⁵ The post-primary sample was carefully selected to minimise overlap with the set of schools that participated in the Programme for International Student Assessment (PISA) 2022 main study in autumn 2022 to avoid overburdening individual schools, given that both the PISA 2022 and TIMSS 2023 main studies took place in the same academic year (2022/23) in Ireland.

One of the selected primary schools was not eligible to participate due to not having students at the target grade level at the time of testing, and another school was unable to participate and was replaced. At post-primary level, two schools were unable to participate and were replaced. In addition, the response rate in the selected class of one post-primary school did not reach the minimum 50% threshold (von Davier et al., 2024) to be included in the final dataset. The final TIMSS 2023 dataset includes 153 primary and 153 post-primary schools, giving weighted school response rates of 100.0% at primary level and 99.4% at post-primary level.

The next stage of sampling involved selecting classes within schools. Participating primary schools were asked to indicate the number of Fourth Class groups in their school. Where a school had either one or two Fourth Class groups, all Fourth Class pupils were selected to take part in the assessment. Where a school had three or more Fourth Class groups, two of them were selected at random by the ERC using specialised sampling software provided by the IEA. Post-primary schools provided the number of Second Year base class groups (i.e., the class groups into which students are grouped for tutor groups or form groups) in their school, and depending on the size of the school, either one class group (in schools with 150 students or fewer) or two class groups (in schools with more than 150 students) were selected at random. All selected classes – 230 Fourth

⁵ Data used for the sampling frame were based on the 2019/20 school year.

Class groups at primary level and 246 Second Year class groups at post-primary level – took part in the study, giving weighted class response rates of 100.0% at both grade levels.

All students in selected classes were encouraged to participate, and special accommodations (e.g., a magnified booklet for students with visual impairment) were made where necessary, and if possible. However, a small number of students were excluded from the assessment at their teacher’s discretion due to functional or intellectual disabilities or limited English/Irish proficiency at both grade levels (Table 2.1).

Table 2.1: Numbers and percentages of students excluded from TIMSS 2023 at Fourth Class and Second Year in Ireland

	Fourth Class		Second Year	
	N	%	N	%
Students with functional disabilities	5	0.1	19	0.3
Students with intellectual disabilities	26	0.5	49	0.8
Non-native language speakers	36	0.7	75	1.2
Total	67	1.3	143	2.3

Note. Teachers were advised to exclude only students who had been in Ireland for less than one year (and therefore had received less than one year of instruction in English/Irish at the time of the TIMSS test) and if they believed these students would struggle to attempt the test due to limited language proficiency. Teachers were encouraged to include any students who they believed could reasonably attempt the test.

After exclusions (as outlined in Table 2.1), 5,166 Fourth Class pupils and 6,091 Second Year students were eligible to participate in TIMSS 2023. Of these, parental permission to participate in the study was denied for 14 pupils (0.3%) at Fourth Class and 96 (1.6%) students at Second Year. These rates show a decrease in parental withdrawals at Fourth Class relative to the TIMSS 2019 cycle, down from 233 (4.6%), while the rate at Second Year remained relatively stable following 82 withdrawals (1.8%) in 2019 (Perkins & Clerkin, 2020). In addition, in the period between sampling and testing, 68 Fourth Class pupils and 51 Second Year students had left their schools permanently and were no longer considered eligible for testing, while 334 (6.5%) Fourth Class pupils and 854 (14.0%) Second Year students were absent on the day of testing.

Table 2.2 presents the final (weighted) response rates for the tests and questionnaires at Fourth Class, after accounting for parental withdrawals and student exclusions and absences. In total, 4,750 Fourth Class pupils (93.3% after weighting) completed at least part of the test.^{6, 7} Similar proportions of boys (51.3%) and girls (48.7%) participated in the assessment.⁸

Of the 4,750 pupils who completed the test, nearly all (99.7%) also completed a Pupil Questionnaire. The return rate for the Home Questionnaire, while high, was slightly lower than that of the Pupil Questionnaire, at 94.2%. Anecdotal evidence suggests that some parents/guardians were hesitant to provide personal details, which influenced their decision not to return the questionnaire. Teachers of 4,723 pupils (99.6%) and school principals of the vast majority of pupils (97.7%) returned their respective questionnaires.

6 Among these Fourth Class pupils, 58 participated in the achievement session with special accommodation, and 57 participated in the questionnaire session with special accommodation.

7 The overall weighted participation rate at Fourth Class, taking into consideration the school (100.0%), class (100.0%), and student (93.3%) participation rates, is 93.3%.

8 In line with the approach taken in the international TIMSS report, this report uses the *ITSEX* variable—reflecting pupil gender as indicated by their school—for all analyses involving pupil gender, rather than the equivalent variable from the Pupil Questionnaire. It is important to note, though, that, for the first time in TIMSS 2023, Fourth Class pupils were given three options when asked about their gender: *boy, girl, other*.

Table 2.2: Weighted response rates to tests and questionnaires at Fourth Class in Ireland

	N	Weighted %
TIMSS test	4,750	93.3
Pupil Questionnaire	4,735	99.7
Home Questionnaire (Early Learning Survey)	4,465	94.2
Teacher Questionnaire	4,723	99.6
School Questionnaire	4,684	97.7

Note. Response rates for the questionnaires are reported based on the number of pupils who completed a test and whose parents/guardians, teachers, or school principals completed the corresponding questionnaires. Pupils for whom questionnaire data exist but no test data are available are not included.

Table 2.3 presents the final (weighted) response rates for the tests and questionnaires at Second Year, after accounting for parental withdrawals and student exclusions and absences. In total, 5,090 Second Year students (84.1% after weighting) completed at least one part of the test.^{9, 10, 11} The sample comprised slightly more boys (53.2%) than girls (46.8%).¹² Of the 5,090 students who completed the test, nearly all (98.7%) also completed a Student Questionnaire. The students' mathematics and science teachers were also invited to complete questionnaires.^{13, 14} School principals of 94.0% of students returned a School Questionnaire.

Table 2.3: Weighted response rates to tests and questionnaires at Second Year in Ireland

	N	Weighted %
TIMSS test	5,090	84.1
Student Questionnaire	5,043	98.7
Mathematics Teacher Questionnaire	4,618	90.3
Science Teacher Questionnaire	4,590	91.6
School Questionnaire	4,768	94.0

Note. Response rates for the questionnaires are reported based on the number of students who completed a test and whose teachers or school principals completed the corresponding questionnaires. Students for whom questionnaire data exist but no test data are available are not included. Of the participating students, 5,090 had at least one mathematics teacher who received a questionnaire and 4,902 had at least one science teacher who received a questionnaire.

Overall, the weighted student response rates in TIMSS 2023 increased by 2.3 percentage points at Fourth Class and decreased by 3.9 percentage points at Second Year compared to the response rates in TIMSS 2019 (Perkins & Clerkin, 2020). This small decrease at Second Year in 2023 was due to a higher absence rate among eligible students, as may have been expected given guidance around COVID-19 at the time. In 2023, response rates for the Home and Teacher Questionnaires at Fourth Class were slightly higher compared to the previous TIMSS cycle. However, response rates for the Teacher Questionnaires at Second Year, as well as the School Questionnaires for both Fourth Class and Second Year, were slightly lower than those in the previous cycle.

9 A minority of students missed the first part of the test due to arriving late or left after the first part of the test due to other circumstances.

10 Among these Second Year students, five participated in the achievement and questionnaire sessions with special accommodation.

11 The overall weighted response rate at Second Year, taking into consideration the school (99.4%), class (100.0%), and student (84.1%) response rates, is 83.6%.

12 In line with the approach taken in the international TIMSS report, this report uses the *ITSEX* variable—reflecting student gender as indicated by their school—for all analyses involving student gender, rather than the equivalent variable from the Student Questionnaire. It is important to note, though, that, for the first time in TIMSS 2023, Second Year students were given four options when asked about their gender: *boy, girl, non-binary, other*.

13 Of the Second Year students who completed at least part of the TIMSS test, 92.4% studied science.

14 Some Second Year students in Ireland had more than one mathematics and/or science teacher. The response rates presented here refer to the weighted percentage of students whose teachers returned a questionnaire.

Considering the numerous COVID-19-related demands on students, parents/guardians, and school staff during and leading up to the 2023 testing period, the achieved response rates highlight a strong commitment across each of these groups to participating as fully as possible in TIMSS. This collective effort has ensured that the data collected can be considered representative of the wider population of students at both grade levels for this cycle of TIMSS in Ireland.

Administration of TIMSS 2023 in Ireland

Both primary and post-primary schools participating in the main study were asked to conduct TIMSS between March and April 2023. Each school nominated a designated TIMSS School Coordinator to liaise with the ERC in advance of testing. Materials, including test booklets, questionnaires, and manuals (e.g., explaining procedures related to the standardised administration of the assessment), were sent to each School Coordinator at least two weeks before the test date in most cases. Informational videos for both students and parents/guardians were made available on the ERC website several months prior to the administration, and School Coordinators were asked to direct people to these resources as necessary. Information letters for parents/guardians were also included in the materials sent to the School Coordinators, who were asked to provide each student with a letter to give to their parents/guardians at least one week in advance of testing. Parents/guardians had the option to withdraw their child from the assessment by contacting the ERC using information provided in their letter.

During test administration, students were provided with information about data protection on the first screen of their questionnaire. Teachers administered the assessment in primary schools, while Test Administrators, employed and trained by the ERC, administered the assessment in post-primary schools. Several external collaborators, employed and trained (where necessary) by the ERC, were instrumental in the administration of TIMSS 2023 in Ireland. Their contributions included translating materials from English to Irish and other languages (including Lithuanian, Polish, Romanian, and Ukrainian), providing laptops and necessary equipment, offering technical support, and handling data entry for paper-based materials.

Test administration

The main study across both grade levels was administered using laptops provided by the ERC. Fourth Class pupils were allowed 72 minutes to complete their two-part test, while Second Year students were allowed 90 minutes to complete their two-part test. A short break was given between the two test parts at both grade levels.

TIMSS uses a rotated booklet design where each student receives only a subset of the total pool of items. There were 14 test booklets in total at each grade level, with each student completing just one booklet. As described in Chapter 1, items are repeated across booklets to enable linkage of student performance across different sets. Each booklet comprised both mathematics and science items, with equal testing time allocated to each subject.

At primary level, 20 participating schools taught through Irish (Gaelscoileanna and schools in Gaeltacht areas). Teachers could choose to administer the tests to their Fourth Class pupils, as a whole class, in either Irish or English. Of these schools, five chose to administer the test materials in Irish, resulting in 110 pupils completing the assessment in Irish. At post-primary level, eight participating schools taught through Irish (Gaelscoileanna and schools in Gaeltacht areas). As with primary schools, teachers of post-primary schools could choose to administer the tests to their Second Year students, as a whole class, in either Irish or English.

Of these schools, seven chose to administer the test materials in Irish, resulting in 155 students completing the assessment in Irish.

Questionnaire administration

Student Questionnaires

After the test (following a short break), students at both grade levels were asked to complete a 30-minute questionnaire that asked about their home background, and their experiences of and attitudes towards school and learning mathematics and science. In Ireland, both Fourth Class pupils and Second Year students were also asked to complete a five-minute national questionnaire (Test-Taking Questionnaire) regarding their experience with the TIMSS test.

Home Questionnaire (Early Learning Survey)

School Coordinators were instructed to distribute an envelope including the Home Questionnaire (Early Learning Survey) (alongside a cover letter and a return envelope in which completed questionnaires could be sealed) to each participating Fourth Class pupil at least one week before testing. In turn, pupils were asked to give those questionnaires to their parents/guardians. This questionnaire, which could be completed digitally or on paper, and in English or Irish for parents/guardians of pupils attending Irish-medium schools, asked pupils' parents/guardians about pupils' home environments, including educational resources at home, parental involvement in their child's education, and socioeconomic status. School Coordinators were responsible for returning all Home Questionnaires in their envelopes, whether completed (digitally or on paper) or blank, to the ERC when returning all testing materials after testing had taken place.

Teacher Questionnaires

The class teachers of Fourth Class pupils and the mathematics and science teachers of Second Year students at the time of testing were asked to complete Teacher Questionnaires, which were distributed to them (alongside a cover letter and a return envelope in which completed questionnaires could be sealed) by the School Coordinators at least one week before testing. The Teacher Questionnaires at both grade levels could be completed digitally or on paper, and in English or Irish for teachers in Irish-medium schools. The Teacher Questionnaire for Fourth Class asked about teachers' instructional practices, their professional development, and their perceptions of the school environment and resources. Similarly, the Mathematics and Science Teacher Questionnaires for Second Year asked about teachers' instructional practices, their professional development, and their perceptions of curriculum and classroom resources specific to mathematics and science. School Coordinators of primary schools were responsible for returning all Teacher Questionnaires in their envelopes, whether completed (digitally or on paper) or blank, directly to the ERC when returning all test materials, while School Coordinators of post-primary schools were responsible for returning all Teacher Questionnaires in their envelopes, whether completed (digitally or on paper) or blank, to the Test Administrator, who then managed their return to the ERC.

School Questionnaire

The school principal or an assigned deputy or assistant principal in each participating school was asked to complete a School Questionnaire, which was distributed to them (alongside a cover letter and a return envelope in which completed questionnaires could be sealed) by the School Coordinators at least one week before testing. The School Questionnaires at both grade levels could be completed digitally or on paper, and in English or Irish for school principals in Irish-medium schools. The School Questionnaire asked about a range of topics, including school characteristics, educational practices, curriculum emphases, and resources available

to support student learning. School Coordinators of primary schools were responsible for returning all School Questionnaires in their envelopes, whether completed (digitally or on paper) or blank, directly to the ERC when returning all testing materials, while School Coordinators of post-primary schools were responsible for returning all School Questionnaires in their envelopes, whether completed (digitally or on paper) or blank, to the Test Administrator, who then managed their return to the ERC.

Quality monitoring

As required for participation in TIMSS, all aspects of the study administration in Ireland were implemented in adherence to the IEA's international standard operating procedures. This included several layers of quality monitoring which was carried out, as in all participating countries, to ensure that the same testing procedures were applied within and across countries.

International quality control monitors, employed and trained by the IEA, visited approximately 10% of participating schools at each grade level on their testing day. Additionally, a separate set of schools, again, approximately 10% at each grade level, were visited by national quality control monitors, who were members of the Department of Education Inspectorate and trained by the ERC in relation to TIMSS quality monitoring. The role of quality control monitors, both international and national, was to observe testing sessions and to interview School Coordinators to ensure that international testing standards were adhered to, as well as to seek schools' feedback about their experience of administering the study (e.g., the quality of communication with the ERC, quality of manuals and information provided). The feedback received from these quality monitors indicated that the administration of TIMSS in Ireland met all required standards.

Certain quality monitoring procedures were also implemented to ensure that students' responses to constructed-response test items were scored accurately according to TIMSS international standards and guidelines for both assessment modes (digital and paper). These responses were scored, using the international scoring guides, by trained scorers at the ERC, whose work was overseen by ERC staff members who had been trained directly by the IEA. Digital scoring provided the advantage of real-time checks on scores assigned to student responses, allowing scorers to flag responses for review by ERC staff, who could promptly approve or correct scores without delays.

To establish the reliability of TIMSS 2023 scoring within each country, a random sample of 200 responses for each constructed-response item was scored twice by two independent scorers. The degree of agreement between scores served as the measure of scoring reliability. Additionally, scorers in Ireland and other participating countries with English as a language of the test were required to score a common set of English-language responses to assess cross-country scoring reliability. Due to the transition from paper to digital administration in 2023, scoring reliability across cycles could not be assessed in Ireland on this occasion because sufficient items were not available from the previous (paper-based) cycle in 2019.

Chapter 3:

Fourth Class Mathematics

This chapter describes performance on the TIMSS 2023 Fourth Grade mathematics test. Overall performance is explored as well as the distribution of achievement (performance at various percentiles), performance at the International Benchmarks and performance on the content and cognitive domains.

For each of these sections, performance in Ireland is explored in the context of selected countries (as described in Chapter 1); compared with three previous cycles of TIMSS at Fourth Grade (2019, 2015, and 2011); examined by gender; and where applicable, examined by different socioeconomic measures (school DEIS status and a TIMSS-derived measure of individual socioeconomic status).

Finally, curriculum coverage for Fourth Class mathematics is explored. As mentioned in Chapter 1, TIMSS is a curriculum-based study and as part of this, a Test-Curriculum Matching Analysis (TCMA) is conducted for each cycle. This section presents the results of the TCMA, followed by teachers' report of TIMSS topic coverage.

Mean achievement for Fourth Class mathematics

This section describes overall performance on the mathematics test for pupils in each country and benchmarking participant that took part in TIMSS 2023. Performance in Ireland is compared across three previous cycles of TIMSS (2019, 2015, and 2011) as well as exploring the differences from the most recent cycle in Ireland and selected countries. Within Ireland, differences in the mean mathematics achievement of girls and boys and two variables relating to socioeconomic status are also presented.

Overall results

Table 3.1 presents the mean Fourth Grade mathematics achievement of TIMSS pupils in Ireland and all other participating countries and benchmarking participants. At Fourth Grade, 58 countries and five benchmarking participants took part in TIMSS 2023.¹⁵ Pupils in Singapore achieved the highest mean score in mathematics (615), followed by Chinese Taipei (607), the Republic of Korea (594), and Hong Kong (594).

Fourth Class pupils in Ireland achieved a mean mathematics score of 546, which was significantly above the TIMSS international average (503). Pupils in seven countries (Singapore, Chinese Taipei, the Republic of Korea, Hong Kong, Japan, Macao, and Lithuania) achieved a mean mathematics score which was significantly above pupils in Ireland. Four countries (Türkiye, England, Poland, and Romania) had a mean mathematics score which was similar and not statistically significantly different to Ireland. Finally, 46 countries including Sweden, Australia, Finland, and the United States achieved significantly lower mean mathematics scores than pupils in Ireland.

Twenty-one countries in the European Union (EU) participated in TIMSS 2023 and of these, Lithuania was the only EU country which achieved a mean mathematics score that was significantly higher than the mean mathematics score for Ireland. Two countries in the EU had a similar and not significantly different mean mathematics score to Ireland (Poland and Romania).

Table 3.1 also shows the standard deviation for each participating country and benchmarking participant. The standard deviation for Fourth Class pupils in mathematics was 82 scale points. Kuwait had the largest standard deviation of 115 scale points while the Netherlands had the smallest standard deviation of 65 scale points.

¹⁵ Iraq and the Kurdistan Region of Iraq also participated at Fourth Grade but their data are not included because of data quality issues.

Table 3.1: Mean achievement scores and standard errors of countries and benchmarking participants, Fourth Grade mathematics

Country				Mean	(SE)	SD	Country	Mean	(SE)	SD	
Singapore				615	(2.9)	88	Canada	504	(2.0)	81	
Chinese Taipei				607	(1.7)	67	TIMSS 2023 International Average	503	(0.4)	-	
Korea, Rep. of				594	(2.6)	75	Spain	498	(2.1)	75	
Hong Kong SAR				594	(4.0)	84	United Arab Emirates	498	(1.2)	107	
Japan				591	(2.3)	71	Georgia	498	(3.1)	79	
Macao SAR				582	(1.0)	79	Azerbaijan	494	(3.5)	91	
Lithuania				561	(2.9)	76	New Zealand	490	(2.6)	91	
Türkiye (5)				553	(4.1)	99	Belgium (French)	489	(2.4)	76	
England				552	(2.7)	92	Kazakhstan	487	(3.6)	87	
Poland				546	(2.0)	76	France	484	(2.9)	77	
Ireland				546	(2.9)	82	Montenegro	477	(2.1)	76	
Romania				542	(4.8)	85	North Macedonia	474	(3.6)	85	
Netherlands				537	(2.0)	65	Qatar	464	(3.5)	97	
Latvia				534	(2.8)	77	Bahrain	462	(4.1)	99	
Norway (5)				531	(2.0)	74	Kosovo	451	(3.4)	80	
Czech Republic				530	(2.2)	74	Bosnia & Herzegovina	447	(3.2)	75	
Sweden				530	(2.8)	76	Chile	444	(2.8)	80	
Bulgaria				530	(3.6)	91	Uzbekistan	443	(3.2)	82	
Finland				529	(2.5)	80	Jordan	427	(5.3)	101	
Australia				525	(2.6)	91	Oman	421	(4.0)	99	
Germany				524	(2.1)	75	Iran, Islamic Rep. of	420	(4.2)	98	
Denmark				524	(2.1)	72	Saudi Arabia	420	(4.2)	94	
Serbia				523	(3.3)	80	Brazil	400	(3.4)	90	
Belgium (Flemish)				521	(2.4)	71	Morocco	393	(4.6)	102	
Hungary				520	(3.6)	91	Kuwait	382	(4.4)	115	
Portugal				517	(2.8)	82	South Africa (5)	362	(3.5)	114	
United States				517	(3.1)	97					
Cyprus				516	(2.5)	81	Benchmarking Participants				
Slovak Republic				515	(3.1)	81	Dubai, UAE	557	(1.6)	91	
Slovenia				514	(1.8)	73	Quebec, Canada	515	(2.7)	74	
Italy				513	(2.8)	80	Sharjah, UAE	504	(3.3)	96	
Armenia				513	(2.8)	70	Ontario, Canada	503	(3.4)	82	
Albania				512	(4.9)	81	Abu Dhabi, UAE	459	(1.9)	108	
	Average achievement significantly higher than Ireland							Average achievement significantly lower than Ireland			

Note. Norway, Türkiye, and South Africa assessed pupils in Fifth Grade rather than Fourth Grade.

Multiple comparisons are not taken into account when testing significant differences.

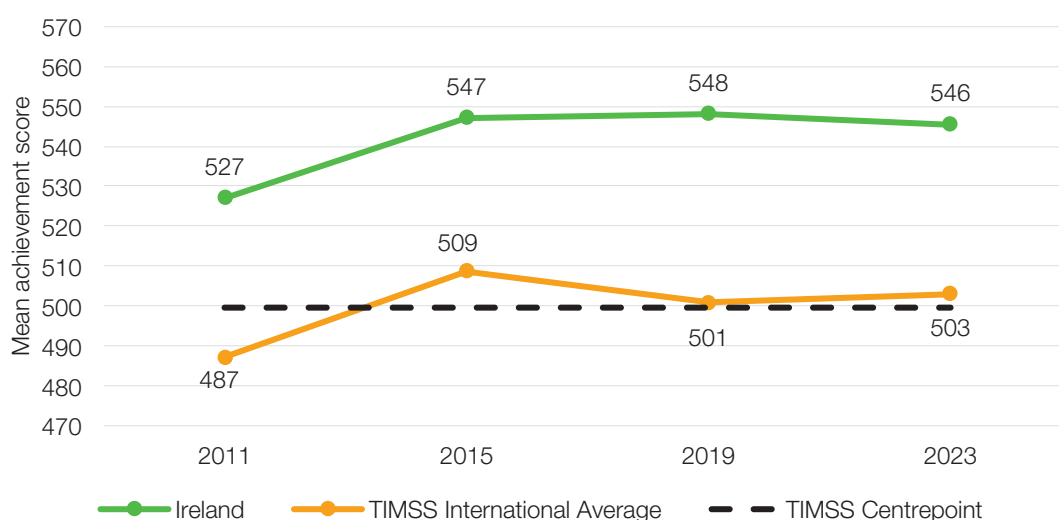
Source: e-Appendix Table A3.1.

Trends in achievement

Pupil achievement for each cycle of TIMSS has been placed on a common scale to enable the reliable monitoring of changes in achievement across assessment cycles. Figure 3.1 presents the mean mathematics achievement across TIMSS cycles for Fourth Class pupils. The TIMSS international average for any given cycle is the average mean score of the countries which participated in that cycle. This international average included 52 countries in 2011, 48 countries in 2015 and 58 countries in 2019 and 2023. The TIMSS centrepoint relates to the mean originally set in the first cycle of TIMSS and provides a stable reference point when examining trends over time.

In Ireland, the mean mathematics achievement in 2023 was similar to the achievement reported in the previous two cycles of TIMSS (2019 and 2015). The mean score in 2023 (546) was three score points (rounded) lower than in 2019 (548) and one score point lower than in 2015 (547). This suggests a high degree of stability in mean mathematics achievement since 2015. On the other hand, the mean mathematics achievement in 2023 is statistically significantly higher than in 2011 (527).

Figure 3.1: Mean achievement scores across TIMSS cycles for Ireland and TIMSS average, Fourth Grade mathematics

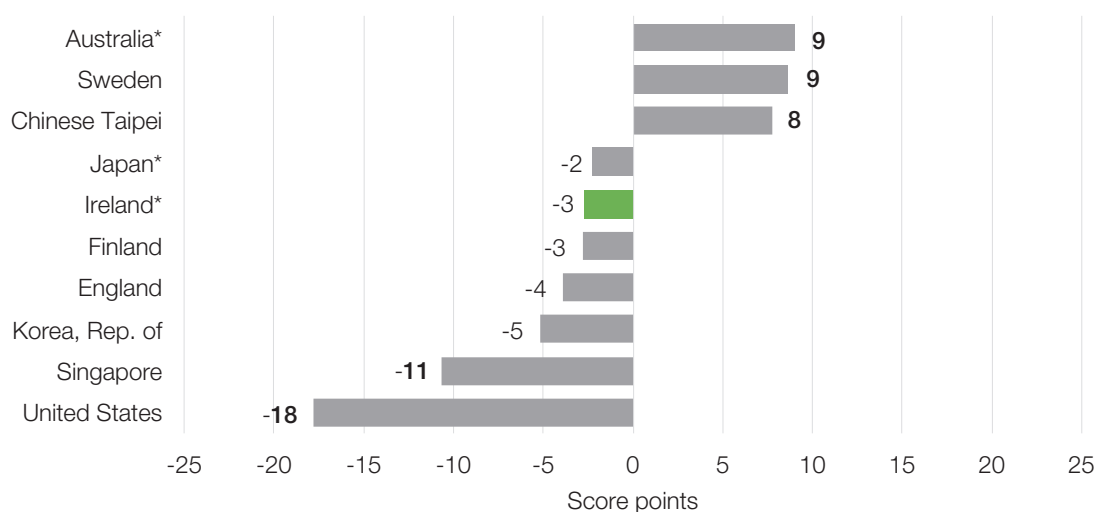


Note. TIMSS international average includes all countries that participated in the cycle. Countries included in TIMSS international average: 2023=58; 2019=58; 2015=48; 2011=52.

Source: e-Appendix Table A3.2.

Figure 3.2 shows the differences in the mean mathematics score between 2019 and 2023 for Ireland and selected countries. Countries that transitioned from paper to digital testing in this cycle among those selected include Australia, Ireland, and Japan. Three countries – Australia, Sweden, and Chinese Taipei – had a significant increase in mean mathematics performance from 2019 to 2023. For England, Finland, Japan, and the Republic of Korea, similar to Ireland, there were small but non-significant decreases in mean mathematics achievement. Singapore and the United States had significant decreases, of 11 score points and 18 score points respectively, in mean mathematics performance from 2019 to 2023.

Figure 3.2: Change in mean achievement score between 2019 and 2023 for Ireland and selected countries, Fourth Grade mathematics



Note. Figures in **bold** indicate a significant difference from the previous cycle.

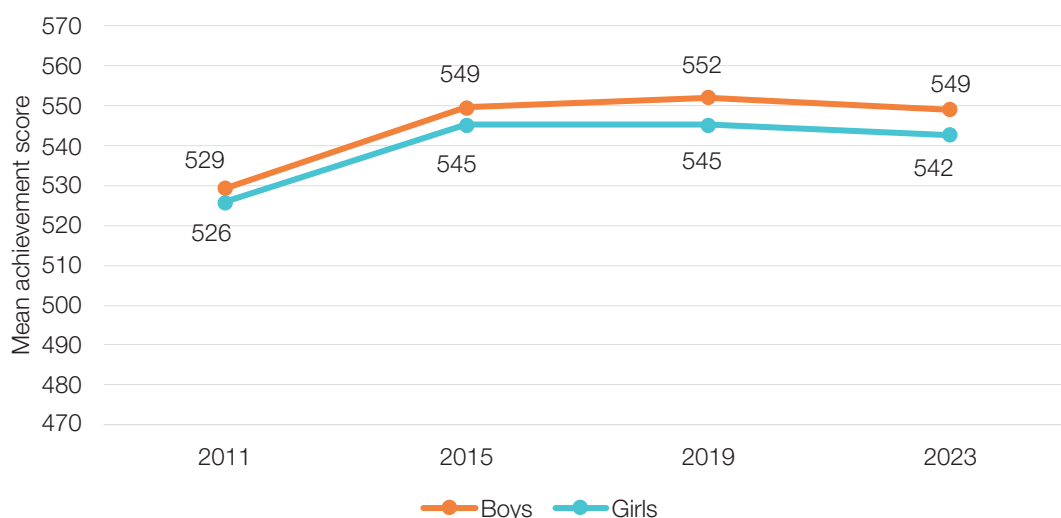
* indicates country changed mode of assessment in TIMSS 2023.

Source: e-Appendix Table A3.3.

Achievement differences by gender

Figure 3.3 shows the mean mathematics achievement of boys and girls at Fourth Class in TIMSS 2011, 2015, 2019, and 2023. In TIMSS 2023, the mean mathematics achievement of boys was 549, six score points higher (rounded) than that of girls (542). This advantage, in favour of boys, is non-significant. The 2023 gender gap of six score points is similar to the gap observed in TIMSS 2019 (seven) and slightly larger than the gaps observed in 2011 (three) and 2015 (four). The mean achievement of boys and girls disimproved slightly between 2019 and 2023 by similar amounts (three score points), resulting in a broadly similar gender difference.

Figure 3.3: Mean achievement scores among girls and boys in Ireland across TIMSS cycles, Fourth Class mathematics



Note. Figures in **bold** indicate a significant difference between boys and girls.

Source: e-Appendix Table A3.4.

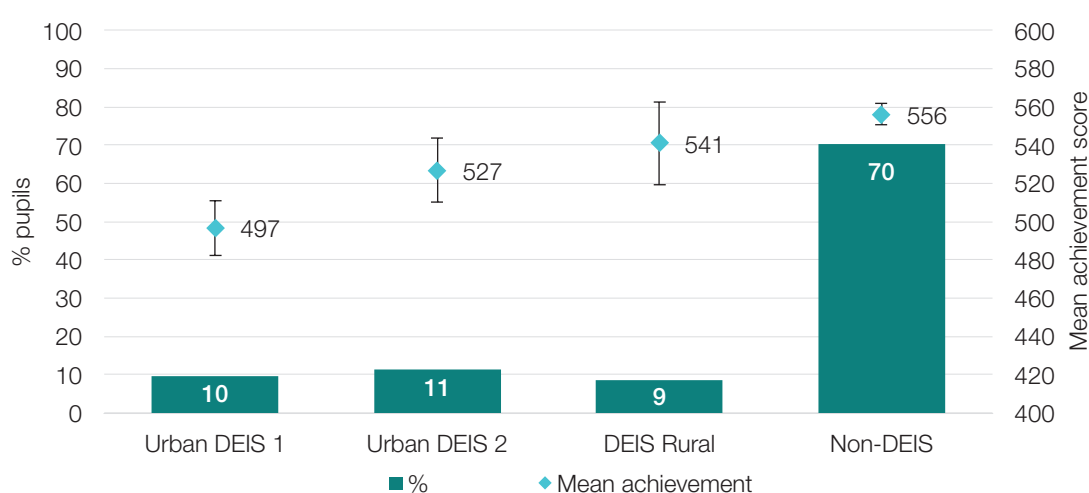
On average internationally, boys (508) significantly outperformed girls (498) by 11 score points. In 40 of the 58 TIMSS countries at Fourth Grade, boys had a significantly higher mean mathematics score than girls, with differences ranging from six score points for Finland to 23 score points for France (von Davier et al., 2024). In one country only, South Africa, girls had a significantly higher mean mathematics score than boys (by 29 score points). The remaining 17 countries, including Ireland, had small and non-significant differences between boys and girls in mathematics achievement. For comparison, 27 countries in the previous cycle did not observe any significant difference between girls and boys (Perkins & Clerkin, 2020), indicating a greater number of countries with significant gender differences for Fourth Grade mathematics in 2023.

Achievement differences by school DEIS status

Figure 3.4 presents the percentages of pupils attending schools in each DEIS category for Fourth Class mathematics, along with estimates of their mean mathematics achievement and associated confidence intervals. Of the Fourth Class pupils in TIMSS 2023, 70% attended schools which did not have DEIS status in 2023 (labelled as non-DEIS). Approximately one-tenth of pupils attended DEIS Urban Band 1 schools (i.e., schools designated as experiencing the highest level of disadvantage; 10%), DEIS Urban Band 2 schools (11%), and DEIS Rural schools (9%).

Pupils in DEIS Urban Band 1 schools achieved a mean mathematics score of 497, 60 score points lower than pupils in non-DEIS schools (556). This gap is more than half a standard deviation on the TIMSS scale, which is substantial and statistically significant. Pupils in Urban DEIS Band 2 schools achieved a mean score of 527, also substantially and significantly lower (by 29 score points) than pupils in non-DEIS schools. Pupils in DEIS Rural schools had an average mathematics score of 541 (15 score points lower than in non-DEIS schools). This 15 score point difference is not significant, given the large margin of error around the estimate. This pattern of significant and non-significant differences in achievement between the school DEIS categories is the same as was observed in the previous cycle of TIMSS in 2019.

Figure 3.4: Percentages and mean achievement of pupils in Ireland by school DEIS category, Fourth Class mathematics



Note. Mean scores are presented with a 95% confidence interval around the estimate.

Source: e-Appendix Table A3.5.

Achievement differences by pupils’ socioeconomic status

TIMSS 2023 includes a new scale that provides an individual measure of pupils’ socioeconomic status (SES). The scale is based on parents’ reports about the number of books and children’s books in the home, and their own education level and occupation. Based on these reports, pupils were classified into *higher SES*, *middle SES* or *lower SES* groups. The scale has an international centrepoint of 10.0 and a standard deviation of 2.0 (von Davier et al., 2024). In Ireland, the average SES score was 11.0, half a standard deviation above the international centrepoint. This shows a high overall level of SES relative to the international average.

Table 3.2 shows the percentages of pupils in each category and their associated mean mathematics achievement in Ireland and selected reference countries. In Ireland, half of the pupils (50%) had *higher SES*, 42% had *middle SES*, and 7% had *lower SES*. Singapore, Sweden, and Finland reported broadly similar levels of SES to Ireland, while the Republic of Korea had the highest proportion in the *higher SES* category (65%) and the lowest proportion in *lower SES* (3%).

In Ireland and internationally, the achievement of pupils with *higher SES* was substantially higher than that of their peers in the *middle SES* and *lower SES* groups. In Ireland, *higher SES* pupils had a significant 38 score point advantage over pupils with *middle SES*, and a significant 102-point advantage (rounded) over pupils with *lower SES*. Internationally, the corresponding differences were 42 and 85 score points, respectively. Of the reference countries, only Singapore reported a wider gap (50 score points and 109 score points) to that reported for Ireland.

Table 3.2: Percentages and mean achievement of pupils by Socioeconomic Status (SES) scale in Ireland and selected countries, Fourth Grade mathematics

	Mean	Higher SES		Middle SES		Lower SES	
		%	Mean	%	Mean	%	Mean
Singapore	615	54	653	43	603	4	544
Chinese Taipei	607	37	632	50	602	14	562
Korea, Rep. of	594	65	613	32	568	3	517
Japan	591	25	629	62	586	13	553
England	552	-	-	-	-	-	-
Ireland	546	50	573	42	535	7	472
Sweden	530	55	559	39	512	6	482
Finland	529	51	556	44	516	6	476
Australia	525	-	-	-	-	-	-
United States	517	-	-	-	-	-	-

Note. Data are not available for England, Australia or the United States as they did not administer the Home Questionnaire in TIMSS 2023. Source: e-Appendix Table A3.6.

Distribution of achievement for Fourth Class mathematics

In addition to the overall mean scores presented in the previous section, we can examine pupil performance at various percentiles of achievement. This allows us to investigate the distribution of achievement and the differences in performance between the highest- and lowest-achieving pupils. This section presents the

performance at various percentiles (5th, 25th, 75th, and 95th) for Ireland and selected countries in TIMSS 2023 as well as comparing the trends in distribution of achievement for Ireland in 2011, 2015, 2019, and 2023. Subsequently, within Ireland, the distribution of achievement is examined by gender and socioeconomic status. A more detailed description of the percentiles and the distribution of achievement presented in this section is given in Chapter 1.

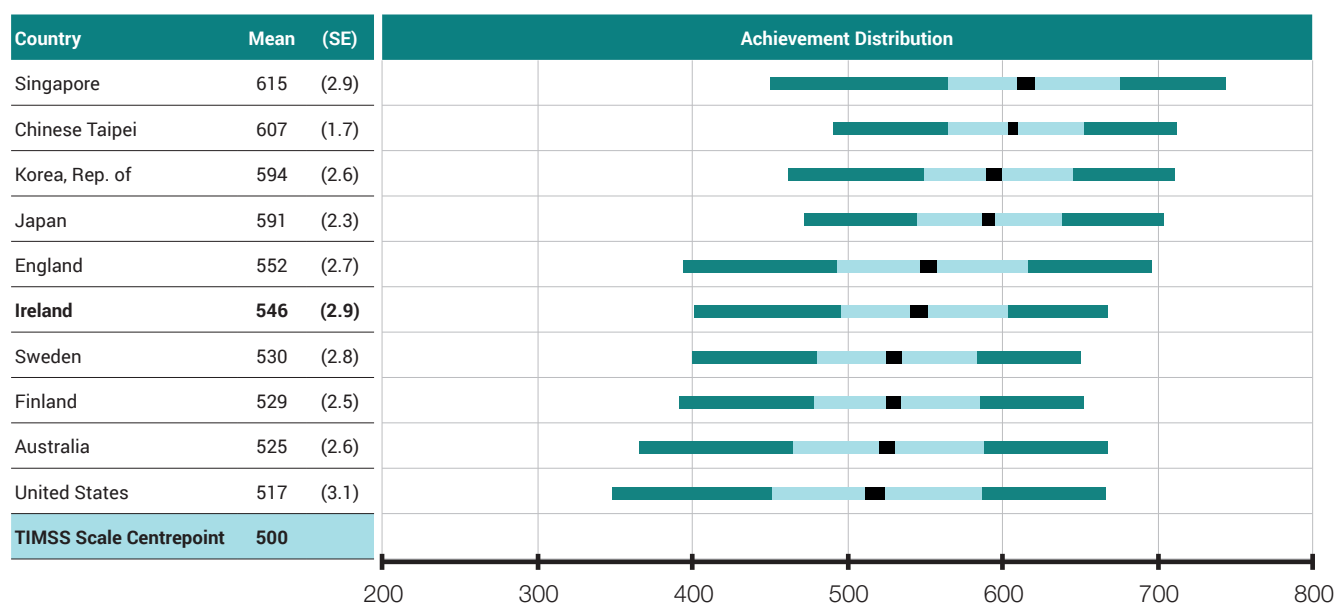
Distribution of achievement in Ireland and selected countries

Figure 3.5 presents the distribution of Fourth Grade mathematics achievement in Ireland and selected countries. Looking at the range of the distribution – that is, the difference between the highest- and lowest-achieving pupils (95th and 5th percentile respectively) – substantial differences among the selected countries are apparent. The United States has the largest range of distribution with a difference of 319 score points, or more than three standard deviations on the TIMSS scale. Chinese Taipei has the smallest range among these countries with a difference of 221 score points, indicating a relatively narrow range of achievement in this country. The magnitude of Ireland's range falls in the middle of the selected countries, with a 266-point difference. Singapore, the country with the highest mean mathematics achievement, had a larger range in distribution than Ireland (293 score points).

In Ireland, the mean mathematics achievement among pupils at the 5th percentile was 401 scale points. Across the selected countries, Chinese Taipei had the highest mean score at this percentile (491) while the United States had the lowest mean achievement at this percentile (348). Mean achievement at the 5th percentile in England (393) was below that observed in Ireland, despite similar mean achievement overall (Table 3.1).

At the 95th percentile, pupils in Ireland had a mean mathematics achievement of 667. Australia and the United States had similar scores to Ireland (668 and 667 respectively). This suggests that despite average achievement in Ireland being significantly higher than in Australia and the United States (Table 3.1), the highest-achieving pupils in these countries performed similarly to the highest-achieving pupils in Ireland. The score at the 95th percentile in Singapore was substantially higher, at 743 scale points.

Figure 3.5: Distribution of achievement in Ireland and selected countries, Fourth Grade mathematics



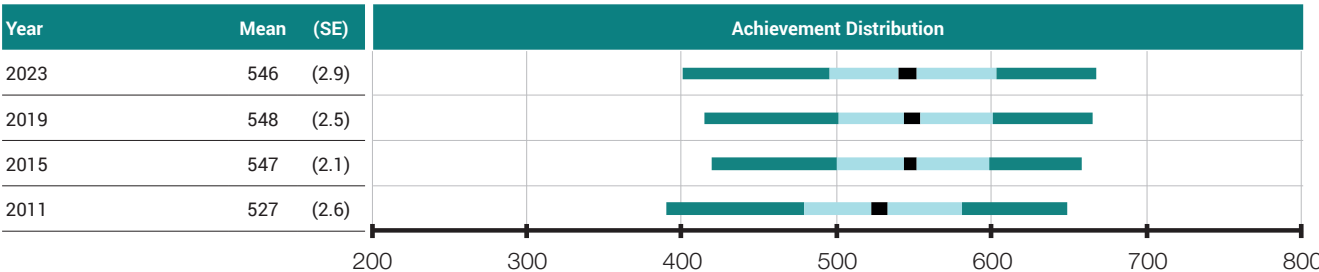
Note. See Figure 1.1 (Chapter 1) for guidance on how to interpret this graph.
Source: e-Appendix Table A3.7.

Trends in distribution of achievement

Figure 3.6 presents the distribution of pupil achievement in mathematics at Fourth Class for the four most recent cycles of TIMSS. The range between the 5th and 95th percentile increased by 16 score points from 2019 (250) to 2023 (266), continuing a trend that began previously with an increase in the range from 239 in 2015. By contrast, the range decreased between 2011 (258) and 2015. The current increase in the range of achievement is explained by a decrease in performance at the 5th percentile (the lowest-achieving pupils), from 414 in 2019 to 401 in 2023, a non-significant decrease of 14 score points. This follows a decrease observed between 2015 (420) and 2019. The difference between 2015 and 2023 is significant. This indicates that the lowest-achieving pupils in Ireland are performing significantly less well in mathematics in 2023 than in 2015.

At the upper end of the distribution, mean mathematics achievement at the 95th percentile was similar from 2019 (665) to 2023 (667), maintaining a previous increase observed since 2015 (658).

Figure 3.6: Distribution of achievement across TIMSS cycles in Ireland, Fourth Class mathematics



Note. See Figure 1.1 (Chapter 1) for guidance on how to interpret this graph.
Source: e-Appendix Table A3.8.

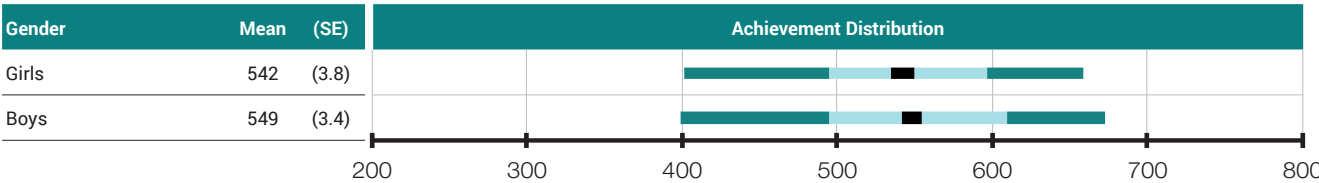
Distribution of achievement, by gender

As described in the previous section, there was no significant difference in the mean mathematics achievement of boys and girls at Fourth Class. Figure 3.7 presents the distribution of achievement at Fourth Class for girls and boys. Boys in Ireland (274 scale points) have a wider range of distribution (the difference between the 5th and 95th percentile) than girls (257).

At the 5th percentile, girls had a mean score (402) which was similar to the mean score for boys (399). This suggests that the lowest-achieving girls performed similarly to the lowest-achieving boys.

Among the highest-achieving pupils (at the 95th percentile), boys had a 13 score point advantage over girls. This indicates that the highest-achieving boys in Ireland are performing somewhat better, though not significantly, than the highest-achieving girls.

Figure 3.7: Distribution of achievement by gender in Ireland, Fourth Class mathematics



Note. See Figure 1.1 (Chapter 1) for guidance on how to interpret this graph.
Source: e-Appendix Table A3.9.

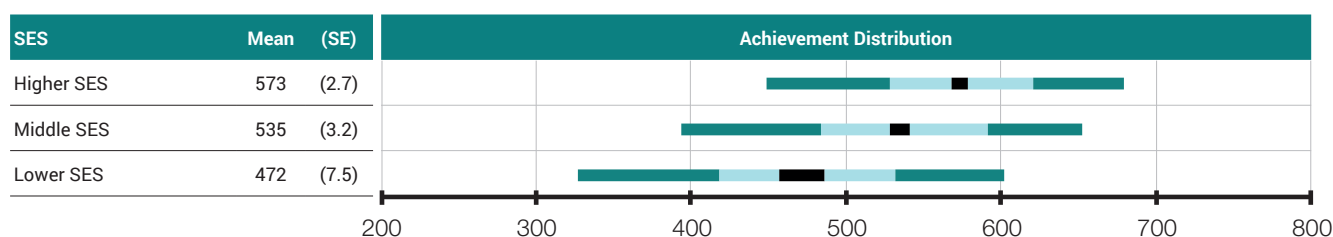
Distribution of achievement, by socioeconomic status

Figure 3.8 presents the distribution of mathematics achievement at Fourth Class for each category of the TIMSS Home Socioeconomic Status (SES) scale. It should be highlighted that the estimates of achievement at each percentile within the *lower SES* group are accompanied by relatively large standard errors (indicating a greater margin of error) due to the small numbers in that category.

The range of distribution is smallest for the *higher SES* group (231) compared to the *middle SES* (258) and *lower SES* (275) groups. Achievement at the 5th percentile for the *higher SES* group was 448. For the *middle SES* group, achievement at the 5th percentile was 393 (a significant difference of 55 points below the *higher SES* group). Achievement at the 5th percentile for *lower SES* pupils was 449 (a significant difference of 121 points below the *higher SES* group).

A similar pattern is observed for the higher-achieving pupils in each of these groups. The difference in achievement at the 95th percentile between the *higher SES* group (679) and the *middle SES* group and the *lower SES* group was 27 and 78 score points respectively. In both instances, these differences are significant.

Figure 3.8: Distribution of achievement by Socioeconomic Status (SES) scale in Ireland, Fourth Class mathematics



Note. See Figure 1.1 (Chapter 1) for guidance on how to interpret this graph.

Source: e-Appendix Table A3.10.

Performance at International Benchmarks for Fourth Class mathematics

This section focuses on the TIMSS International Benchmarks which describe the skills and knowledge demonstrated by pupils at different levels of achievement. The cumulative percentages of pupils reaching each of the four International Benchmarks are presented for Ireland, in selected reference countries and at the TIMSS median. Within Ireland, performance at the International Benchmarks over the last four cycles of TIMSS (2011, 2015, 2019, 2023) is compared, followed by performance by gender.

TIMSS International Benchmarks for Fourth Grade mathematics

Table 3.3 outlines the skills and knowledge required to meet each TIMSS International Benchmark for Fourth Grade mathematics. Pupils who reach the Low Benchmark can consistently demonstrate some basic mathematical skills. For example, they can add and subtract whole numbers up to three digits, multiply and divide single-digit whole numbers, or read data from different representations and complete simple bar graphs. Pupils who reach the Intermediate Benchmark have demonstrated the skills and knowledge required to meet the Low Benchmark and can also demonstrate mathematical knowledge in simple situations and relate representations such as computations with three-digit whole numbers in a variety of situations and add and order simple decimals. The

High Benchmark requires pupils to relate concepts or representations in extended contexts including applying knowledge of properties of whole numbers to justify a solution. Pupils reaching the Advanced Benchmark have demonstrated the skills associated with all lower benchmarks while showing the ability to select and relate information to implement appropriate operations to solve problems.

Table 3.3: International Benchmarks - Fourth Grade mathematics

Benchmark	Scoring at least	Pupils typically can:
Advanced <i>Pupils can select and relate information to implement appropriate operations to solve problems.</i>	625	<p>Interpret the results of computations given in problem contexts, formulate a variety of expressions and patterns, and relate fractions and decimals.</p> <p>Estimate and relate measures, apply knowledge of two- and three-dimensional shapes, identify simple properties of lines and angles, and show a basic understanding of surface area and perimeter in simple shapes.</p> <p>Interpret data and make choices about data given in numerous contexts.</p>
High <i>Pupils relate concepts or representations in extended contexts.</i>	550	<p>Apply knowledge of properties of whole numbers to justify a solution.</p> <p>Show an understanding of the number line, multiples, factors, rounding numbers, and operations with fractions and decimals.</p> <p>Resolve measurement tasks across numerous contexts.</p> <p>Relate two-dimensional shapes to unfamiliar three-dimensional figures and demonstrate basic understanding of angles.</p> <p>Interpret features of data representations and represent data in a variety of graphs.</p>
Intermediate <i>Pupils demonstrate mathematical knowledge in simple situations and relate representations.</i>	475	<p>Perform computations with three-digit whole numbers in a variety of situations.</p> <p>Add and order simple decimals.</p> <p>Measure straight distances and describe three-dimensional shapes.</p> <p>Use data from multiple sources to relate representations.</p>
Low <i>Pupils demonstrate basic mathematical understanding.</i>	400	<p>Add and subtract whole numbers with up to three digits, multiply and divide single-digit whole numbers, and solve simple word problems.</p> <p>Apply basic measurement ideas and properties of common geometric shapes.</p> <p>Read data from different representations and complete simple bar graphs.</p>

Source: Adapted from Exhibit 1.1.3 in von Davier et al. (2024).

Achievement at the International Benchmarks

Table 3.4 presents the cumulative percentages of pupils reaching each of the four International Benchmarks, in Ireland, in selected comparison countries, and the TIMSS median. The percentage of pupils who reached each International Benchmark was higher in Ireland than was found internationally at the TIMSS median. A large majority of pupils in Ireland demonstrated the skills to reach the Low (95%) and Intermediate International (81%) Benchmarks. Over half of pupils in Ireland (52%) reached the High International Benchmark for mathematics, while the Advanced International Benchmark was reached by about one-in-six pupils (16%).

Across the selected countries, most pupils reached the Low Benchmark (albeit to a lesser degree in Australia and the United States) with all pupils in Chinese Taipei achieving this level. At the Intermediate Benchmark, the percentages ranged from 68% in the United States to 97% in Chinese Taipei. There was much more variation for both the High and Advanced Benchmarks among the selected reference countries. In the highest-performing country for mathematics at Fourth Grade, Singapore, almost half of pupils demonstrated the skills needed to reach the Advanced International Benchmark. Sweden had the lowest proportion of pupils at this level (10%) among the selected countries.

Table 3.4: Cumulative percentages of pupils reaching each International Benchmark in Ireland and selected countries, Fourth Grade mathematics

	Mean	Low (400)	Intermediate (475)	High (550)	Advanced (625)
Singapore	615	98	93	79	49
Chinese Taipei	607	100	97	81	40
Korea, Rep. of	594	99	93	75	36
Japan	591	99	95	73	32
England	552	94	80	53	22
Ireland	546	95	81	52	16
Sweden	530	95	77	41	10
Finland	529	94	76	42	11
Australia	525	91	72	41	13
United States	517	87	68	39	13
TIMSS (median)		91	70	35	7

Note. The percentages of Fourth Class pupils within each International Benchmark of mathematics (i.e., discrete categories) in Ireland are: 4.9% (Below Low); 14.1% (Low); 28.8% (Intermediate); 36.5% (High); 15.7% (Advanced).

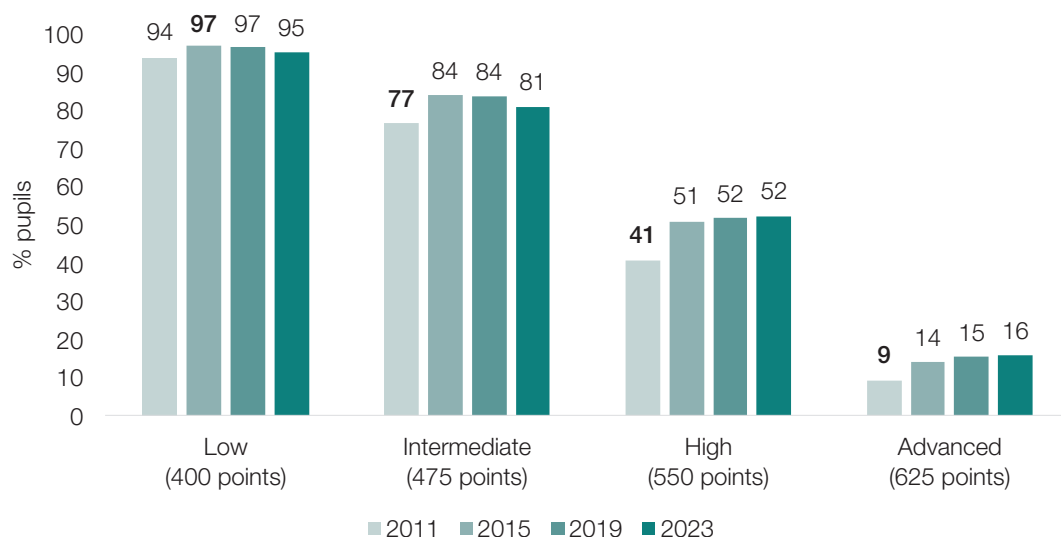
Source: e-Appendix Table A3.11 and Exhibit 1.1.4 in von Davier et al. (2024).

Trends in performance at International Benchmarks

Figure 3.9 presents the cumulative percentages of Fourth Class pupils reaching each International Benchmark for mathematics across the previous four cycles of TIMSS. In each cycle, the majority of pupils have reached the Low International Benchmark. The proportion at this level in 2023 (95.1%) has decreased by less than two percentage points since 2019 (96.6%), which is not a statistically significant difference. However, compared to the previous cycle in 2015 (97.0%), significantly fewer pupils reached the Low Benchmark in 2023.

The proportion of pupils reaching the Intermediate Benchmark has decreased (non-significantly) by less than three percentage points from 2019. Similar proportions of pupils have reached both the High and Advanced Benchmarks over the past three cycles, with the percentages in 2023 (52% and 16%, respectively) significantly above the corresponding percentages in 2011 (41% and 9%).

Figure 3.9: Cumulative percentages of pupils reaching each International Benchmark across TIMSS cycles in Ireland, Fourth Class mathematics



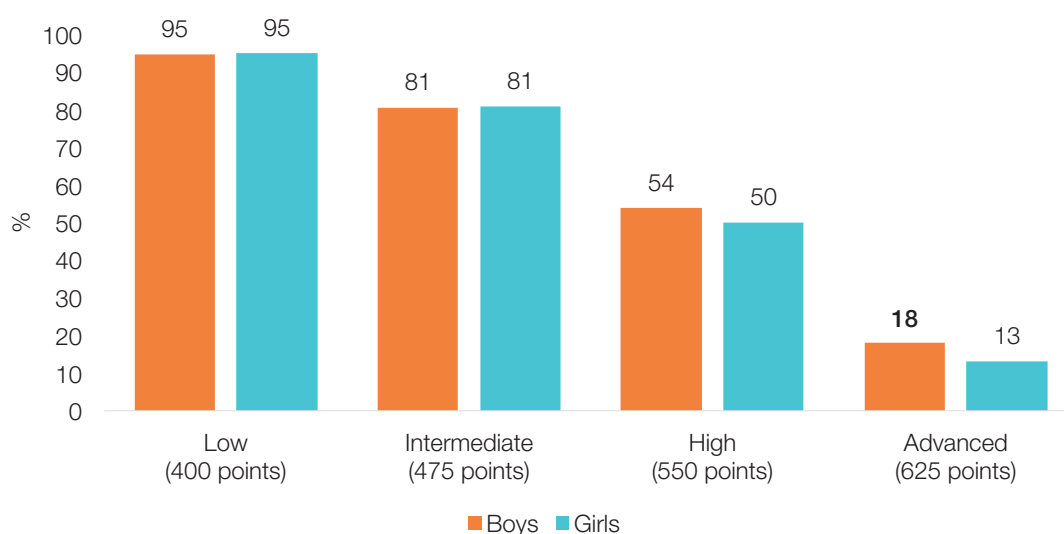
Note. Percentages in **bold** are significantly different to the equivalent in 2023.

Source: e-Appendix Table A3.12.

Performance at the International Benchmarks, by gender

The cumulative percentage of boys and girls in Ireland reaching each of the International Benchmarks in Fourth Grade mathematics are shown in Figure 3.10. Very similar proportions of girls and boys reached the Low (95%) and Intermediate (81%) Benchmarks. At the High Benchmark, over half of boys and girls reached this benchmark, with no significant difference between them. However, significantly more boys (18%) than girls (13%) demonstrated the skills to successfully reach the Advanced Benchmark.

Figure 3.10: Cumulative percentages of girls and boys reaching each International Benchmark in Ireland, Fourth Class mathematics



Note. Percentages in **bold** indicate a significant difference between boys and girls.

Source: e-Appendix Table A3.13.

Performance on content and cognitive domains for Fourth Class mathematics

As described in Chapter 1, the TIMSS assessment is based upon an Assessment Framework which is revised and updated each cycle to accurately reflect the curricula of participating countries (Mullis et al., 2021). This section presents the performance on the content and cognitive domains in Ireland and selected countries. Performance is compared to overall mathematics performance at Fourth Grade which highlights areas of relative strengths and weaknesses in Ireland and selected countries. Within Ireland, performance on the content and cognitive domains is examined by gender.

Performance on content domains

The content domains and the proportions given to each reflect the mathematics widely taught at Fourth Grade. As presented in Chapter 1, there are three content domains at Fourth Grade: Number, Measurement & Geometry, and Data. Number accounts for half of the assessment, Measurement & Geometry for 30% of the assessment, and Data for the remaining 20% of the assessment.

Each of the content domains are made up of different topic areas which include a number of different topics. Number includes three topic areas: whole numbers; expressions, simple equations and relationships; and fractions and decimals. Measurement & Geometry includes two topic areas: measurement; and geometry. Data also includes two topic areas: reading and displaying data; and interpreting, combining, and comparing data.

Table 3.5 presents the mean achievement on each of the three content domains in Ireland and selected countries. Pupils in Ireland performed similarly to their overall mathematics performance (546) in both Number (548) and Data (546), but showed a relatively weaker performance in Measurement & Geometry (-5 points). Comparing this with 2019, Measurement & Geometry was also an area of relative weakness in 2019. Data was an area of relative weakness while Number was an area of relative strength (Perkins & Clerkin, 2020).

Among the selected countries, Singapore, Chinese Taipei, the Republic of Korea, Japan, and Finland showed a relative strength in Measurement & Geometry. Singapore was the only one of the selected countries to show no areas of relative weakness. Seven of the ten selected countries showed a relative strength in Data, while Chinese Taipei was the only country, of those selected, to show relative weakness in Data. The United States was the only country, of those selected, to show relative strength in Number while six countries had a relative weakness in Number.

Table 3.5: Mean achievement scores on content domains in Ireland and selected countries, Fourth Grade mathematics

	Mean	Number	Measurement & Geometry	Data
Singapore	615	613	619	616
Chinese Taipei	607	602	622	601
Korea, Rep. of	594	586	605	606
Japan	591	581	605	598
England	552	556	539	561
Ireland	546	548	540	546
Sweden	530	527	532	535
Finland	529	522	539	536
Australia	525	520	522	540
United States	517	523	499	519

Note. Light shading indicates that the subscale score is significantly lower than the country's overall mathematics scale score. Dark shading indicates that the subscale score is significantly higher than the country's overall mathematics scale score.

Source: Adapted from Exhibit 1.1.13 in von Davier et al. (2024).

Table 3.6 presents the mean mathematics achievement of Fourth Class girls and boys on each of the content domains. Boys had a significantly higher mean score than girls on the content domain of Data, while there were no significant differences for either Number or Measurement & Geometry.

Table 3.6: Mean achievement scores of girls and boys on content domains in Ireland, Fourth Class mathematics

	Mean	Number	Measurement & Geometry	Data
Girls	542	545	537	541
Boys	549	551	543	551

Note. Shading indicates that the subscale score is significantly higher than for the other gender on that subscale.

Source: e-Appendix Table A3.14.

Performance on cognitive domains

The three cognitive domains in mathematics apply to both the Fourth and Eighth Grades. Each item in the mathematics test is classified as one of the three cognitive domains: Knowing, Applying, and Reasoning.

Table 3.7 presents the mean Fourth Grade mathematics scores on the three cognitive domains in Ireland and selected countries. Pupils in Ireland had a mean score in Knowing which was significantly above their overall mean score (+5 points), which indicates that Knowing was an area of relative strength. In contrast, Reasoning was an area of relative weakness (-5 points). In Applying, pupils in Ireland performed similarly to their overall mean. In 2019, Reasoning was also an area of relative weakness while Applying had been an area of relative strength (Perkins & Clerkin, 2020). Knowing had been similar to the overall mathematics performance in 2019.

Of the selected countries, seven countries had a relative strength in Knowing (including Ireland). None of the countries showed a relative strength in Reasoning, although five countries – Singapore, Chinese Taipei, Japan, Ireland, and the United States – had a relative weakness. For Applying, most of the selected countries

performed similarly to their overall performance but two countries, Chinese Taipei and Japan, had a relative strength, while Finland and Australia had a relative weakness in this area.

Table 3.7: Mean achievement scores on cognitive domains in Ireland and selected countries, Fourth Grade mathematics

	Mean	Knowing	Applying	Reasoning
Singapore	615	624	615	609
Chinese Taipei	607	619	612	589
Korea, Rep. of	594	600	593	592
Japan	591	591	597	576
England	552	558	550	550
Ireland	546	551	546	541
Sweden	530	525	530	533
Finland	529	538	525	528
Australia	525	529	523	526
United States	517	521	517	513

Note. Light shading indicates that the subscale score is significantly lower than the country's overall mathematics scale score. Dark shading indicates that the subscale score is significantly higher than the country's overall mathematics scale score.

Source: Adapted from Exhibit 1.1.14 in von Davier et al. (2024).

The difference in the performance of girls and boys on the three cognitive domains is presented in Table 3.8. Boys significantly outperformed girls in both Knowing (10 score points rounded) and Reasoning (13 score points). Performance in Applying was broadly similar, with a non-significant three-point difference in favour of boys.

Table 3.8: Mean achievement scores of girls and boys on cognitive domains in Ireland, Fourth Class mathematics

	Mean	Knowing	Applying	Reasoning
Girls	542	546	545	534
Boys	549	555	547	547

Note. Shading indicates that the subscale score is significantly higher than for the other gender on that subscale.

Source: e-Appendix Table A3.15.

Curriculum coverage for Fourth Class mathematics

As outlined in Chapter 1, a test-curriculum matching analysis (TCMA) was conducted to establish whether the topic of each item in the TIMSS assessment was likely to have been covered by the majority of Fourth Class pupils by the time of TIMSS testing in March/April. This section presents the results of the TCMA for Fourth Class mathematics followed by findings from the Teacher Questionnaire where teachers reported the coverage of TIMSS topics.

Test-Curriculum Matching Analysis for Fourth Grade mathematics

Table 3.9 presents the outcomes of the TCMA for Fourth Class mathematics in Ireland. It was judged that the vast majority of items in the TIMSS assessment would have been covered by the spring of Fourth Class. In total, seven items were deemed not to be included in the Fourth Class curriculum: three items relating to Number, two items relating to Measurement & Geometry, and two items relating to Data. Both of the items relating to Measurement & Geometry were from the Geometry topic area. Overall, the proportion of the assessment expected to have been covered by pupils was 96% (ranging from 95% for Data to 97% for Number).

Table 3.9: TCMA overall and by content domain – Fourth Grade mathematics items

	Number of items	Number of items included in curriculum	% included in curriculum
Number	94	91	97%
Measurement & Geometry	49	47	96%
Data	40	38	95%
Overall	183	176	96%

As part of the TCMA, a hypothetical scale score based only on the subset of items that were judged to be part of a country's curriculum was calculated by the IEA (Appendix C.1 in von Davier et al., 2024). Pupils in Ireland would have had a mean achievement score of 546 if only the items considered to be part of the Irish curriculum were included, which is very similar to their actual achieved score (546) (von Davier et al., 2024). Similarly, internationally, most countries observed only small fluctuations between the actual and hypothetical mean scores.

Teacher reports of topic coverage for Fourth Grade mathematics

The first part of this section outlined the differences between the TIMSS Assessment Framework and the Irish curriculum at Fourth Class in mathematics in terms of high-level content domains. However, each of these content domains contains multiple topic areas with various topics at a more granular level.

As part of the Teacher Questionnaire, teachers were asked to indicate whether, for a range of topics in each of the content domains, they had been *mostly taught before this year*, *mostly taught this year*, or *not yet taught*. These data provide a clearer indication of the extent to which pupils in Ireland and other countries may be expected to have been familiar with the topics covered by the TIMSS assessment.

Table 3.10 shows the percentage of pupils who had been taught the TIMSS topics in Fourth Grade mathematics, according to their teachers. In Ireland, the percentages for each of the content domains were above those reported on average across all TIMSS countries. Coverage in Ireland was particularly high for both Number (91%) and Data (87%), while almost four-fifths of pupils in Ireland had been taught the topics relating to Measurement & Geometry (79%).

Almost all of the selected countries, except for Sweden, had proportions greater than 80% for Number (Table 3.10). Conversely, for Measurement & Geometry, only Australia had a proportion greater than 80%. Five countries – Ireland as well as Singapore, Chinese Taipei, the Republic of Korea, and Australia – had high coverage of Data topics. Sweden had the lowest proportions, among the selected countries, for each of the content domains.

Table 3.10: Percentages and standard errors of pupils taught the TIMSS topics – Fourth Grade mathematics

	Number (12 topics)		Measurement & Geometry (8 topics)		Data (3 topics)	
	%	(SE)	%	(SE)	%	(SE)
Singapore	100	(0.1)	74	(0.8)	88	(1.1)
Chinese Taipei	90	(0.6)	80	(1.0)	83	(2.3)
Korea, Rep. of	87	(0.9)	65	(1.4)	95	(1.0)
Japan	89	(0.6)	71	(1.6)	62	(3.5)
England	96	(0.7)	78	(2.6)	71	(3.7)
Ireland	91	(0.8)	79	(1.3)	87	(2.2)
Sweden	71	(1.4)	52	(2.4)	65	(3.0)
Finland	89	(0.8)	74	(1.3)	62	(2.5)
Australia	84	(1.0)	83	(1.3)	93	(1.3)
United States	92	(0.6)	69	(1.7)	71	(2.2)
TIMSS average (57)	84	(0.1)	75	(0.2)	78	(0.3)

Note. Percentages of pupils mostly taught before or in the assessment year, averaged across topics.
 57 countries in the TIMSS average rather than 58 as Norway did not administer the Teacher Questionnaire.
 See e-Appendix Table A3.16 for more detailed information on individual topics.

Chapter 4:

Fourth Class Science

This chapter focuses on Fourth Grade pupils' performance in the TIMSS 2023 science assessment. Overall performance in science is examined, as well as the distribution of achievement, performance at the International Benchmarks, and performance on the science content and cognitive domains.

Each section explores the performance of pupils in Ireland as well as in selected countries (as described in Chapter 1). Comparisons between participating pupils' performance in TIMSS 2023 with three prior cycles of TIMSS (2019, 2015, and 2011) are made. Finally, where applicable, differences between girls and boys, differences relating to schools' DEIS categorisation, and differences between categories on a TIMSS-specific measure of socioeconomic status (SES) are presented.

The final section describes curriculum coverage for Fourth Grade science. As described in Chapter 1, TIMSS is a curriculum-based study with a Test-Curriculum Matching Analysis (TCMA) conducted for each cycle. The results of the TCMA are presented below along with teacher reports of TIMSS topic coverage.

Mean achievement for Fourth Class science

This section describes the overall performance in science of Fourth Grade pupils in each country and benchmarking participant that took part in TIMSS 2023. The performance of pupils in Ireland is compared to the performance of pupils in three previous cycles of TIMSS: 2019, 2015, and 2011. Differences in Fourth Class mean achievement in science between girls and boys, between DEIS status categories and socioeconomic status categories are also presented.

Overall results

Table 4.1 presents the mean science achievement scores of Fourth Grade pupils in Ireland and all other participating countries and benchmarking participants. A total of 58 countries participated in TIMSS 2023 at Fourth Grade along with five benchmarking participants.¹⁶ Pupils in Singapore achieved the highest mean score in science (607), followed by the Republic of Korea (583), Chinese Taipei (573), and Türkiye (570).

Fourth Class pupils in Ireland achieved a mean score of 532 in science, significantly above the TIMSS 2023 international average (494). Pupils in 10 countries achieved mean scores that were significantly higher than that of pupils in Ireland (Singapore, the Republic of Korea, Chinese Taipei, Türkiye, England, Japan, Poland, Australia, Hong Kong, and Finland). Pupils in 11 countries did not score significantly higher or lower than pupils in Ireland (Lithuania, Macao, Sweden, United States, Norway, Bulgaria, Romania, Czech Republic, Slovenia, Latvia, and Hungary). Pupils in 36 countries scored significantly lower than pupils in Ireland (including Denmark, Canada, New Zealand, Germany, and France).

Including Ireland, 21 EU countries participated in TIMSS 2023. Of these, two scored significantly higher than pupils in Ireland in Fourth Grade science (Poland and Finland), 11 countries scored significantly lower (Denmark, Slovak Republic, Netherlands, Germany, Portugal, Italy, Serbia, Spain, both French and Flemish speaking Belgium, France, and Cyprus) and seven did not score significantly higher or lower than pupils in Ireland (Lithuania, Sweden, Bulgaria, Romania, Czech Republic, Slovenia, Latvia, and Hungary).

¹⁶ Iraq and the Kurdistan Region of Iraq also participated at Fourth Grade but their data are not included because of data quality issues.

The standard deviation (spread) around each mean score is also presented in Table 4.1. In Ireland, for Fourth Class science, the standard deviation was 80 score points. Internationally, the country with the lowest standard deviation was Armenia with 61 score points, while South Africa had the largest standard deviation at 153 score points.

Table 4.1: Mean achievement scores and standard errors of countries and benchmarking participants, Fourth Grade science

Country	Mean	(SE)	SD	Country	Mean	(SE)	SD
Singapore	607	(2.8)	84	TIMSS 2023 International Average	494	(0.4)	-
Korea, Rep. of	583	(2.5)	74	Albania	491	(4.5)	77
Chinese Taipei	573	(1.7)	71	Belgium (Flemish)	488	(2.6)	73
Türkiye (5)	570	(3.4)	86	France	488	(3.0)	74
England	556	(2.6)	80	Cyprus	487	(3.1)	88
Japan	555	(2.4)	68	Belgium (French)	481	(2.8)	77
Poland	550	(2.2)	71	Chile	479	(2.7)	80
Australia	550	(2.3)	81	Bahrain	475	(3.9)	106
Hong Kong SAR	545	(3.8)	88	Qatar	472	(3.6)	104
Finland	542	(2.9)	79	Kazakhstan	467	(3.5)	91
Lithuania	537	(2.9)	74	Georgia	465	(3.4)	72
Macao SAR	536	(1.4)	81	Montenegro	461	(2.0)	75
Sweden	533	(3.2)	82	Armenia	457	(2.7)	61
United States	532	(2.8)	93	Bosnia & Herzegovina	448	(3.7)	72
Ireland	532	(3.2)	80	North Macedonia	439	(3.9)	86
Norway (5)	530	(2.6)	75	Oman	433	(4.2)	103
Bulgaria	530	(4.8)	104	Iran, Islamic Rep. of	432	(4.5)	109
Romania	526	(4.8)	81	Saudi Arabia	428	(4.0)	100
Czech Republic	526	(2.3)	71	Brazil	425	(3.5)	94
Slovenia	526	(2.3)	74	Azerbaijan	422	(3.3)	80
Latvia	526	(3.0)	77	Jordan	418	(4.9)	102
Hungary	524	(3.2)	85	Uzbekistan	412	(3.5)	83
Denmark	522	(2.6)	75	Kosovo	403	(3.6)	74
Canada	521	(2.0)	76	Morocco	390	(5.3)	118
Slovak Republic	521	(3.3)	87	Kuwait	373	(5.5)	126
New Zealand	517	(2.8)	87	South Africa (5)	308	(4.7)	153
Netherlands	517	(2.9)	67	Benchmarking Participants			
Germany	515	(2.8)	84	<i>Dubai, UAE</i>	<i>562</i>	<i>(1.8)</i>	<i>95</i>
Portugal	511	(2.3)	73	<i>Ontario, Canada</i>	<i>525</i>	<i>(3.2)</i>	<i>76</i>
Italy	511	(2.5)	70	<i>Quebec, Canada</i>	<i>508</i>	<i>(2.7)</i>	<i>71</i>
Serbia	510	(3.2)	74	<i>Sharjah, UAE</i>	<i>503</i>	<i>(3.9)</i>	<i>105</i>
Spain	504	(2.1)	72	<i>Abu Dhabi, UAE</i>	<i>446</i>	<i>(2.6)</i>	<i>125</i>
United Arab Emirates	495	(1.8)	118				
Average achievement significantly higher than Ireland				Average achievement significantly lower than Ireland			

Note. Norway, Türkiye, and South Africa assessed pupils in Fifth Grade rather than Fourth Grade.

Multiple comparisons are not taken into account when testing significant differences.

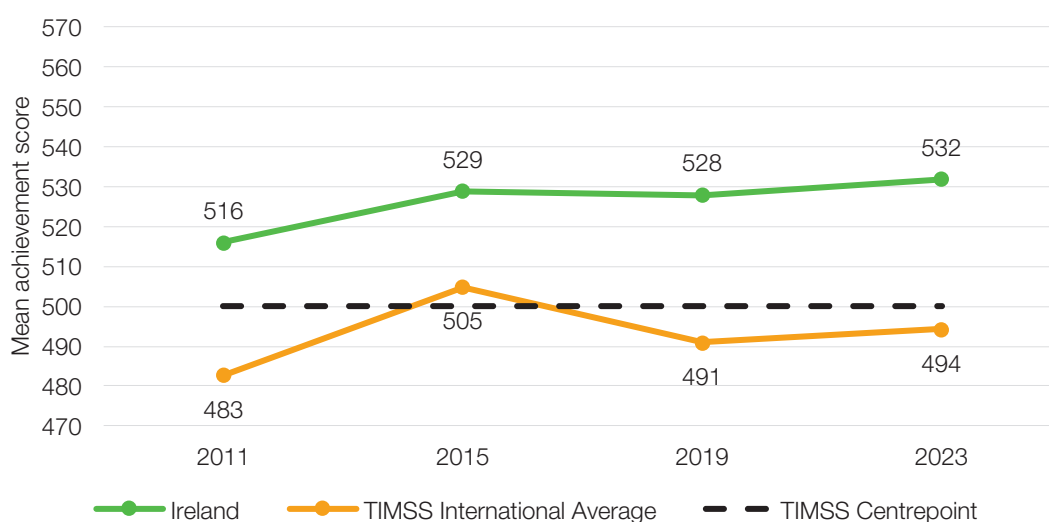
Source: e-Appendix Table A4.1.

Trends in achievement

Figure 4.1 presents the average mean science achievement for Fourth Class in 2023 and in three previous cycles of TIMSS (2019, 2015, and 2011), together with the international average for countries participating in these cycles and the constant scale centrepoint. The international average shown below is the average score for all countries within each particular cycle, which included 52 countries in 2011, 48 countries in 2015, and 58 countries in 2019 and 2023.

Ireland's scores in science have remained relatively stable since the previous TIMSS cycle, with a slight increase of four score points in 2023 (532) compared with 2019 (528). This difference is not statistically significant, indicating that there has been no meaningful change in Fourth Class pupils' science proficiency over the last four years. Similarly, there has been no significant change in science proficiency compared with 2015 (529). However, mean achievement in science remains statistically significantly higher than in 2011 (516).

Figure 4.1: Mean achievement scores across TIMSS cycles for Ireland and TIMSS average, Fourth Grade science

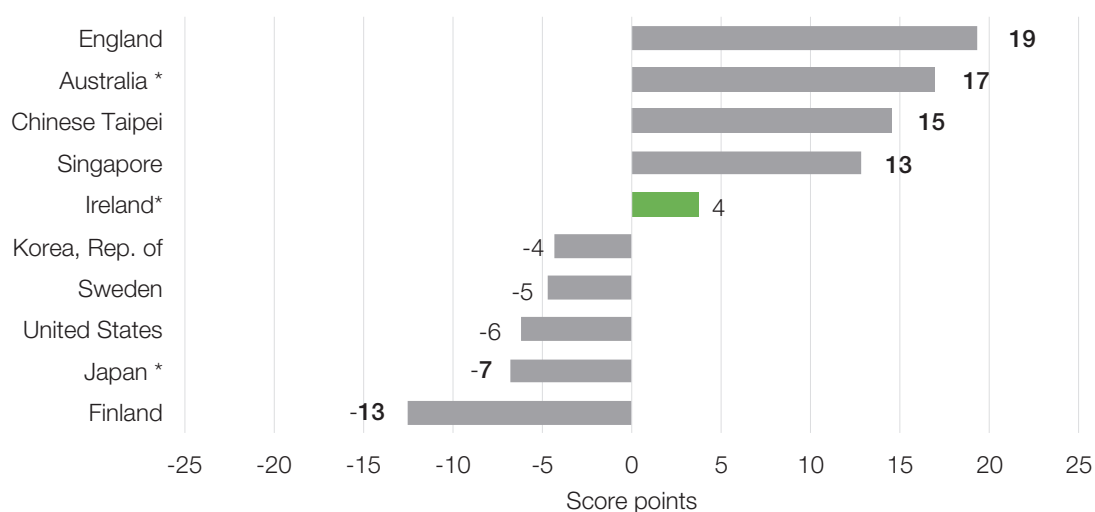


Note. TIMSS international average includes all countries that participated in the cycle. Countries included in TIMSS international average: 2023=58; 2019=58; 2015=48; 2011=52.

Source: e-Appendix Table A4.2.

Figure 4.2 shows the difference in mean science achievement from 2019 to 2023 for Fourth Grade pupils in Ireland and selected reference countries. Three of these countries transitioned from paper to digital testing in TIMSS 2023: Australia, Ireland, and Japan. Four of the selected countries had a statistically significant increase: England, Australia, Chinese Taipei, and Singapore. Ireland, as well as the Republic of Korea, Sweden, and the United States had similar mean science achievement in 2019 and 2023. Two countries showed statistically significant decreases in mean science achievement: Finland and Japan.

Figure 4.2: Change in mean achievement score between 2019 and 2023 for Ireland and selected countries, Fourth Grade science



Note. Figures in **bold** indicate a significant difference from the previous cycle.

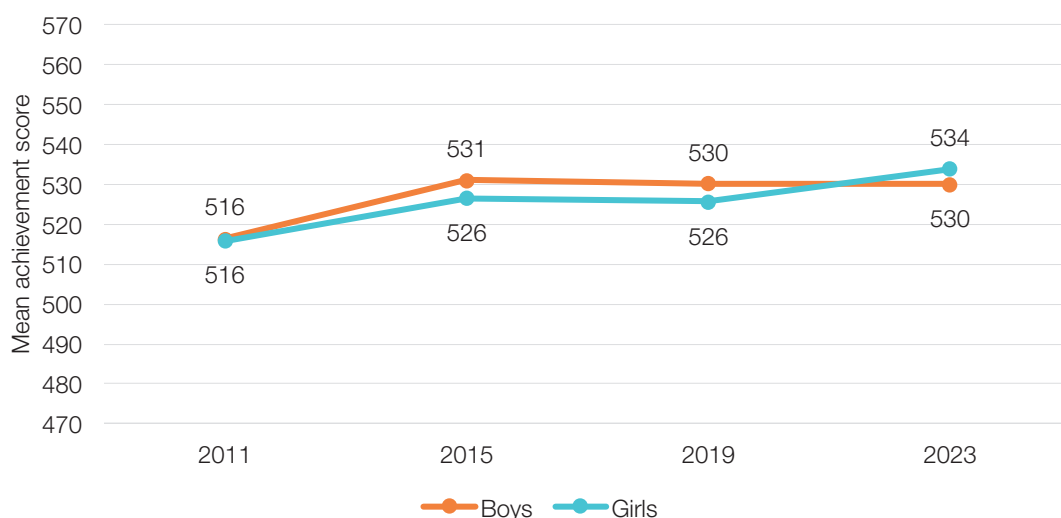
* indicates country changed mode of assessment in TIMSS 2023.

Source: e-Appendix Table A4.3.

Achievement differences by gender

Figure 4.3 shows gender differences in mean science achievement at Fourth Class in TIMSS 2023 and in the three previous cycles. In 2023, girls (534) achieved a higher average score than boys (530), although this difference is not statistically significant. Girls scored higher in 2023 compared with 2019 (526) and 2015 (526). The eight score point increase for girls from 2019 or 2015 was not significant. For boys, scores were almost identical in 2023 (530), 2019 (530), and 2015 (531). These differences were not significantly different. Both boys and girls scored significantly higher in 2023 compared with their counterparts in 2011 (516 for both girls and boys).

Figure 4.3: Mean achievement scores among girls and boys in Ireland across TIMSS cycles, Fourth Class science



Note. Figures in **bold** indicate a significant difference between boys and girls.

Source: e-Appendix Table A4.4.

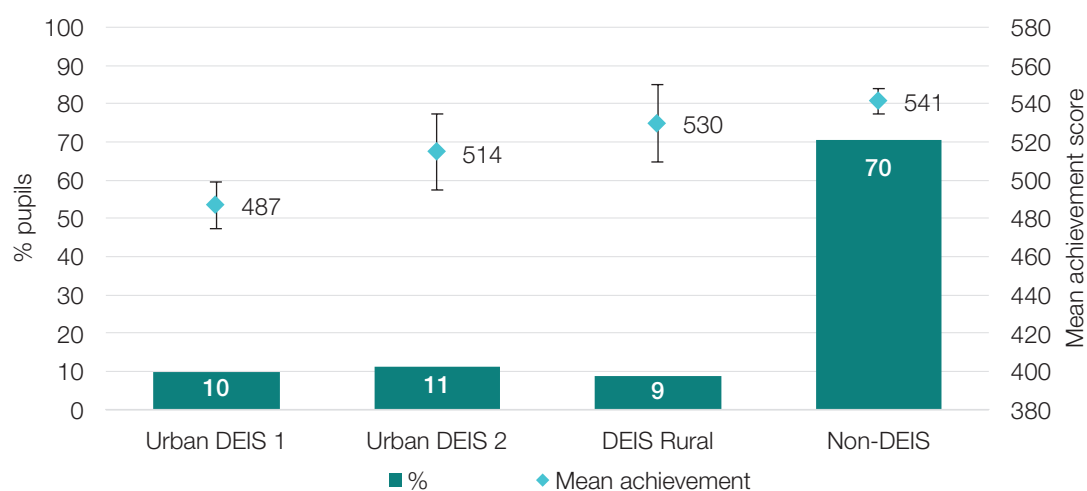
At the international average, gender differences were small with girls (495) achieving a slightly higher, but not significantly different, mean score in science compared with boys (494). Overall, 26 countries, including Ireland, observed no statistically significant difference between girls and boys. An additional 20 countries observed a significant difference in favour of boys (with differences ranging from five to 15 points), while 12 countries observed a significant difference in favour of girls (ranging from eight to 39 points).

Achievement differences by school DEIS status

Figure 4.4 shows the percentages of pupils attending schools in each DEIS category, together with estimates of mean science achievement (and confidence intervals around the estimates). Of the Fourth Class pupils that participated in TIMSS 2023, 70% attended non-DEIS schools, 9% attended schools designated DEIS Rural, 10% attended DEIS Urban Band 1 schools, and 11% attended DEIS Urban Band 2 schools.

Pupils in non-DEIS schools achieved a mean science score of 541. This was significantly higher than the mean score achieved by pupils in DEIS Urban Band 1 (487) or DEIS Urban Band 2 (514) schools, but not significantly different from pupils in DEIS Rural schools (530). The interpretation of these differences should be approached with caution, however, given the small sample sizes in each of the three DEIS categories and the large standard errors associated with the mean scores. The pattern of significance and non-significance between the school DEIS categories is the same in 2023 as in 2019.

Figure 4.4: Percentages and mean achievement of pupils in Ireland by school DEIS category, Fourth Class science



Note. Mean scores are presented with a 95% confidence interval around the estimate.
Source: e-Appendix Table A4.5.

Achievement differences by pupils' socioeconomic status

Table 4.2 shows the percentage of pupils in each SES category (as described in Chapter 3) with estimated mean achievement. In Ireland, 50% of pupils were in the *higher SES* category, 42% were in the *middle SES* category, and 7% were in the *lower SES* category. Of the reference countries, the Republic of Korea reported the highest percentage of pupils in the *higher SES* category (65%), Japan reported the highest percentage of pupils in the *middle SES* category (62%) and Chinese Taipei reported the highest percentage of pupils in the *lower SES* category (14%). Singapore, Finland, and Sweden reported broadly similar percentages to Ireland in each of the

three categories. As England, Australia, and the United States did not administer the Home Questionnaire, no data on SES are available for these countries.

In Ireland, pupils in the *higher SES* category achieved a higher mean score in science (560) compared with pupils in the *middle SES* (518) and the *lower SES* (462) categories. These differences were statistically significant. A similar pattern was observed amongst the reference countries where pupils in the *higher SES* category scored significantly higher than pupils in the *middle SES* or *lower SES* categories.

Internationally, the average gap between *higher SES* and *middle SES* categories was around 45 score points, while the gap between *higher SES* and *lower SES* categories was 91 score points. In Ireland, the gap between *higher SES* and *middle SES* categories was similar to that seen internationally (41 points). The gap between *higher SES* and *lower SES* in Ireland was also similar to the international average (97 points). Of the selected countries, most reported a larger gap between *higher SES* and *middle SES* categories than Ireland, with only Chinese Taipei reporting a smaller gap (37 points), and Japan reporting a similar gap (42 points). Half of the selected countries with SES data reported a larger gap between *higher SES* and *lower SES* categories than Ireland: Finland (99 score points), Sweden (111), and Singapore (116).

Table 4.2: Percentages and mean achievement of pupils by Socioeconomic Status (SES) scale in Ireland and selected reference countries, Fourth Class science

	Mean	Higher SES		Middle SES		Lower SES	
		%	Mean	%	Mean	%	Mean
Singapore	607	54	647	43	592	4	531
Korea, Rep. of	583	65	601	32	557	3	514
Chinese Taipei	573	37	602	50	565	14	523
England	556	-	-	-	-	-	-
Japan	555	25	592	62	550	13	517
Australia	550	-	-	-	-	-	-
Finland	542	51	572	44	528	6	473
Sweden	533	55	569	39	511	6	458
United States	532	-	-	-	-	-	-
Ireland	532	50	560	42	518	7	462

Note. Data are not available for England, Australia or the United States as they did not administer the Home Questionnaire in TIMSS 2023. Source: e-Appendix Table A4.6.

Distribution of achievement for Fourth Class science

As well as mean scores, we can estimate pupil performance at various percentiles of the achievement distribution. This facilitates examination of the relative performance of lowest- and highest-achieving pupils. This section examines Fourth Grade pupils' distribution of achievement for TIMSS 2023 science at the 5th, 25th, 75th, and 95th percentiles.

As with overall science achievement in the previous section, this section compares the distribution of achievement in TIMSS 2023 with three previous cycles of TIMSS (2019, 2015, and 2011) and examines differences between boys and girls, as well as differences between socioeconomic categories. For a more detailed description on the percentiles and the distribution of achievement presented in this section, see Chapter 1.

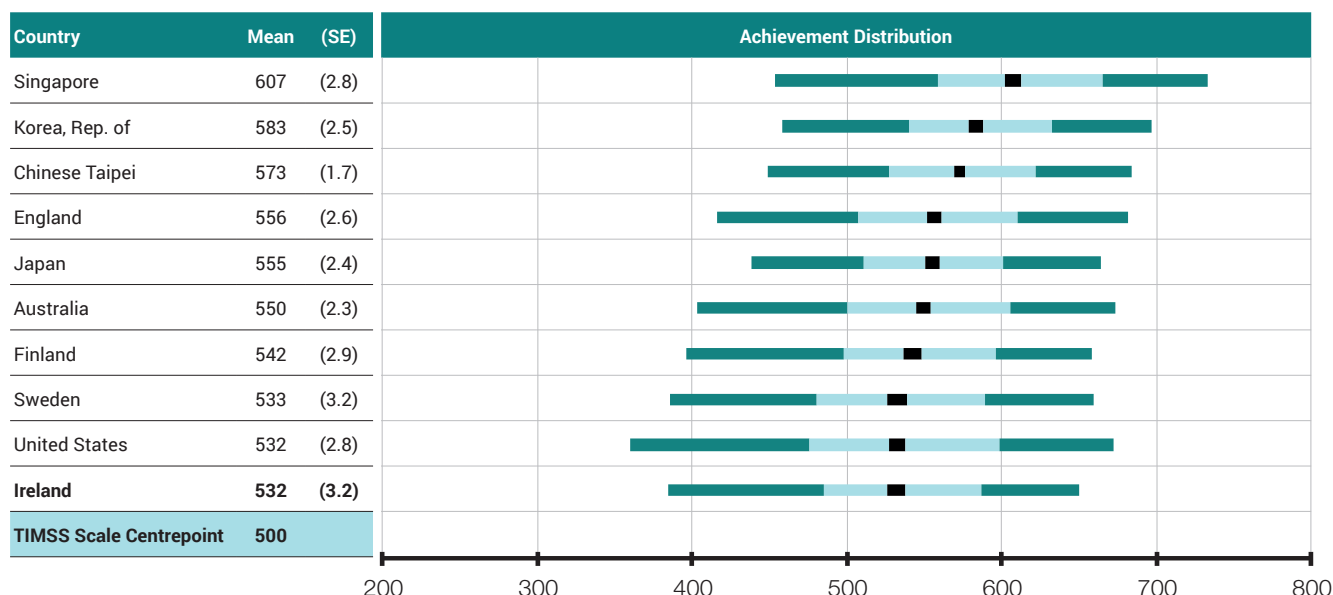
Distribution of achievement in Ireland and selected countries

Figure 4.5 shows the distribution of achievement for pupils in Fourth Grade who participated in TIMSS 2023 in Ireland and selected reference countries. When looking at the range in the distribution (the difference between the 5th and 95th percentiles, or the markers used here to represent the lowest- and highest-scoring pupils respectively) amongst the selected countries, the range is greatest in the United States (312 score points) and lowest in Japan (225). The range in Ireland falls in the middle of the set of selected countries, at 266 score points. A similar range is seen in England (266) and Australia (270). Singapore, the country with the highest mean achievement, has a somewhat wider range of distribution (280 score points) than some other selected countries.

In Ireland, pupils at the 5th percentile (the lowest-achieving pupils) had a mean science achievement of 384. In general, selected countries with a higher overall mean score in science also achieved a higher score at the 5th percentile, with two exceptions. The United States (532) had a similar overall mean score in science as Ireland, but a score of 360 at the 5th percentile (24 score points lower than in Ireland). Additionally, while England and Japan had similar overall mean scores (556 and 555, respectively), the score in Japan at the 5th percentile (439) was 23 points higher than for England (416).

At the 95th percentile (the highest-achieving pupils), pupils in Ireland had an estimated mean achievement of 650. As with the 5th percentile, the pattern was generally as expected (such that countries with higher scores overall also had higher scores at the 95th percentile), with some minor exceptions. One country that did not follow this pattern was the United States, where pupils at the 95th percentile had an estimated score of 672 (22 points higher than in Ireland, despite similar overall mean achievement). The United States also scored higher than Sweden (659) and Finland (658) at the 95th percentile, despite both these countries achieving higher overall mean scores.

Figure 4.5: Distribution of achievement in Ireland and selected countries, Fourth Grade science



Note. See Figure 1.1 (Chapter 1) for guidance on how to interpret this graph.

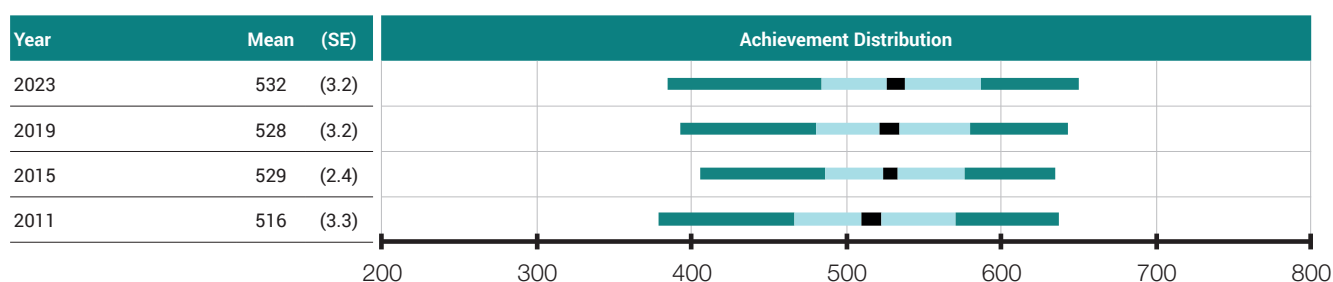
Source: e-Appendix Table A4.7.

Trends in distribution of achievement

Figure 4.6 shows the distribution of science achievement for Fourth Class in TIMSS 2023 and the three previous cycles (2019, 2015, and 2011). The range in the distribution of science achievement increased by 16 score points in 2023 (to 266 score points) compared with 2019 (250). This followed an increase of 20 score points between 2015 and 2019 (230), after a decrease of 27 score points from 2011 (257).

As with mathematics, this increase in the range can be explained, in part, by a decrease in performance at the 5th percentile and an increase in performance at the 95th percentile. Pupils in Ireland at the 5th percentile achieved an estimated mean score in science of 384 while their counterparts in 2019 achieved an estimated mean achievement score of 393, a non-significant difference of nine score points. Conversely, pupils at the 95th percentile achieved a mean score of 650 in 2023 compared with 643 in 2019, a non-significant seven score point increase. By comparison, while the gap between lowest- and highest- performing pupils decreased between 2011 and 2015, this was a result of the performance of the lowest-achieving pupils increasing (from 379 in 2011 to 405 in 2015) while pupils at the 95th percentile in 2011 and 2015 had similar mean scores (637 and 635, respectively).

Figure 4.6: Distribution of achievement across TIMSS cycles in Ireland, Fourth Class science



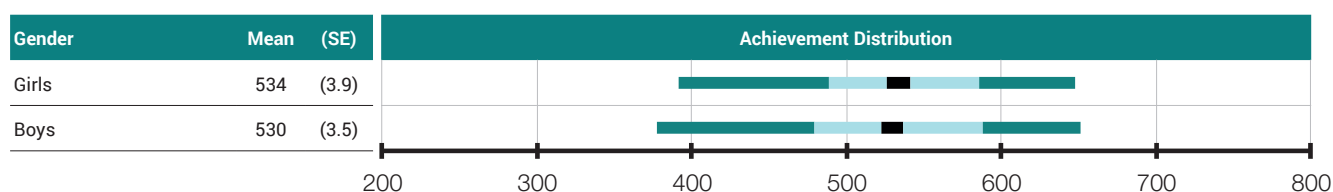
Note. See Figure 1.1 (Chapter 1) for guidance on how to interpret this graph.
Source: e-Appendix Table A4.8.

Distribution of achievement, by gender

Figure 4.7 shows the distribution of science achievement for girls and boys in Fourth Class in TIMSS 2023. As previously stated, there was no statistically significant difference in overall achievement between girls and boys. However, the range between the 5th and 95th percentiles for girls (257 score points) was smaller than for boys (274).

At the 5th percentile, girls (391) had a higher mean score than boys (378) (a difference of 13 score points), though this difference was not significant. At the 95th percentile, girls (648) had a lower estimated score than boys (651) (a difference of three score points), a difference which was not significant. This indicates that while the lowest-achieving girls outperformed the lowest-achieving boys, the highest-achieving boys slightly outperformed the highest-achieving girls, though neither of these differences were statistically significant.

Figure 4.7: Distribution of achievement by gender in Ireland, Fourth Class science



Note. See Figure 1.1 (Chapter 1) for guidance on how to interpret this graph.
Source: e-Appendix Table A4.9.

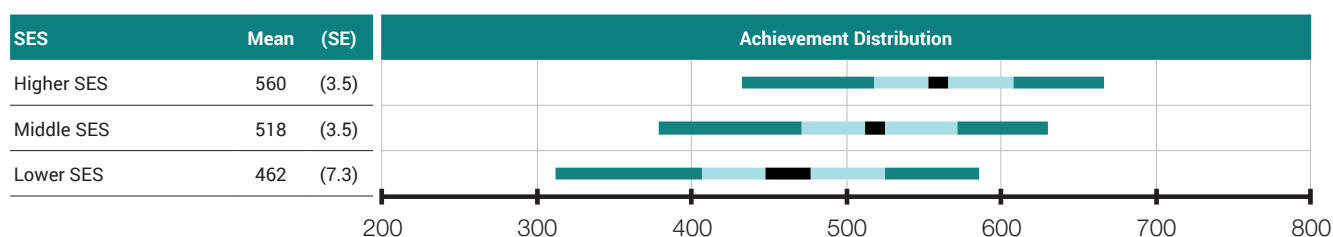
Distribution of achievement, by socioeconomic status

Figure 4.8 shows the distribution of achievement for Fourth Class pupils by *higher SES*, *middle SES*, and *lower SES* categories. As noted in Chapter 3, the standard errors associated with estimates for the *lower SES* category are substantially higher than for other categories due to the lower number of pupils in the *lower SES* category, which means that comparisons should be made cautiously.

The range of distribution for pupils with *higher SES* was 234 score points, which was 18 score points narrower than the range among pupils with *middle SES* (252). This was, in turn, 22 points narrower than the estimated range among pupils with *lower SES* (274).

At the 5th percentile, pupils with *higher SES* had an estimated mean score of 432, which was significantly higher than their peers in the *middle SES* (379) or *lower SES* (312) categories. Performance at the 95th percentile followed a similar pattern: pupils in the *higher SES* category had an estimated mean score of 666, which was significantly higher than pupils with *middle SES* (630) or *lower SES* (586). The difference in score between *higher SES* pupils and *lower SES* pupils at the 5th percentile was 120 scale points, and at the 95th percentile was 80 points.

Figure 4.8: Distribution of achievement by Socioeconomic Status (SES) scale in Ireland, Fourth Class science



Note. See Figure 1.1 (Chapter 1) for guidance on how to interpret this graph.

Source: e-Appendix Table A4.10.

Performance at International Benchmarks for Fourth Class science

This section shows the cumulative percentages of Fourth Class pupils reaching each of the four International Benchmarks for TIMSS 2023 science in Ireland and selected reference countries. These benchmarks indicate the skills and knowledge demonstrated by Fourth Class pupils at different levels of science achievement. This section compares performance at the International Benchmarks for pupils in Ireland in 2023 and in three previous cycles of TIMSS (2019, 2015, and 2011). Differences between boys and girls in Ireland at each International Benchmark are also presented.

TIMSS International Benchmarks for Fourth Grade science

Table 4.3 describes the International Benchmarks for science at Fourth Grade. In brief, pupils who achieve the Low Benchmark can consistently demonstrate limited scientific knowledge of, for example, living things, the environment and Earth's characteristics. Pupils achieving the Intermediate Benchmark have demonstrated the requirements to meet the Low Benchmark and can also demonstrate more specific knowledge of the physical and life sciences, such as human health, energy, and light. They can also apply some basic knowledge about force and motion and provide partial descriptions of scientific observations.

At the High Benchmark, pupils demonstrate the knowledge and skills to achieve the Low and Intermediate Benchmarks and also show greater knowledge of a variety of scientific topics, including reproduction in living things and Earth's characteristics. They can also apply their knowledge of, for example, life cycles, states and properties of matter, and the Earth-Sun system, as well as interpreting models and graphs. Finally, at the Advanced Benchmarks, pupils can demonstrate all the requirements to achieve the lower benchmarks as well as showing more complex scientific knowledge of the characteristics of living things, biological inheritance, germs, and the properties of matter and can also apply this knowledge. They can communicate this understanding effectively, design scientific tests, evaluate conclusions, and reason with representations of the relationships between living things.

Table 4.3: International Benchmarks - Fourth Grade science

Benchmark	Scoring at least	Pupils typically can:
Advanced <i>Pupils can show, apply, and communicate their knowledge of life, physical, and earth sciences, and engage in multiple scientific inquiry practices.</i>	625	<p>Show knowledge of the characteristics of living things and can construct and reason with representations of the relationships among organisms in ecosystems.</p> <p>Demonstrate knowledge of inheritance, killing germs, and environmental pollution.</p> <p>Show knowledge of properties of matter and of changes in states of matter, and reason about dissolving rates in a laboratory setting.</p> <p>Communicate their understanding of Earth's physical characteristics and processes and of how humans use and impact the Earth's natural resources.</p> <p>Show knowledge of the motion and relative position of the Earth, moon, and sun. Design fair tests, predict outcomes, and evaluate possible conclusions.</p>
High <i>Pupils can show and apply knowledge of life, physical, and earth science, and they engage in some scientific inquiry practices.</i>	550	<p>Distinguish between living and non-living things, show knowledge about plant and animal reproduction and survival, and can apply knowledge about some of the characteristics of plants and animals and their life cycles.</p> <p>Apply knowledge about the spread of germs.</p> <p>Apply knowledge about states and properties of matter, magnets, sound, and heat and reason using knowledge of dissolving rates in an everyday context.</p> <p>Show and apply some knowledge of forces and motion.</p> <p>Know various facts about the Earth's physical characteristics and apply their knowledge about Earth's different climates and changes over time.</p> <p>Apply knowledge of the Earth-sun system and show basic knowledge of the moon's phases.</p> <p>Describe observations and interpret models and graphical representations.</p>
Intermediate <i>Pupils can show and apply knowledge of some scientific concepts.</i>	475	<p>Show and apply some knowledge about plants and animals and have basic knowledge of human health.</p> <p>Show knowledge about properties of matter, energy, and light, and apply basic knowledge about forces and motion.</p> <p>Show basic understanding of the Earth's surface.</p> <p>Provide partial descriptions of observations and can relate observations and data to scientific facts.</p>
Low <i>Pupils can show knowledge of some science facts.</i>	400	<p>Demonstrate basic knowledge of plants, animals, and the environment.</p> <p>Show knowledge about some properties of matter in everyday situations and know that turbines provide electricity to some regions.</p> <p>Show some knowledge about Earth's characteristics, its changes over time, and its climate.</p>

Source: Adapted from Exhibit 2.1.3 in von Davier et al. (2024).

Achievement at the International Benchmarks

Table 4.4 shows the percentages of Fourth Grade pupils achieving each International Benchmark for science in TIMSS 2023 in Ireland and selected reference countries. In Ireland, most pupils reached the Low (93%) and Intermediate (78%) Benchmarks. Almost half of Fourth Class pupils achieved the High Benchmark (45%), and one in ten reached the Advanced Benchmark (10%). The percentage of pupils reaching each International Benchmark in Ireland was higher than the overall TIMSS median.

Comparing Ireland with the reference countries, the United States had a slightly lower percentage of pupils reaching the Low (91%) and Intermediate (75%) Benchmarks while in Sweden, similar percentages of pupils achieved the Low (93%), Intermediate (77%), and High (44%) Benchmarks. Amongst the reference countries, Ireland had the lowest percentage of pupils reaching the Advanced Benchmark.

In the top three countries (Singapore, the Republic of Korea, and Chinese Taipei), almost all pupils reached both the Low and Intermediate Benchmarks. Substantial percentages of pupils reached the Advanced Benchmarks as well, although Singapore achieved a noticeably higher percentage than the Republic of Korea and Chinese Taipei (44%, 28%, and 23% respectively).

Table 4.4: Cumulative percentages of pupils reaching each International Benchmark in Ireland and selected countries, Fourth Grade science

	Mean	Low (400)	Intermediate (475)	High (550)	Advanced (625)
Singapore	607	98	93	78	44
Korea, Rep. of	583	98	93	70	28
Chinese Taipei	573	99	91	64	23
England	556	96	85	55	19
Japan	555	98	88	54	15
Australia	550	95	83	52	17
Finland	542	95	82	50	13
Sweden	533	93	77	44	12
United States	532	91	75	46	15
Ireland	532	93	78	45	10
TIMSS (median)		90	70	31	7

Note. The percentages of Fourth Class pupils within each International Benchmark of science (i.e., discrete categories) in Ireland are: 4.9% (Below Low); 14.1% (Low); 28.8% (Intermediate); 36.5% (High); 15.7% (Advanced).

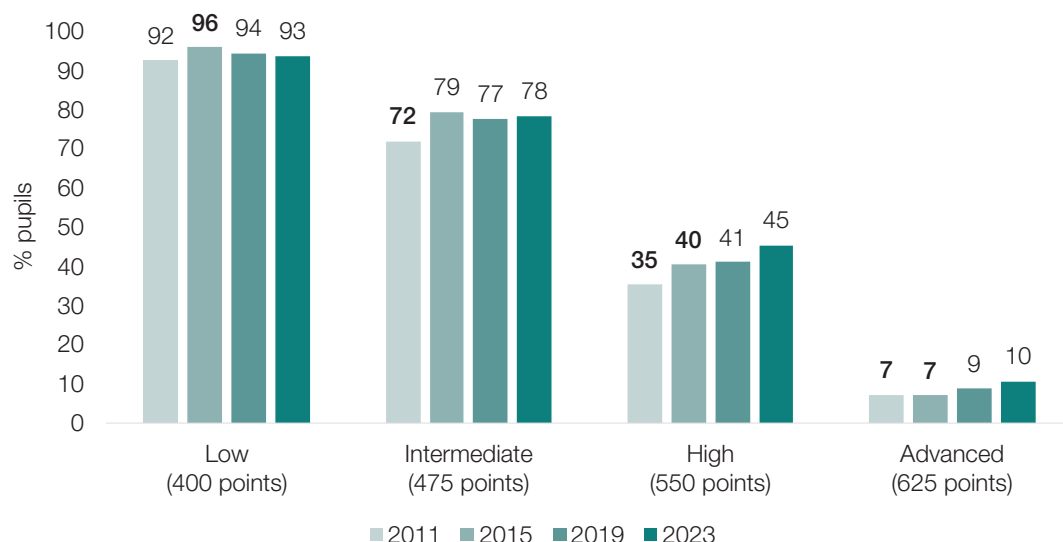
Source: e-Appendix Table A4.11 and Exhibit 2.1.4 in von Davier et al. (2024).

Trends in performance at International Benchmarks

Figure 4.9 shows the percentages of Fourth Class pupils achieving each International Benchmark in science for TIMSS 2023 and in three previous cycles. The percentage of pupils achieving the Low Benchmark in 2023 (93%) was similar to the percentages in 2019 (94%) and 2011 (92%). However, the difference between 2023 and 2015 (96%) was statistically significant. At the Intermediate Benchmark there were no statistically significant differences between 2023 (78%) and 2019 (77%) or 2015 (79%), while the difference between 2023 and 2011 (72%) was statistically significant. In 2023, there was a significant increase in pupils achieving the High Benchmark (45%) when compared with 2015 (40%) and 2011 (35%), and no statistically significant differences when compared with 2019 (41%). Finally, there was a statistically significant increase in pupils achieving the Advanced Benchmark in 2023 (10%) compared with 2015 (7%) and 2011 (7%). The difference between 2023 and 2019 (9%) was not significantly different.

In 2023, there was a significant increase in pupils achieving the High Benchmark (45%) when compared with 2015 (40%) and 2011 (35%), and no statistically significant differences when compared with 2019 (41%). Finally, there was a statistically significant increase in pupils achieving the Advanced Benchmark in 2023 (10%) compared with 2015 (7%) and 2011 (7%). The difference between 2023 and 2019 (9%) was not significantly different.

Figure 4.9: Cumulative percentages of pupils reaching each International Benchmark across TIMSS cycles in Ireland, Fourth Class science



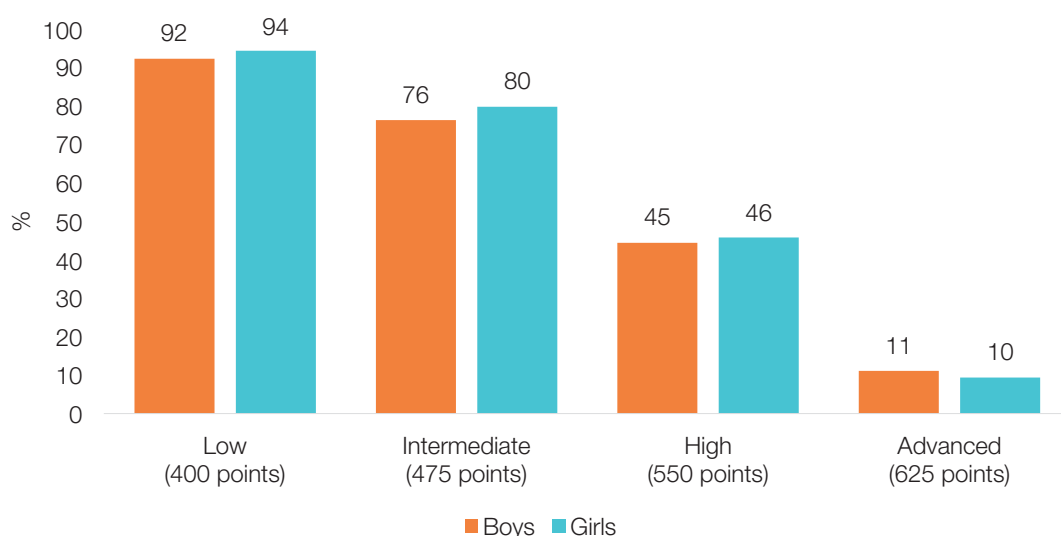
Note. Percentages in **bold** are significantly different to the equivalent in 2023.

Source: e-Appendix Table A4.12.

Performance at the International Benchmarks, by gender

Figure 4.10 shows the percentages of girls and boys in Fourth Class reaching each of the International Benchmarks for science in TIMSS 2023. Similar percentages of girls and boys reached each benchmark. Slightly higher percentages of girls reached each of the Low, Intermediate, and High Benchmarks, while a slightly higher percentage of boys reached the Advanced Benchmark. None of these differences were statistically significant.

Figure 4.10: Cumulative percentages of girls and boys reaching each International Benchmark in Ireland, Fourth Class science



Note. Percentages in **bold** indicate a significant difference between boys and girls.

Source: e-Appendix Table A4.13.

Performance in content and cognitive domains for Fourth Class science

Chapter 1 describes the Assessment Framework that the TIMSS assessment is based upon. This Assessment Framework is reviewed and updated for each TIMSS cycle in order to accurately reflect the curricula of all participating countries (Mullis et al., 2021). This section presents overall achievement in the TIMSS 2023 science assessment in each of the content and cognitive domains for Ireland and selected reference countries. Performance on each of these domains is compared with overall science performance and highlights areas of relative strengths and weaknesses in Ireland and the selected reference countries. Differences between girls and boys in Ireland in each of the content and cognitive domains are also presented.

Performance on content domains

As presented in Chapter 1, there are three science content domains at Fourth Grade: Life Science, Physical Science, and Earth Science. These reflect the science that is generally taught at Fourth Grade, although it must be noted that some of the Earth Science topics would be covered in the geography curriculum in Ireland. Life Science accounts for almost half of the assessment, 45%, Physical Science accounts for just over one-third, 35%, and Earth Science accounts for one-fifth, 20%.

Each of the three content domains are made up of topic areas which are, in turn, made up of a variety of topics. Life Science is made up of five topic areas: characteristics and life processes of organisms; life cycles, reproduction, and heredity; organisms, environment, and their interactions; ecosystems; and human health. Physical Science is made up of three topic areas: classification and properties of matter and changes in matter; forms of energy and energy transfer; and forces and motion. Finally, Earth Science is made up of three topic areas: Earth's physical characteristics, resources, and history; Earth's weather and climates; and Earth in the Solar System.

Table 4.5 shows the mean achievement scores of Fourth Grade pupils in the science content domains for Ireland and selected reference countries. Fourth Class pupils in Ireland showed no significant differences between their overall science score (532) and their scores in the Life Science (535) or Earth Science (534) content domains. However, their score for Physical Science (528) was significantly lower than the overall score. Of the reference countries, only Australia showed a similar pattern to Ireland, while England and Sweden showed no significant differences for any of the content domains.

Internationally, there was substantial variation in differences between overall science and the three content domains. However, the four top scoring countries (Singapore, the Republic of Korea, Chinese Taipei, and Türkiye) all showed a relative strength in Physical Science, while three of these countries (the Republic of Korea, Chinese Taipei, and Türkiye) showed a relative weakness in Life Science.

Comparing pupils in Ireland's performance in the TIMSS 2023 science content domains with their counterparts in 2019, both groups showed a relative weakness in Physical Science. However, pupils in 2019 also showed a relative strength in Earth Science that pupils in 2023 did not show.

Table 4.5: Mean achievement scores on content domains in Ireland and selected countries, Fourth Grade science

	Mean	Life Science	Physical Science	Earth Science
Singapore	607	614	622	578
Korea, Rep. of	583	579	595	573
Chinese Taipei	573	562	582	574
England	556	555	558	554
Japan	555	544	573	542
Australia	550	554	545	549
Finland	542	543	537	551
Sweden	533	532	532	537
United States	532	541	525	528
Ireland	532	535	528	534

Note. Light shading indicates that the subscale score is significantly lower than the country's overall science scale score. Dark shading indicates that the subscale score is significantly higher than the country's overall science scale score.

Source: Adapted from Exhibit 2.1.13 in von Davier et al. (2024).

Table 4.6 shows the mean achievement of Fourth Class girls and boys in the science content domains. There were no significant differences between girls and boys in either Physical Science or Earth Science. However, girls significantly outperformed boys (by ten points) in Life Science.

Table 4.6: Mean achievement scores of girls and boys on content domains in Ireland, Fourth Class science

	Mean	Life Science	Physical Science	Earth Science
Girls	534	540	528	530
Boys	530	530	527	538

Note. Shading indicates that the subscale score is significantly higher than for the other gender on that subscale.
Source: e-Appendix Table A4.14.

Performance on cognitive domains

The three cognitive domains in science are the same at both the Fourth and Eighth Grades. These cognitive domains are: Knowing, Applying, and Reasoning.

Table 4.7 shows the mean achievement scores of Fourth Grade pupils in the science cognitive domains. In Ireland, there were no significant differences between the overall science score and the scores on any of the cognitive domains. This is a change from TIMSS 2019, when pupils displayed a relative strength in the Knowing cognitive domain (Perkins & Clerkin, 2020).

Of the reference countries, the Republic of Korea, England, and Australia similarly lacked any significant differences between their overall scores and their scores on the cognitive domains. Knowing was a relative weakness for two countries (Japan and Sweden) and a relative strength for Chinese Taipei only. Applying was a relative strength for two countries (Japan and Finland) and a relative weakness for just one country (Singapore). Reasoning was a relative weakness for two countries (Chinese Taipei and the United States) and a relative strength for three countries (Singapore, Japan, and Sweden).

Table 4.7: Mean achievement scores on cognitive domains in Ireland and selected countries, Fourth Grade science

	Mean	Knowing	Applying	Reasoning
Singapore	607	610	595	621
Korea, Rep. of	583	584	584	583
Chinese Taipei	573	580	569	567
England	556	555	558	556
Japan	555	538	560	568
Australia	550	552	548	548
Finland	542	541	545	540
Sweden	533	523	532	546
United States	532	535	530	530
Ireland	532	534	530	531

Note. Light shading indicates that the subscale score is significantly lower than the country's overall science scale score. Dark shading indicates that the subscale score is significantly higher than the country's overall science scale score.
Source: Adapted from Exhibit 2.1.14 in von Davier et al. (2024).

Table 4.8 shows the mean achievement scores of Fourth Class girls and boys in the science cognitive domains. There were no significant differences between girls and boys for Knowing or Applying. However, girls significantly outperformed boys in the Reasoning cognitive domain by 14 score points.

Table 4.8: Mean achievement scores of girls and boys on cognitive domains in Ireland, Fourth Class science

	Mean	Knowing	Applying	Reasoning
Girls	534	532	531	538
Boys	530	535	529	524

Note. Shading indicates that the subscale score is significantly higher than for the other gender on that subscale.
Source: e-Appendix Table A4.15.

Curriculum coverage for Fourth Class science

As stated in Chapter 1, a Test-Curriculum Matching Analysis (TCMA) was conducted to establish whether the topic of each item in the TIMSS assessment was likely to have been taught to the majority of Fourth Class pupils by the testing period in March/April of Fourth Class. In this section, the results of the TCMA for Fourth Class science are presented along with the percentage of TIMSS topics covered in class as reported by teachers on the Teacher Questionnaire.

Test-Curriculum Matching Analysis for Fourth Grade science

Table 4.9 shows the outcomes of the TCMA for Fourth Class science in Ireland. Overall, there was a high degree of overlap for science (87%) but this is somewhat lower than the proportion reported for mathematics (96%). Twenty-two items in total were deemed to be outside the scope of the curriculum at this level. Looking at the percentages by content domain, Physical Science had the highest proportion of overlap and all three items which were deemed outside the scope were from the classification and properties of matter and changes in matter topic area within Physical Science. Life Science also had a very high proportion of 91% with seven items deemed outside the scope of the curriculum.

As Earth Science content area is often covered as part of the geography curriculum, the subject experts were asked to classify the items irrespective of whether they were covered in science or geography. Approximately one-third of the items in Earth Science was deemed to be outside the scope of the curriculum at this level. The items which were excluded were generally not covered by pupils in Ireland until the Fifth and Sixth Class curriculum and related to the topic areas of earth's physical characteristics, resources and history; and earth in the solar system.

Table 4.9: TCMA overall and by content domain – Fourth Grade science items

	Number of items	Number of items included in curriculum	% included in curriculum
Life Science	79	72	91%
Physical Science	61	58	95%
Earth Science	33	21	64%
Overall	173	151	87%

Additionally, a hypothetical scale score that is based solely on the items judged to be part of the country's curriculum was calculated. If only the items considered to be part of the Irish curriculum were included, pupils in Ireland would have achieved a mean score of 533 (von Davier et al., 2024). This is similar to their actual achieved score (532). Internationally, most countries saw minor differences in their hypothetical and actual mean scores. However, two countries observed substantial increases in their hypothetical scores compared to

their actual scores. Singapore's hypothetical score (681) was 74 points higher than their actual score (607) and Japan's hypothetical score (585) was 30 points higher than their actual score (555).

Teacher reports of topic coverage for Fourth Grade science

As with mathematics, teachers were asked whether various topics across content domains had been *mostly taught before this year, mostly taught this year, or not yet been taught*. This was done to provide an indicator of pupils' familiarity with TIMSS 2023 assessment topics in Ireland and other participating countries. The results for Ireland and selected countries are presented in Table 4.10.

Across all three topics, the level of topic coverage reported in Ireland was above the average for all countries participating in TIMSS 2023. In fact, the percentages reported for Ireland are amongst the highest across all three topics when compared with the selected countries. In Life Science, only Australia (81%) reported higher coverage than Ireland (80%), with England and the United States reporting similar levels to Ireland. In Physical Science, only England (81%), Chinese Taipei (67%), and the United States (61%) reported higher coverage than Ireland (60%). Finally, only England reported higher coverage than Ireland in Earth Science (73% and 69% respectively).

Across the selected countries, there was substantial variation in percentages across the three topics. For Life Science, teachers in most countries reported topic coverage greater than 60% except for Singapore and Japan. Singapore and Japan both reported comparatively low percentages for all three topics (all below 50%), with Singapore reporting an unusually low percentage (3%) in Earth Science.

Table 4.10: Percentages and standard errors of pupils taught the TIMSS topics – Fourth Grade science

	Life Science (11 topics)		Physical Science (14 topics)		Earth Science (11 topics)	
	%	(SE)	%	(SE)	%	(SE)
Singapore	45	(0.7)	42	(0.5)	3	(0.6)
Korea, Rep. of	62	(2.1)	49	(1.7)	37	(2.0)
Chinese Taipei	73	(1.4)	67	(1.4)	65	(1.6)
England	80	(1.8)	81	(1.7)	73	(2.2)
Japan	38	(2.0)	45	(1.8)	20	(1.8)
Australia	81	(1.4)	59	(2.2)	67	(2.3)
Finland	71	(0.9)	42	(1.4)	55	(1.6)
Sweden	66	(1.8)	36	(1.5)	54	(2.4)
United States	80	(1.4)	61	(1.5)	69	(1.4)
Ireland	80	(1.4)	60	(2.0)	69	(1.9)
TIMSS average (57)	77	(0.2)	57	(0.2)	61	(0.3)

Note. Percentages of pupils mostly taught before or in the assessment year, averaged across topics.
57 countries in the TIMSS average rather than 58 as Norway did not administer the Teacher Questionnaire.
See e-Appendix Table A4.16 for more detailed information on individual topics.

Chapter 5:

Second Year Mathematics

This chapter describes student performance on the TIMSS 2023 Eighth Grade mathematics assessment. Overall mathematics achievement is described, as well as the distribution of achievement in Ireland and selected countries, student performance at International Benchmarks, and performance on the TIMSS content and cognitive domains.

For each of these sections, the performance of Second Year students is explored with reference to selected countries (as described in Chapter 1); compared with the two most recent cycles of TIMSS at Second Year (2019 and 2015); examined by gender; and examined by differences on socioeconomic measures such as school DEIS status and a TIMSS-derived measure of individual Home Educational Resources (HER).

Finally, the extent of curriculum coverage for Second Year mathematics is explored. As noted in Chapter 1, TIMSS is a curriculum-based study and a Test-Curriculum Matching Analysis (TCMA) is conducted for each cycle. This section presents the results of the TCMA, as well as teachers' report of coverage of the TIMSS topics in the classroom.

Mean achievement for Second Year mathematics

This section presents the main findings relating to the overall performance of Second Year students in Ireland on the TIMSS 2023 Eighth Grade mathematics assessment. Comparisons to the other participating countries are described, as well as differences by gender and by indicators of socioeconomic status.

Overall results

Table 5.1 presents the mean mathematics scores of Second Year students and their peers in other countries. At Eighth Grade, 44 countries and three benchmarking entities participated in TIMSS 2023. The highest mean score (605) was achieved by students in Singapore, followed by Chinese Taipei (602), and the Republic of Korea (596).

Second Year students in Ireland achieved a mean score of 522 in mathematics, significantly above the TIMSS international average (478). Five countries had a score significantly higher than Ireland (Singapore, Chinese Taipei, the Republic of Korea, Japan, and Hong Kong). The scores of students in four countries did not differ significantly from that of Second Year students: England (525), Czech Republic (518), Sweden (517), and Lithuania (514). The scores of students in 34 countries (including Australia, Finland, and the United States) were significantly lower than Ireland's mean score.

Thirteen countries in the EU participated in TIMSS 2023 at Eighth Grade. No EU country had a significantly higher mean mathematics score than Ireland. Three countries in the EU had a similar and not significantly different mean mathematics score to Ireland (Czech Republic, Sweden, and Lithuania).

Table 5.1 also shows the standard deviation for each participating country. The standard deviation for Second Year students in mathematics was 79. Türkiye had the largest standard deviation of 114 while Austria had the smallest standard deviation of 74. The spread in Ireland is one of the lowest, with only four other countries (South Africa, Morocco, Côte d'Ivoire, and Austria) having a lower standard deviation than Ireland.

Table 5.1: Mean achievement scores and standard errors of countries and benchmarking participants, Eighth Grade mathematics

Country	Mean	(SE)	SD	Country	Mean	(SE)	SD
Singapore	605	(6.1)	97	TIMSS 2023 International Average	478	(0.5)	-
Chinese Taipei	602	(3.1)	98	Portugal	475	(2.7)	83
Korea, Rep. of	596	(3.0)	98	Georgia	467	(3.2)	92
Japan	595	(3.0)	84	Kazakhstan	454	(3.5)	92
Hong Kong SAR	575	(5.0)	98	Qatar	451	(4.2)	100
England	525	(4.5)	97	Bahrain	426	(2.4)	99
Ireland	522	(2.7)	79	Iran, Islamic Rep. of	423	(3.6)	90
Czech Republic	518	(2.3)	84	Uzbekistan	421	(4.3)	88
Sweden	517	(2.4)	82	Chile	416	(3.2)	84
Lithuania	514	(3.1)	92	Oman	411	(2.7)	91
Austria	512	(2.3)	74	Malaysia	411	(3.5)	88
Australia	509	(3.5)	93	Kuwait	399	(5.2)	95
Türkiye	509	(4.3)	114	Saudi Arabia	397	(3.3)	83
Hungary	506	(3.7)	91	South Africa (9)	397	(3.1)	78
Finland	504	(2.6)	82	Jordan	388	(3.2)	87
Norway (9)	501	(2.3)	82	Palestinian Nat'l Auth.	382	(3.0)	89
Italy	501	(3.0)	85	Brazil	378	(2.8)	89
Malta	499	(1.2)	90	Morocco	378	(3.0)	75
Romania	496	(4.9)	100				
Cyprus	494	(2.7)	93	New Zealand	485	(4.1)	96
United Arab Emirates	489	(1.7)	104	Côte d'Ivoire	263	(4.9)	75
United States	488	(4.2)	94	Benchmarking Participants			
Israel	487	(3.9)	100	Dubai, UAE	546	(2.8)	98
France	479	(3.1)	81	Sharjah, UAE	496	(4.8)	92
Azerbaijan	479	(3.7)	102	Abu Dhabi, UAE	454	(2.8)	100
	Average achievement significantly higher than Ireland				Average achievement significantly lower than Ireland		

Note. New Zealand and Côte d'Ivoire are not included in the TIMSS 2023 international average.

Norway and South Africa assessed students in Ninth Grade rather than Eighth Grade.

Multiple comparisons are not taken into account when testing significant differences.

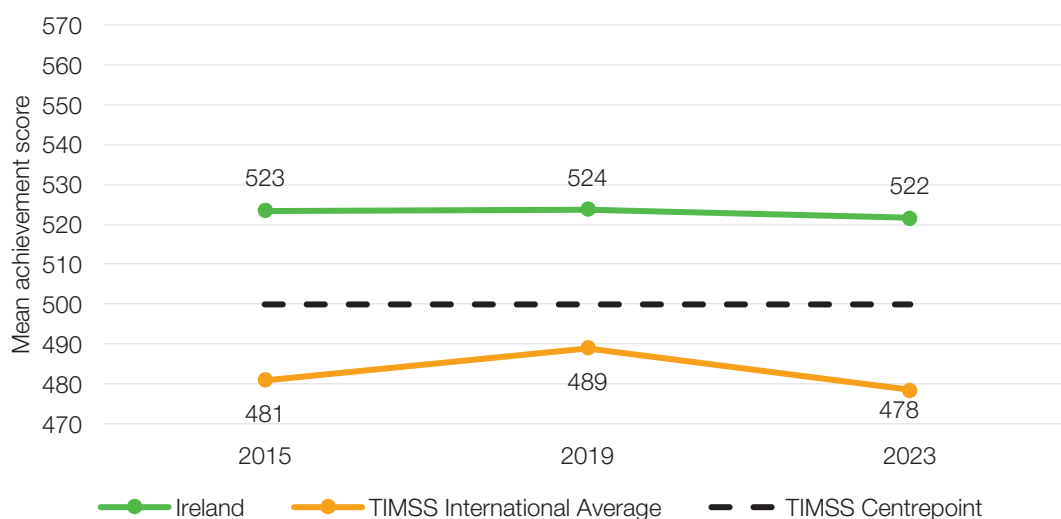
Source: e-Appendix Table A5.1.

Trends in achievement

Ireland's mathematics performance in 2023 can also be considered in the context of performance in previous cycles (Figure 5.1). The TIMSS centrepoint provides a constant point of reference since the first cycle of TIMSS in 1995 and can be used to compare trends over time. Comparisons over time on the TIMSS international average should be made cautiously, given that each cycle contains a slightly different number and set of participating countries. As noted in Chapter 1, Ireland participated at Eighth Grade most recently in 2015 and 2019, which will be the focus of trend achievement for Second Year students.

The performance of Second Year students on the TIMSS mathematics scale has remained stable since 2015. The mean mathematics score in 2023 (522) was two points lower than in 2019 (524) and one point lower than in 2015 (523). These differences are small and neither difference is statistically significant.

Figure 5.1: Mean achievement scores across TIMSS cycles for Ireland and TIMSS average, Eighth Grade mathematics

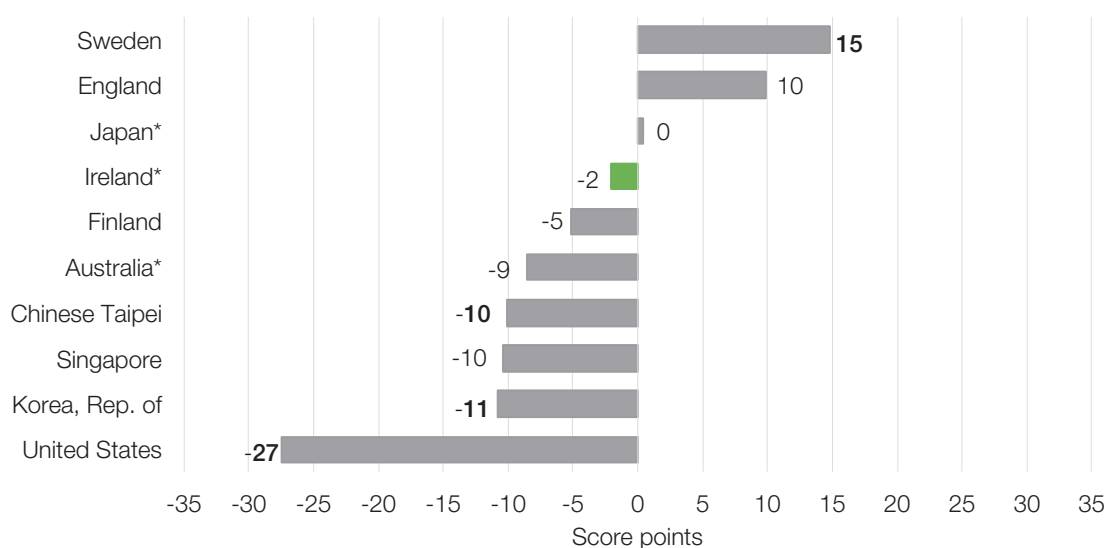


Note. TIMSS international average includes all countries that participated in the cycle. Countries included in TIMSS international average: 2023=42; 2019=39; 2015=40.
Source: e-Appendix Table A5.2.

Figure 5.2 presents the mean score differences in mathematics performance between 2019 and 2023 for Ireland and selected countries. An increase of 15 and 10 score points can be observed in Sweden and England, respectively, though the difference is statistically significant only for Sweden. Ireland's decrease of two score points compared to 2019 is not statistically significant. The United States, the Republic of Korea, and Chinese Taipei saw statistically significant decreases since the TIMSS 2019 cycle (27-, 11-, and 10-point declines, respectively).

Similarly to Ireland, Australia and Japan moved from a paper-based test administration in 2019 to digital testing in 2023 with no significant difference in mean mathematics score between cycles.

Figure 5.2: Change in mean achievement score between 2019 and 2023 for Ireland and selected countries, Eighth Grade mathematics



Note. Figures in **bold** indicate a significant difference from the previous cycle.

* Indicates country changed mode of assessment in TIMSS 2023.

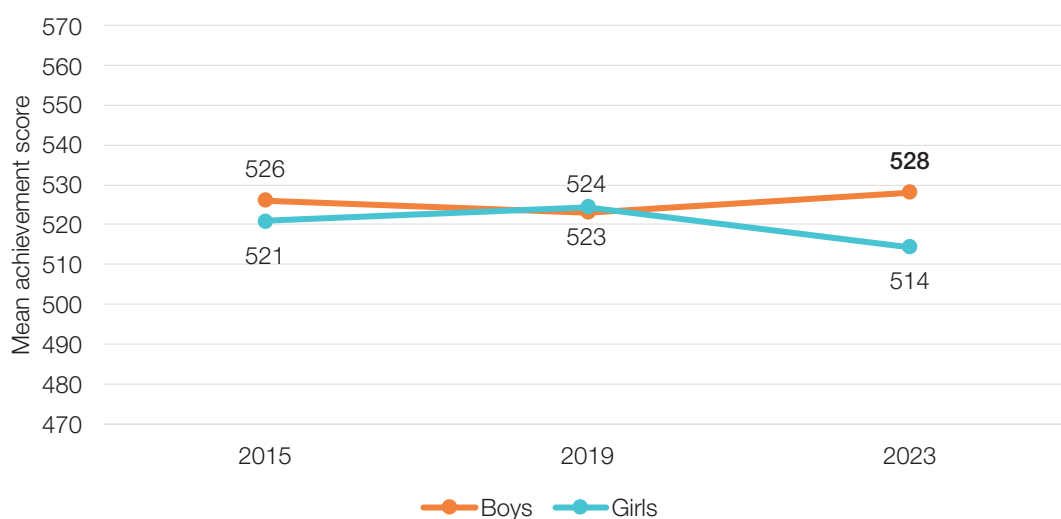
Source: e-Appendix Table A5.3.

Achievement differences by gender

In TIMSS 2023, boys in Second Year achieved a mean mathematics score of 528, while girls achieved a mean score of 514 (Figure 5.3); this difference is statistically significant. By comparison, the TIMSS international average mean score for boys was 481 and 475 for girls, with an average gender difference of six score points.

Compared to previous cycles of TIMSS, the observation of a significant gender difference in mathematics at Second Year is noteworthy and appears to have been driven predominantly by a decline in girls' performance (Figure 5.3). In 2019, the average mathematics performance of Second Year girls and boys was very similar, with girls scoring on average one point higher (524 for girls and 523 for boys). However, for girls, achievement decreased significantly from 524 in 2019 to 514 in 2023. By contrast, boys' performance increased slightly between the two cycles (from 523 in 2019 to 528 in 2023), although the change is not statistically significant.

Figure 5.3: Mean achievement scores among girls and boys in Ireland across TIMSS cycles, Second Year mathematics



Note. Figures in **bold** indicate a significant difference between boys and girls.

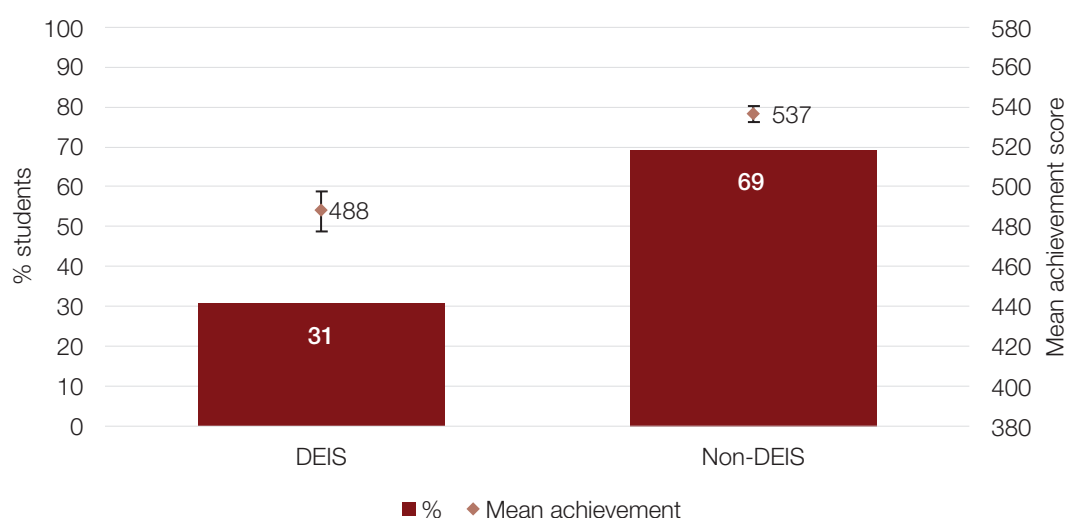
Source: e-Appendix Table A5.4.

Across the 42 countries with comparable data, boys scored significantly higher than girls on average in 21 countries (including Ireland), while girls had a significantly higher mathematics score than boys in four countries (Palestinian National Authority, Oman, Bahrain, and South Africa). Eighth Grade girls and boys achieved similar scores in the remaining 17 countries (including Finland, Chinese Taipei, Singapore, and Hong Kong).

Achievement differences by school DEIS status

In the TIMSS 2023 sample, approximately one-third of Second Year students (31%) were recorded as attending DEIS schools at the time of testing. These students achieved a significantly lower mean score on mathematics than their peers in non-DEIS schools, by 49 score points (Figure 5.4). This gap corresponds to approximately half a standard deviation on the TIMSS scale, which is substantial and statistically significant. The pattern of significance between the school DEIS categories is the same in 2023 as in 2019.

Figure 5.4: Percentages and mean achievement of students in Ireland by school DEIS category, Second Year mathematics



Note. Mean scores are presented with a 95% confidence interval around the estimate.

Source: e-Appendix Table A5.5.

Achievement differences by students' Home Educational Resources

The TIMSS 2023 Home Educational Resources scale at Eighth Grade is based on students' reports about the number of books, number of home study supports in their homes and the highest level of education of either parent. The scale has an international centrepont of 10.0 and a standard deviation of 2.0 (von Davier et al., 2024). In Ireland, the average HER score was 10.9 showing a high level of HER in Ireland relative to the international average. Responses to the scale were categorised at an international level as students having *many resources*, *some resources*, or *few resources* for learning at home.

Internationally, on average, 26% of students were classified as having *many resources*, 45% as having *some resources*, and 28% as having *few resources*. In Ireland, the corresponding figures were 39%, 45%, and 16%, respectively, indicating a relatively high proportion of students with *many resources* and fewer students with *few resources* compared to many other countries (Table 5.2).

In Ireland, students with *many resources* (559) demonstrated significantly higher average achievement in mathematics than students with *few resources* (459) (Table 5.2). This 100-point difference represents one standard deviation on the TIMSS scale. Across the selected countries, the mean achievement difference in mathematics between students with *many resources* and those with *few resources* ranged from 79 score points in Japan to 110 in Australia.

Table 5.2: Percentages and mean achievement of students by Home Educational Resources (HER) scale in Ireland and selected countries, Eighth Grade mathematics

	Mean	Many Resources		Some Resources		Few Resources	
		%	Mean	%	Mean	%	Mean
Singapore	605	33	649	47	601	20	545
Chinese Taipei	602	36	644	43	598	21	539
Korea, Rep. of	596	56	625	34	573	10	518
Japan	595	43	621	46	585	12	541
England	525	36	575	44	518	20	459
Ireland	522	39	559	45	515	16	459
Sweden	517	42	559	43	503	15	459
Australia	509	42	550	45	495	13	440
Finland	504	42	536	46	493	12	448
United States	488	31	545	45	479	23	437

Source: e-Appendix Table A5.6.

Distribution of achievement for Second Year mathematics

Student performance can also be examined at various percentiles of achievement (5th, 25th, 75th, and 95th). A more detailed description on the percentiles and the distribution of achievement presented in this section is given in Chapter 1. This section presents the performance at various percentiles for Ireland and selected countries in TIMSS 2023 as well as comparing the trends in distribution of achievement for Ireland in 2015, 2019, and 2023. The distribution of achievement is also examined by gender and socioeconomic status.

Distribution of achievement in Ireland and selected countries

Figure 5.5 presents the distribution of student achievement in mathematics at Eighth Grade for Ireland and selected countries. The figure presents performance at the 5th, 25th, 75th, and 95th percentiles of achievement, and the 95% confidence interval around the mean score.

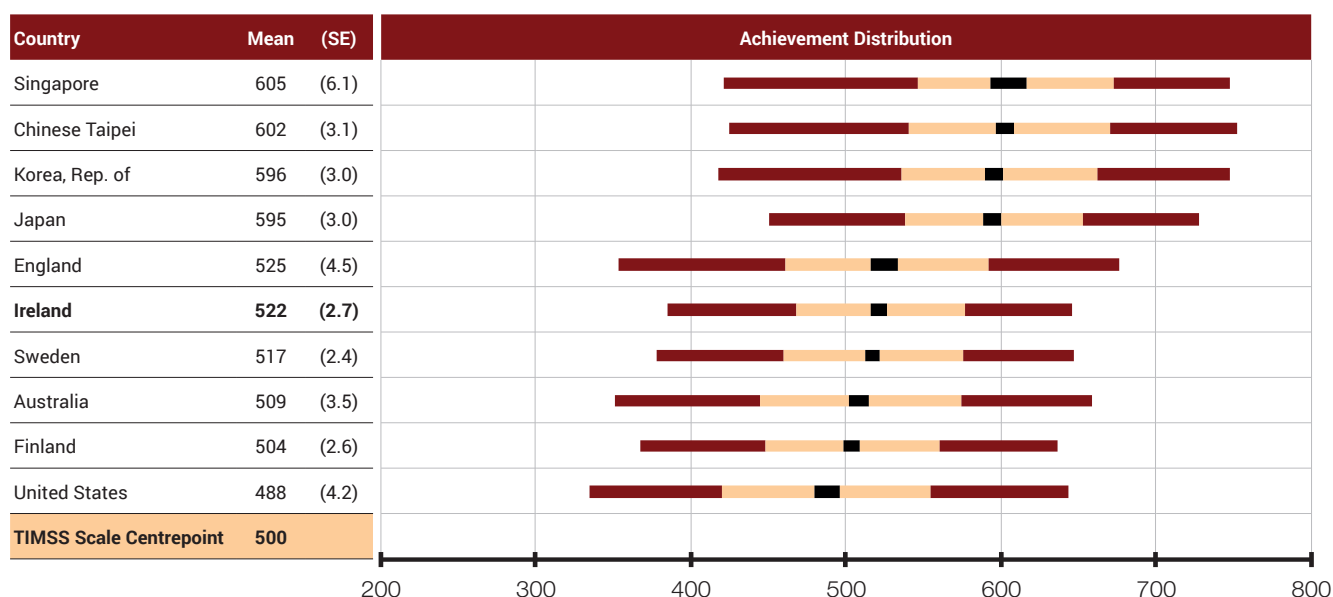
The range in the distribution of mathematics achievement among Second Year students in Ireland (a difference of 261 points from the 5th to 95th percentile) is narrower than in any of the selected countries, with the Republic of Korea (329) having the widest distribution. The performance of students in Ireland at the 5th percentile (lowest-performing students) (385) is nearly 40 points lower than the corresponding score (422) in the highest-performing country (Singapore). At the 95th percentile (the highest-performing students), at the other end of the distribution, students in Singapore scored over 100 points higher than students in Ireland (748 and 646, respectively). Eighth Grade students in the top four performing countries had a higher average score at the 75th percentile than Second Year students in Ireland at the 95th percentile.

While students in England had similar overall mathematics performance to students in Ireland at Eighth Grade (see Table 5.1), a greater spread in the distribution of performance is evident in England. The spread of scores among students scoring between the 5th and 25th percentiles is larger in England compared to Ireland. Similarly, the spread of scores among students scoring between the 75th and 95th percentile is larger in England than in Ireland. This indicates that, despite similar average levels of achievement, the lowest-achieving

students are performing better in Ireland compared to England, and the highest-achieving students in Ireland are underperforming compared to their counterparts in England. For example, at the 95th percentile, Second Year students scored 646 compared to 676 among Eighth Grade students in England.

When compared to students in our selected countries with significantly lower overall mathematics performance (Australia, Finland, and United States; see Table 5.1), the score of Second Year students in Ireland at the 5th percentile was considerably higher (385) than in these countries (351, 368, and 334 respectively). In contrast, the score of Second Year students in Ireland at the 95th percentile was somewhat lower than in Australia (by 14 points) and only slightly higher compared to Finland (nine score points) and United States (one score point).

Figure 5.5: Distribution of achievement in Ireland and selected countries, Eighth Grade mathematics



Note. See Figure 1.1 (Chapter 1) for guidance on how to interpret this graph.

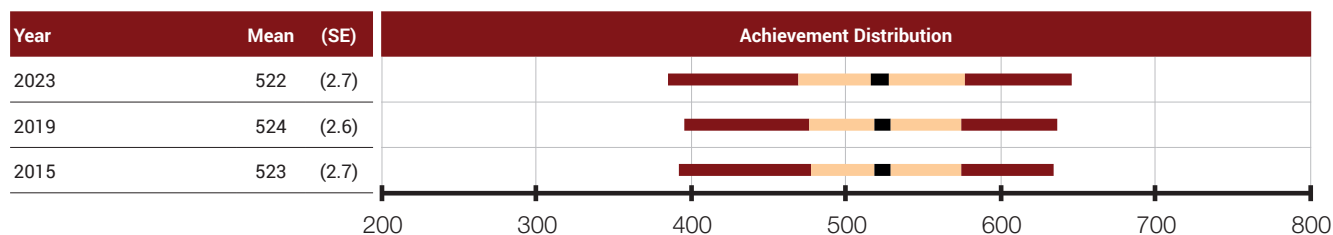
Source: e-Appendix Table A5.7.

Trends in distribution of achievement

Figure 5.6 presents the distribution of mathematics achievement for Second Year students from TIMSS 2015, 2019, and 2023. There has been a significant improvement of about nine score points at the 95th percentile (646 in 2023) since 2019 (636), while scores in 2019 and 2015 (634) were relatively similar. However, at the other end of the distribution, the mathematics scores of students at the 5th percentile decreased by about 10 points between 2019 (395) and 2023 (385). This 10-point difference is not significant given the large standard errors around the estimates.

Overall, the data show a widening of the distribution of mathematics achievement in 2023 compared to the two previous TIMSS cycles, with a slight (though not significant) disimprovement among the lowest-achieving students and a slight (but significant) improvement among the highest-achieving students between 2019 and 2023.

Figure 5.6: Distribution of achievement across TIMSS cycles in Ireland, Second Year mathematics



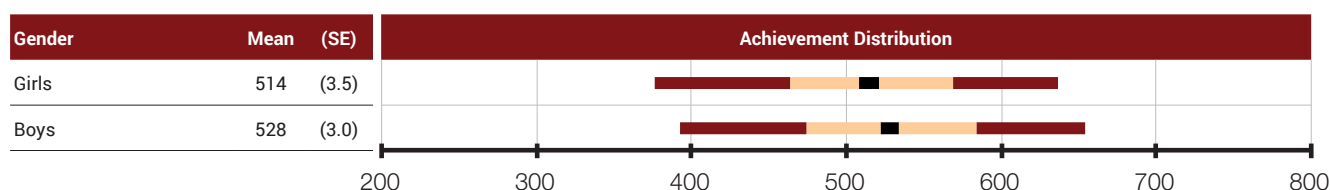
Note. See Figure 1.1 (Chapter 1) for guidance on how to interpret this graph.
Source: e-Appendix Table A5.8.

Distribution of achievement, by gender

As described above (Figure 5.3), boys significantly outperformed girls in mathematics in Ireland at Second Year on average, with a mean score which was 14 score points higher. Figure 5.7 presents the distribution of achievement for boys and girls in Ireland.

While there was no difference in the range of the distribution of girls' (260) and boys' (261) achievement, boys achieved higher scores at all points along the distribution. At the 5th percentile, there was a mean (non-significant) difference of 16 score points in favour of boys (393 vs 377). While at the 95th percentile, the mean difference between boys and girls was 17 score points and this difference, in favour of boys, is statistically significant.

Figure 5.7: Distribution of achievement by gender in Ireland, Second Year mathematics

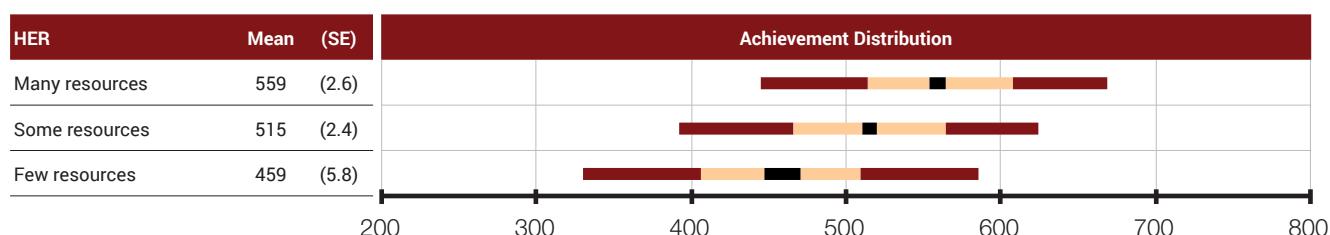


Note. See Figure 1.1 (Chapter 1) for guidance on how to interpret this graph.
Source: e-Appendix Table A5.9.

Distribution of achievement, by Home Educational Resources

Figure 5.8 shows clear patterns of difference in relation to Home Educational Resources, such that students with *few resources* available demonstrate substantially and significantly lower levels of mathematics achievement at each point along the distribution, on average, than those with *many resources*. The difference at the 95th percentile between students with *many resources* (669) and those with *few resources* (585) is 84 score points. At the other end of the distribution, at the 5th percentile, a larger difference is observed (114 score points), although both are statistically significant.

Figure 5.8: Distribution of achievement by Home Education Resources (HER) scale in Ireland, Second Year mathematics



Note. See Figure 1.1 (Chapter 1) for guidance on how to interpret this graph.
Source: e-Appendix Table A5.10.

Performance at International Benchmarks for Second Year mathematics

This section focuses on the TIMSS International Benchmarks used to describe the skills and knowledge demonstrated by students at different levels of achievement. The percentages of students reaching each of the four International Benchmarks are presented for Ireland and selected reference countries. Within Ireland, performance at the International Benchmarks from the last three cycles of TIMSS (2015, 2019, 2023) is compared, in addition to a comparison of gender differences in performance.

TIMSS International Benchmarks for Eighth Grade mathematics

Table 5.3 outlines the International Benchmarks for mathematics at Second Year, which describe the typical skills displayed by students who reach the Low, Intermediate, High, and Advanced International Benchmarks.

In summary, students reaching the Low Benchmark can consistently demonstrate knowledge of integers, basic shapes, and visual representations, whereas those at the Intermediate Benchmark can apply mathematical knowledge in a variety of situations. At the High Benchmark, students can apply their conceptual understanding in a variety of relatively complex situations and, at the Advanced Benchmark, students can extend their understanding beyond working with integers alone to solve a variety of problems in various contexts.

Table 5.3: International Benchmarks - Eighth Grade mathematics

Benchmark	Scoring at least	Students typically can:
Advanced <i>Students can extend their understanding beyond working with integers alone to solve a variety of problems in novel contexts.</i>	625	<p>Interpret relationships among fractions or decimals, negative numbers, or proportions and ratios in multistep problems.</p> <p>Formulate expressions, solve algebraic equations, and demonstrate an understanding of linear functions.</p> <p>Use their knowledge of the properties of geometric figures to find missing measures and identify related shapes.</p> <p>Integrate information across data displays to represent data and justify a conclusion.</p> <p>Implement their understanding of probabilities to relate problem conditions and likelihood.</p>
High <i>Students can apply their conceptual understanding in a variety of relatively complex situations.</i>	550	<p>Relate magnitudes and differences between positive and negative integers, fractions, and decimals to solve problems.</p> <p>Demonstrate an understanding of linear equations and can formulate algebraic expressions to represent a problem.</p> <p>Demonstrate a basic understanding of relationships represented as graphs on a Cartesian plane.</p> <p>Apply basic properties of shapes to solve problems involving triangles, parallel lines, rectangles, and similar figures.</p> <p>Interpret data given in a variety of graphical representations to justify conclusions and solve problems involving outcomes and probabilities in familiar contexts.</p>
Intermediate <i>Students can apply mathematical knowledge in a variety of situations.</i>	475	<p>Solve problems across contexts involving whole numbers, negative numbers, fractions, decimals, and proportional relationships.</p> <p>Interpret relationships given visually or in words to represent them algebraically.</p> <p>Demonstrate some understanding of angle measures and in relating two-dimensional and three-dimensional shapes.</p> <p>Read, interpret, and integrate across sources to represent data.</p>
Low <i>Students have knowledge of integers, basic shapes, and visual representations.</i>	400	<p>Apply basic properties of whole numbers.</p> <p>Demonstrate some knowledge of linear relationships.</p> <p>Find the lengths of sides in polygons and relate views of solids.</p> <p>Read information from graphs and complete data representations.</p>

Source: Adapted from Exhibit 1.2.3 in von Davier et al. (2024).

Achievement at the International Benchmarks

The percentage of students in Ireland and the selected countries reaching each of the four International Benchmarks is presented in Table 5.4. In Ireland, 93% of Second Year students reached at least the Low Benchmark, while almost three-quarters (73%) reached at least the Intermediate Benchmark, 38% reached at least the High Benchmark, and 9% reached the Advanced Benchmark (the highest level of performance).

Comparing mathematics achievement across the selected countries, the percentage of students reaching at least the Low Benchmark in Ireland was somewhat lower than in the highest-achieving countries (97% in Singapore, Chinese Taipei, and the Republic of Korea, and 99% in Japan) but slightly higher than in England

(89%) and Sweden (91%). The gap in performance between Ireland and the highest-achieving countries widened at the higher benchmarks. While 38% of students in Ireland reached the High Benchmark, a greater proportion of students (over 40% in each case) reached the Advanced Benchmark in Singapore, Chinese Taipei, and the Republic of Korea.

Table 5.4: Cumulative percentages of students reaching each International Benchmark in Ireland and selected countries, Eighth Grade mathematics

	Mean	Low (400)	Intermediate (475)	High (550)	Advanced (625)
Singapore	605	97	89	74	46
Chinese Taipei	602	97	89	72	44
Korea, Rep. of	596	97	88	70	40
Japan	595	99	92	71	37
England	525	89	71	42	15
Ireland	522	93	73	38	9
Sweden	517	91	69	36	9
Australia	509	87	64	34	11
Finland	504	90	64	29	7
United States	488	82	55	26	8
TIMSS (median)	-	81	55	28	7

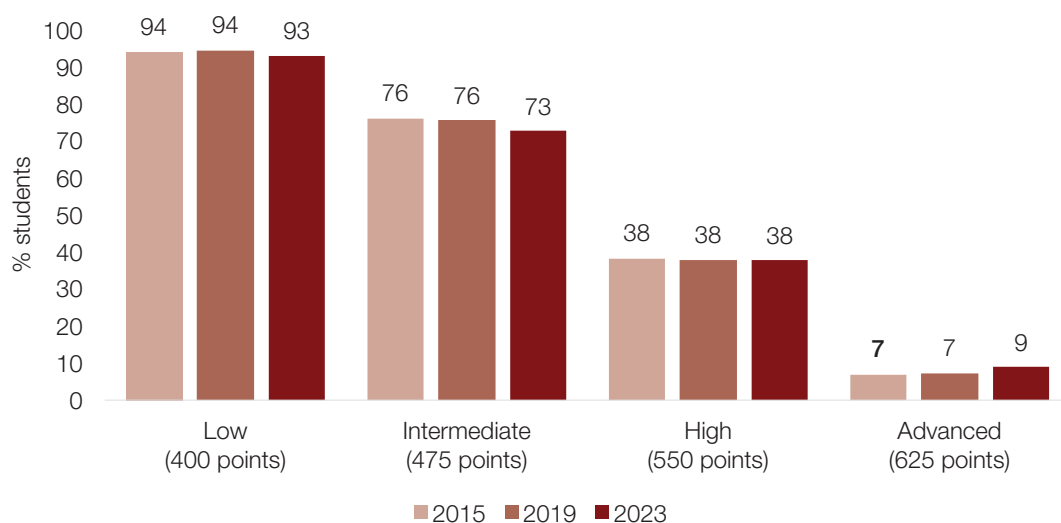
Note. The percentages of Second Year students within each International Benchmark of mathematics (i.e., discrete categories) in Ireland are: 7.1% (Below Low); 20.3% (Low); 34.9% (Intermediate); 28.8% (High); 8.9% (Advanced).

Source: e-Appendix Table A5.11 and Exhibit 1.2.4 in von Davier et al. (2024).

Trends in performance at International Benchmarks

The percentage of Second Year students reaching the Low Benchmark has remained relatively stable from 2015 to 2023, with no statistically significant changes across the three cycles (Figure 5.9). Similar stability is seen at the High Benchmark. At the Intermediate Benchmark, a slight decrease in the percentage of students reaching this level can be seen between 2019 (76%) and 2023 (73%), although the difference is not statistically significant. The percentage of students reaching the Advanced Benchmark in 2023 (8.9%) is not significantly different from the corresponding figure in 2019 (7.3%) but is significantly higher than in 2015 (6.8%).

Figure 5.9: Cumulative percentages of students reaching each International Benchmark across TIMSS cycles in Ireland, Second Year mathematics



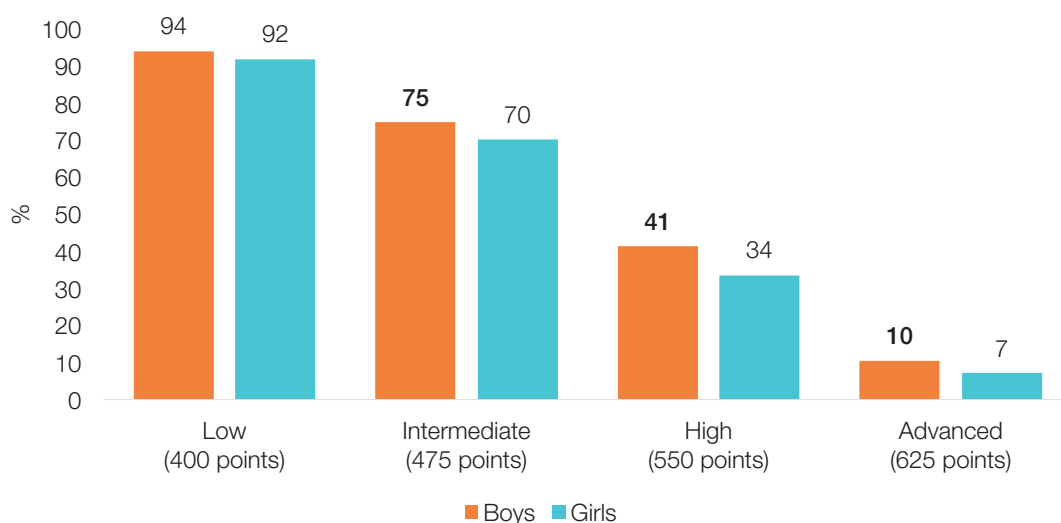
Note. Percentages in **bold** are significantly different to the equivalent in 2023.

Source: e-Appendix Table A5.12.

Performance at the International Benchmarks, by gender

Figure 5.10 presents the percentages of Second Year boys and girls reaching each of the four International Benchmarks. A significantly higher percentage of boys than girls reached the Intermediate Benchmark (75% and 70% respectively), the High Benchmark (41% and 34%, respectively) and the Advanced Benchmark (10% and 7%, respectively). There is no significant difference at the Low Benchmark.

Figure 5.10: Cumulative percentages of girls and boys reaching each International Benchmark in Ireland, Second Year mathematics



Note. Percentages in **bold** indicate a significant difference between boys and girls.

Source: e-Appendix Table A5.13.

Performance in content and cognitive domains for Second Year mathematics

The TIMSS assessment is based upon an Assessment Framework which is revised and updated each cycle to accurately reflect the curricula of participating countries (Mullis et al., 2021). This section presents the performance on the content and cognitive domains in Ireland and selected countries. Performance on these domains is compared to overall mathematics performance at Eighth Grade. Performance is also examined by gender within Ireland along with comparisons to performance in 2019.

Performance on content domains

As presented in Chapter 1, the Eighth Grade mathematics assessment includes four content areas: Number (30%); Algebra (30%); Geometry & Measurement (20%); and Data & Probability (20%). Each content domain includes different topic areas. Number includes three topic areas: integers; fractions and decimals; and proportions, ratios, and percentages. Algebra has two topic areas: expressions, operations and equations; and relationships and functions. Geometry & Measurement includes two topic areas: measurement; and geometry and Data & Probability also includes two topic areas: data; and probability.

Table 5.5 presents the relative strengths and weaknesses across these content areas when compared to overall national mathematics achievement. Second Year students were found to have relative strengths on the Number (+6 points) and Data & Probability (+24 points) domains. In contrast, they were found to have relative weaknesses on Algebra (-19 points) and Geometry & Measurement (-9 points). The same pattern of performance was also found in TIMSS 2019 for Second Year students.

Data & Probability was the only domain of relative strength for Eighth Grade students in Singapore, with the other domains similar to the overall mathematics performance. Indeed, Data & Probability was found to be a relative strength for almost all of our selected countries, except for Chinese Taipei and the Republic of Korea.

Table 5.5: Mean achievement scores on content domains in Ireland and selected countries, Eighth Grade mathematics

	Mean	Number	Algebra	Geometry & Measurement	Data & Probability
Singapore	605	606	604	605	615
Chinese Taipei	602	611	612	600	585
Korea, Rep. of	596	602	595	603	584
Japan	595	590	593	600	609
England	525	532	513	519	537
Ireland	522	528	503	513	546
Sweden	517	514	511	516	532
Australia	509	505	498	506	532
Finland	504	504	490	513	508
United States	488	486	492	480	492

Note. Light shading indicates that the subscale score is significantly lower than the country's overall mathematics scale score. Dark shading indicates that the subscale score is significantly higher than the country's overall mathematics scale score.

Source: Adapted from Exhibit 1.2.13 in von Davier et al. (2024).

Table 5.6 shows differences in average achievement between Second Year girls and boys on the four mathematics content domains. In Ireland, boys significantly outperformed girls on the Number and on the Geometry & Measurement content domains. There are no significant gender differences in Ireland for Algebra or Data & Probability.

Table 5.6: Mean achievement scores of girls and boys on content domains in Ireland, Second Year mathematics

	Mean	Number	Algebra	Geometry & Measurement	Data & Probability
Girls	514	515	499	507	541
Boys	528	539	506	519	550

Note. Shading indicates that the subscale score is significantly higher than for the other gender on that subscale.

Source: e-Appendix Table A5.14.

Performance on cognitive domains

Similar to Fourth Grade, each item in the mathematics test is classified as one of the three cognitive domains, that of Knowing, Applying, and Reasoning.

Table 5.7 shows average achievement in the Knowing, Applying, and Reasoning cognitive domains relative to overall national average achievement. Students in Ireland were found to have a relative strength on Applying (+5 points) and a relative weakness on Reasoning (-6 points). In 2019, Second Year students were found to have a relative strength on the Knowing and Applying domains and, similar to 2023, a relative weakness on the Reasoning domain.

Across all of our selected countries, Reasoning was either similar (Chinese Taipei, Sweden, and Finland) or lower (all other countries) to overall national performance. A similar pattern was found among Eighth Grade students in Singapore as to Eighth Grade students in Ireland. In just two of the selected countries (Sweden and Finland), students had a similar performance across all cognitive domains.

Table 5.7: Mean achievement scores on cognitive domains in Ireland and selected countries, Eighth Grade mathematics

	Mean	Knowing	Applying	Reasoning
Singapore	605	606	611	600
Chinese Taipei	602	611	601	600
Korea, Rep. of	596	602	596	592
Japan	595	591	594	591
England	525	528	530	516
Ireland	522	520	526	516
Sweden	517	518	518	515
Australia	509	508	511	504
Finland	504	505	504	501
United States	488	496	484	480

Note. Light shading indicates that the subscale score is significantly lower than the country's overall mathematics scale score. Dark shading indicates that the subscale score is significantly higher than the country's overall mathematics scale score.

Source: Adapted from Exhibit 1.2.14 in von Davier et al. (2024).

Gender differences at Second Year for the three cognitive domains in mathematics are presented in Table 5.8. In Ireland, boys outperformed girls in each cognitive domain.

Table 5.8: Mean achievement scores of girls and boys on cognitive domains in Ireland, Second Year mathematics

	Mean	Knowing	Applying	Reasoning
Girls	514	512	519	508
Boys	528	527	532	523

Note. Shading indicates that the subscale score is significantly higher than for the other gender on that subscale.
Source: e-Appendix Table A5.15.

Curriculum coverage for Second Year mathematics

This section presents the results of the TCMA for Second Year mathematics followed by findings from the Teacher Questionnaire where teachers reported the coverage of TIMSS topics. As outlined in Chapter 1, a TCMA was conducted to establish whether the topic of each item in the TIMSS assessment was likely to have been covered by the majority of Second Year students by the time of TIMSS testing in spring 2023.

Test-Curriculum Matching Analysis for Eighth Grade mathematics

Table 5.9 presents the outcomes of the TCMA for Second Year mathematics in Ireland. Overall, the proportion of the assessment considered to have been covered by Second Year students in Ireland was 89%. Almost all students were deemed to have covered topics on the Number domain (98%). Nearly nine in ten students were estimated to have covered topics on the Data & Probability domain. Across the other two domains (Algebra and Geometry & Measurement) approximately 82% of the Second Year Students were reckoned to have covered topics in these domains.

Table 5.9: TCMA overall and by content domain – Eighth Grade mathematics items

	Number of items	Number of items included in curriculum	% included in curriculum
Number	63	62	98%
Algebra	58	47	81%
Geometry & Measurement	42	35	83%
Data & Probability	37	33	89%
Overall	200	177	89%

Further analysis conducted by the IEA examined the question ‘what score would have been achieved if students in country X had only been asked to answer items that were covered by the curriculum in country X?’ Exhibit C.3 in the TIMSS 2023 International Results in Mathematics and Science (von Davier et al., 2024) presents the average scale scores for each country based on the mathematics TCMA. Students in Ireland would have a mean achievement score of 523 if only the items considered to be part of the curriculum were included, which is the very similar to the actual achieved achievement score (522). Overall, across all the participating countries at Grade 8, most countries only observed small fluctuations between the mean score achieved and the score they would achieve if only the items considered to be part of the curriculum were included.

Teacher reports of topic coverage for Eighth Grade mathematics

The teacher questionnaire included questions on whether specific mathematics topics had been *mostly taught before this year, mostly taught this year, or not yet taught this year*. The latter category also includes topics that were not in the curriculum. Table 5.10 presents results for Ireland and the selected countries in terms of the percentage of students whose teachers reported that the topics had been mostly taught in the assessment year or in the year before – that is, the percentage of students who might be expected to have been exposed to these topics in class prior to taking the TIMSS assessment.

In Ireland, Geometry & Measurement is the one area where teachers' reports differ substantially when compared to the international average. According to their teachers, only 59% of Second Year students had covered the topics in this domain, compared with 80% of students internationally. In England, where overall mathematics achievement did not differ significantly to Ireland (see Table 5.1), 74% of students were taught by teachers who reported having covered Geometry & Measurement. In Singapore, at least 90% of students had covered all four mathematics content domains according to their teachers' reports.

Table 5.10: Percentages and standard errors of students taught the TIMSS topics – Eighth Grade mathematics

	Number (7 topics)		Algebra (8 topics)		Geometry & Measurement (6 topics)		Data & Probability (4 topics)	
	%	(SE)	%	(SE)	%	(SE)	%	(SE)
Singapore	100	(0.0)	90	(1.0)	90	(0.7)	90	(1.3)
Chinese Taipei	99	(0.4)	87	(0.7)	80	(1.1)	64	(1.8)
Korea, Rep. of	94	(1.0)	79	(0.7)	89	(1.0)	76	(1.2)
Japan	92	(0.9)	76	(1.2)	77	(1.1)	93	(1.7)
England	98	(0.9)	72	(1.8)	74	(2.3)	82	(2.8)
Ireland	97	(0.7)	72	(1.3)	59	(2.1)	76	(1.9)
Sweden	83	(1.0)	54	(1.4)	55	(1.5)	67	(2.8)
Australia	97	(0.9)	58	(1.9)	81	(1.5)	90	(1.5)
Finland	97	(0.5)	51	(0.9)	69	(1.3)	31	(2.9)
United States	99	(0.3)	87	(0.9)	87	(1.5)	84	(1.8)
TIMSS average (43)	97	(0.1)	69	(0.2)	79	(0.2)	72	(0.3)

Note. Percentages of students mostly taught before or in the assessment year, averaged across topics.
43 countries in the TIMSS average rather than 44 as Norway did not administer the Teacher Questionnaire.
See e-Appendix Table A5.16 for more detailed information on individual topics.

Chapter 6: Second Year Science

This chapter describes the performance of students on the TIMSS 2023 Eighth Grade science assessment. Overall science achievement is described along with the distribution of achievement, student performance at International Benchmarks, and performance on the content and cognitive domains.

For each of these sections, performance in Ireland is explored with reference to selected countries (as described in Chapter 1); compared with the two most recent cycles of TIMSS at Second Year (2019 and 2015); examined by gender; and examined by differences on socioeconomic measures such as school DEIS status and a TIMSS-derived measure of individual Home Educational Resources.

Finally, the extent of curriculum coverage for Second Year science is explored. As noted in Chapter 1, TIMSS is a curriculum-based study and a Test-Curriculum Matching Analysis (TCMA) is conducted for each cycle. This section presents the results of the TCMA, as well as teachers' report of coverage of the TIMSS topics in the classroom.

Mean achievement for Second Year science

This section presents the main findings relating to the overall performance of Second Year students in Ireland on the TIMSS 2023 Eighth Grade science assessment. Comparisons to the other participating countries are described, along with examination of differences by gender and by indicators of socioeconomic status.

Overall results

The mean science scores of Second Year students in Ireland and other participating countries in TIMSS 2023 are presented in Table 6.1. Similar to the mathematics assessment, the highest mean score in science (606) was achieved by students in Singapore.

Students in Ireland achieved a mean score of 525 in science, significantly above the TIMSS international average (478). Four countries achieved mean scores that were significantly higher than Ireland's (Singapore, Chinese Taipei, Japan, and the Republic of Korea), while students in nine countries achieved mean scores that were similar to the score achieved by Second Year students (England, Finland, Türkiye, Hong Kong, Czech Republic, Hungary, Sweden, Australia, and Lithuania). The remaining 30 countries achieved mean scores in science that were significantly lower than Ireland's mean score.

Thirteen countries in the EU participated in TIMSS 2023 at Eighth Grade. No EU country had a significantly higher mean science score than Ireland. Five countries in the EU had a similar and not significantly different mean science score to Ireland (Finland, Czech Republic, Hungary, Sweden, and Lithuania).

The standard deviation for Second Year students on the science scale was 88 (Table 6.1), which is somewhat higher than the corresponding figure for mathematics (79; see Chapter 5). Côte d'Ivoire and the United Arab Emirates have the largest standard deviations (123 and 117 respectively) while Uzbekistan has the smallest standard deviation (74).

Table 6.1: Mean achievement scores and standard errors of countries and benchmarking participants, Eighth Grade science

Country	Mean	(SE)	SD	Country	Mean	(SE)	SD
Singapore	606	(5.7)	99	Romania	466	(4.1)	85
Chinese Taipei	572	(2.4)	90	Cyprus	464	(3.0)	92
Japan	557	(3.1)	79	Oman	456	(2.6)	99
Korea, Rep. of	545	(2.2)	87	Chile	455	(2.7)	82
England	531	(4.3)	98	Bahrain	452	(2.6)	106
Finland	531	(3.2)	94	Georgia	448	(2.9)	79
Türkiye	530	(3.6)	97	Kazakhstan	443	(3.0)	83
Hong Kong SAR	528	(4.7)	95	Malaysia	426	(3.7)	93
Czech Republic	527	(2.0)	77	Brazil	420	(2.5)	88
Ireland	525	(3.5)	88	Kuwait	420	(5.8)	103
Hungary	522	(3.3)	84	Saudi Arabia	419	(3.4)	95
Sweden	521	(2.9)	98	Iran, Islamic Rep. of	419	(3.6)	93
Australia	520	(3.2)	94	Jordan	413	(3.6)	98
Lithuania	519	(3.0)	85	Azerbaijan	411	(3.0)	80
United States	513	(3.9)	95	Uzbekistan	396	(3.7)	74
Austria	512	(2.4)	84	Palestinian Nat'l Auth.	393	(2.9)	97
Portugal	506	(2.4)	82	South Africa (9)	362	(4.0)	104
Malta	501	(1.6)	105	Morocco	327	(3.4)	81
Italy	501	(3.2)	82				
Norway (9)	488	(2.6)	91	New Zealand	502	(4.0)	96
United Arab Emirates	486	(2.0)	117	Cote d'Ivoire	183	(8.2)	123
France	486	(3.2)	81	Benchmarking Participants			
Qatar	481	(4.3)	103	Dubai, UAE	547	(3.2)	104
Israel	481	(3.6)	100	Sharjah, UAE	499	(4.9)	102
TIMSS 2023 International Average	478	(0.5)	-	Abu Dhabi, UAE	443	(3.8)	122
	Average achievement significantly higher than Ireland				Average achievement significantly lower than Ireland		

Note. New Zealand and Côte d'Ivoire are not included in the TIMSS 2023 international average.

Norway and South Africa assessed students in Ninth Grade rather than Eighth Grade.

Multiple comparisons are not taken into account when testing significant differences.

Source: e-Appendix Table A6.1.

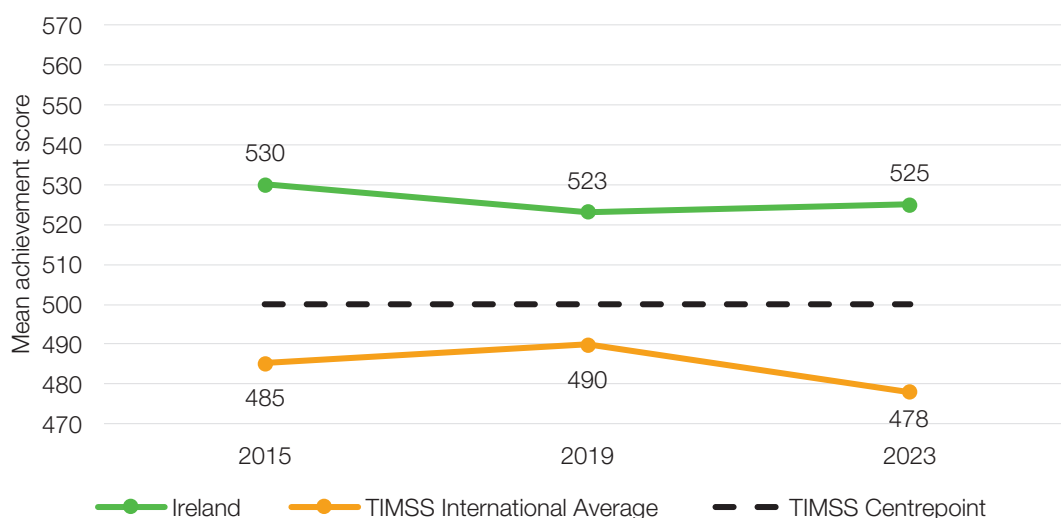
Trends in achievement

Figure 6.1 presents Ireland's science performance in TIMSS 2023 with reference to performance in recent TIMSS cycles, the TIMSS centrepont (which provides a constant point of reference since the first cycle of TIMSS in 1995), and the TIMSS international average for the countries that participated in each cycle. Comparisons over time of the TIMSS international average should be made cautiously, given that each cycle contains a slightly different number and set of participating countries.

As shown, the performance of Second Year students on the TIMSS science assessment has remained relatively stable since 2015, with no statistically significant changes in 2023 relative to 2015 and 2019. The

mean science score in 2023 (525) is two points higher than in 2019 (523) and five points lower than in 2015 (530). The TIMSS 2023 international average included 42 countries with an average science score of 478.

Figure 6.1: Mean achievement scores across TIMSS cycles for Ireland and TIMSS average, Eighth Grade science



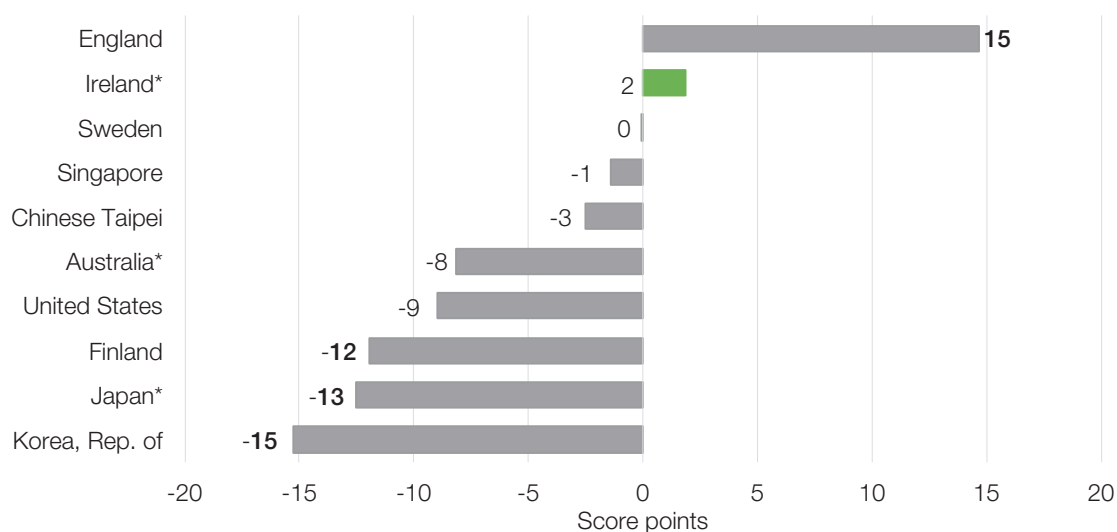
Note. TIMSS international average includes all countries that participated in the cycle. Countries included in TIMSS international average: 2023=42; 2019=39; 2015=40.

Source: e-Appendix Table A6.2.

Figure 6.2 presents the differences in mean scores in science between 2019 and 2023 for Ireland and selected countries. As noted above, the two score point increase in Ireland's score is not statistically significant. In contrast, there is a statistically significant increase of 15 score points in England and significant decreases in science achievement in Finland (12 score points), Japan (13 score points), and the Republic of Korea (15 score points).

As noted in the previous chapter, Japan and Australia were among the countries that, like Ireland, moved from a paper-based administration of TIMSS in 2019 to digital assessment in 2023. Although Japan saw no significant difference in mean mathematics score between the two cycles (see Chapter 5), there is a significant decline in the science achievement of students in Japan.

Figure 6.2: Change in mean achievement score between 2019 and 2023 for Ireland and selected countries, Eighth Grade science



Note. Figures in bold indicate a significant difference from the previous cycle.

* Indicates country changed mode of assessment in TIMSS 2023.

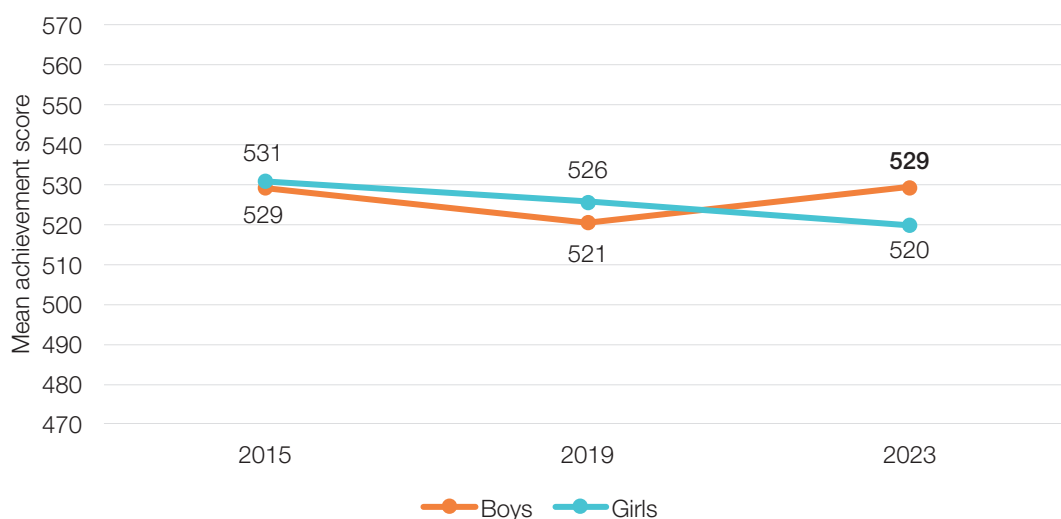
Source: e-Appendix Table A6.3.

Achievement differences by gender

Figure 6.3 presents the mean science achievement among Second Year girls and boys across TIMSS cycles. In TIMSS 2023, boys in Ireland achieved a mean science score of 529, while girls achieved a mean score of 520. This nine score point difference is statistically significant. The opposite pattern is seen at the TIMSS international average, where girls had a score of 480 compared to 477 for boys.

The observation of a significant gender difference in achievement for Second Year science marks a change from the previous two cycles of TIMSS, where no statistically significant differences were noted. Since 2019, the average science score for Second Year girls has decreased by six score points (Figure 6.3), although this change is not statistically significant. However, the longer-term decline in girls' science achievement since 2015 (11 score points) is significant. The increase in boys' science achievement from 2019 (521) to 2023 (529) is not statistically significant.

Figure 6.3: Mean achievement scores among girls and boys in Ireland across TIMSS cycles, Second Year science



Note. Figures in **bold** indicate a significant difference between boys and girls.

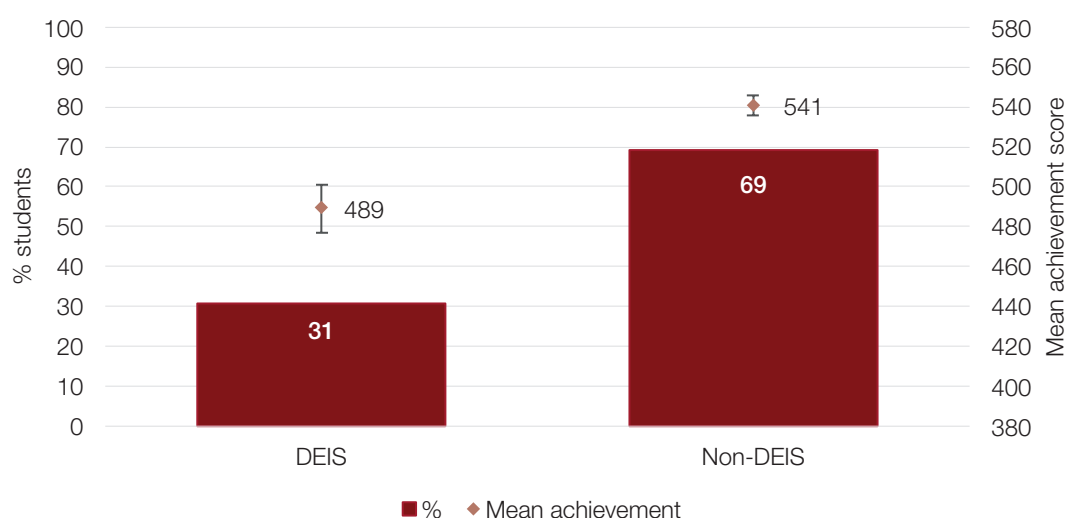
Source: e-Appendix Table A6.4.

Across the 42 countries with internationally comparable data, girls had significantly higher achievement on average than boys in 11 countries, and in 12 countries boys had significantly higher achievement than girls. In the remaining 19 countries, there is no statistically significant difference between boys and girls (von Davier et al., 2024).

Achievement differences by school DEIS status

Figure 6.4 presents the percentages of Second Year students attending DEIS or non-DEIS schools, and their estimated mean science achievement. In the TIMSS 2023 study, almost one-third of Second Year students (31%) were attending DEIS schools. These students achieved a significantly lower mean score on science than their peers in non-DEIS schools, by 52 score points. This gap corresponds to just over half a standard deviation on the TIMSS scale, which is both substantial and statistically significant. The pattern of significance between the school DEIS categories is the same in 2023 as in 2019.

Figure 6.4: Percentages and mean achievement of students in Ireland by school DEIS category, Second Year science



Note. Mean scores are presented with a 95% confidence interval around the estimate.

Source: e-Appendix Table A6.5.

Achievement differences by students' Home Educational Resources

The TIMSS-derived measure of individual socioeconomic status at Eighth Grade is the Home Educational Resources scale, which is based on student reports about the number of books and other home study supports, and the highest level of education attained by their parent(s). The scale has an international centrepoint of 10.0 and a standard deviation of 2.0 (von Davier et al., 2024). In Ireland, the average HER score was 10.9, half a standard deviation above the international centrepoint. This shows a high overall level of HER relative to the international average.

Table 6.2 presents the percentages of students in each category (*many resources*, *some resources*, or *few resources*) and their mean achievement in Ireland and selected countries (von Davier et al., 2024). In Ireland, students with *many resources* (567) achieved a substantially and significantly higher average score in science than students with *few resources* (460). Across the selected countries, the mean difference in science between students with *many resources* and those with *few resources* ranged from 73 score points in Japan to 130 in Sweden.

Table 6.2: Percentages and mean achievement of students by Home Educational Resources (HER) scale in Ireland and selected countries, Eighth Grade science

	Mean	Many Resources		Some Resources		Few Resources	
		%	Mean	%	Mean	%	Mean
Singapore	606	33	652	47	602	20	542
Chinese Taipei	572	36	612	43	567	21	513
Japan	557	43	581	46	549	12	508
Korea, Rep. of	545	56	569	34	527	10	481
England	531	36	584	44	523	20	461
Finland	531	42	570	46	518	12	458
Ireland	525	39	567	45	516	16	460
Sweden	521	42	574	43	503	15	444
Australia	520	42	564	45	508	13	443
United States	513	31	571	45	506	23	459

Source: e-Appendix Table A6.6.

Distribution of achievement for Second Year science

As noted previously, student performance can also be examined across the wider distribution of achievement. Next, we examine the performance of students at various percentiles (5th, 25th, 75th, and 95th) for TIMSS 2023 as well as comparing the trend in the distribution of achievement for Ireland over the past three cycles of TIMSS. After this, the distribution of achievement is examined by two subgroups (gender and students' Home Educational Resources).

Distribution of achievement in Ireland and selected countries

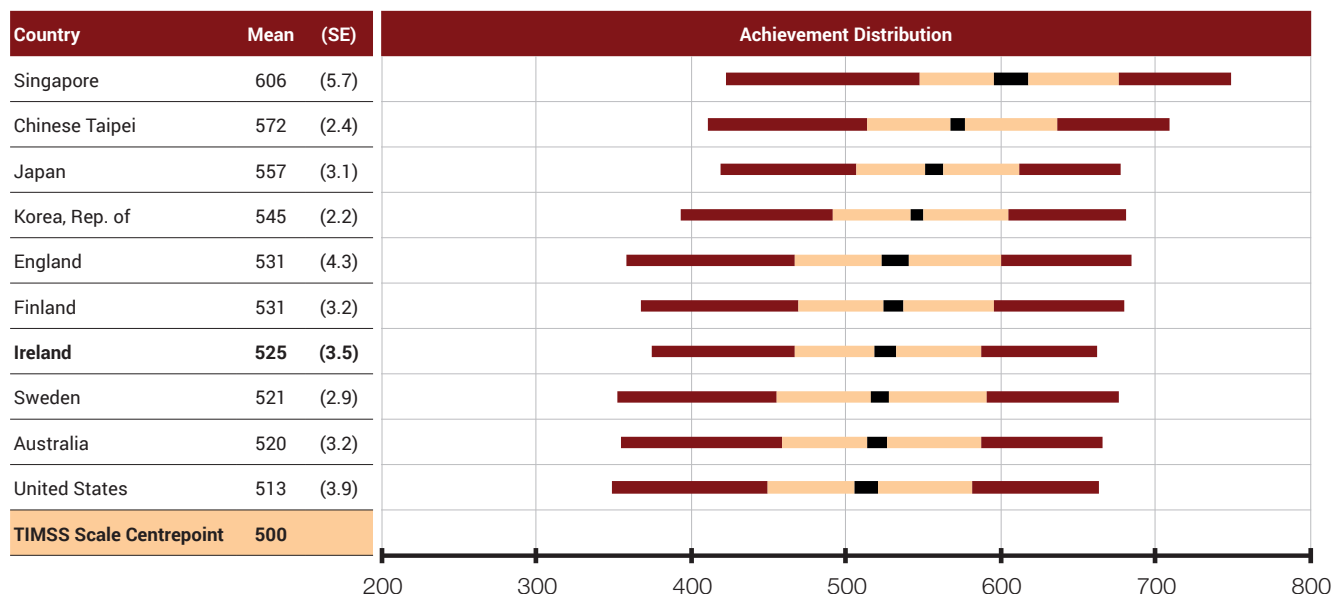
Figure 6.5 presents the distribution of student achievement in science at Eighth Grade for Ireland and selected countries. In Ireland, the performance of students at the 5th percentile (the lowest-performing students) (374) was nearly 50 points lower than the corresponding score (422) in the highest-performing country (Singapore). At the other end of the distribution, at the 95th percentile (the highest-performing students), students in Singapore scored 87 points higher than students in Ireland (749 and 662, respectively). Similar to mathematics, the performance of students at the 95th percentile in Ireland is lower than the performance of students at the 75th percentile in Singapore (although, unlike for mathematics, this is not the case on the science scale for the three other highest-achieving countries).

Compared to countries with similar overall performance, Ireland has the narrowest distribution of science achievement, with a range of 288 score points between the 5th and 95th percentiles. For comparison, the corresponding range in England is 326, and in Sweden is 324. Among our selected countries, only the Republic of Korea (287) and Japan (259) had narrower ranges than Ireland.

As shown in Figure 6.5, the performance of the lowest-achieving students (5th percentile) is somewhat higher, and the performance of the highest-achieving students is lower, in Ireland than in countries with similar overall achievement in science. This suggests that the highest-achieving students (those at the 95th percentile) in Ireland are underperforming (with an average score of 662) compared to their counterparts in Sweden (676),

Finland (679), and England (684), although achievement among this group in the United States (664) and Australia (666) is similar.

Figure 6.5: Distribution of achievement in Ireland and selected countries, Eighth Grade science



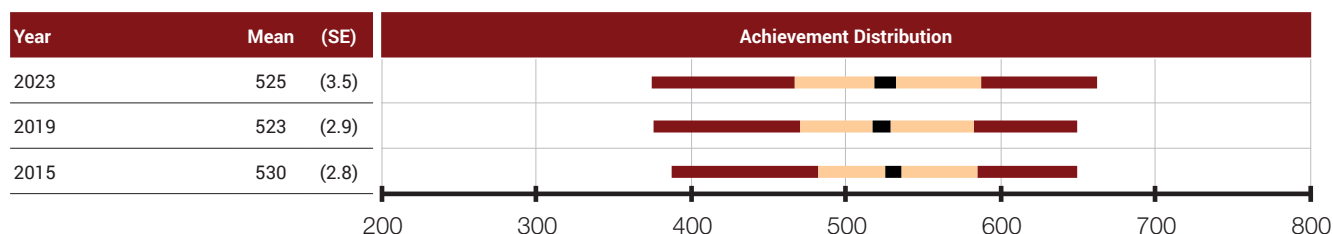
Note. See Figure 1.1 (Chapter 1) for guidance on how to interpret this graph.
Source: e-Appendix Table A6.7.

Trends in distribution of achievement

The distribution of science achievement at Second Year in TIMSS 2023 and previous cycles is presented in Figure 6.6. As shown, there has been an increase in the range of distribution in 2023 (288) compared to 2019 (274). This follows on from an increase observed between 2015 (262) and 2019. This current increase is explained, in part, by a slight improvement among the highest-achieving students. There has been an increase (although not statistically significant) of about 13 score points at the 95th percentile since 2019, with a mean score of 662 in 2023 compared to 649 in 2019 and 650 in 2015.

At the other end of the distribution, the science scores of students at the 5th percentile decreased by about 13 points (non-significant) between 2015 (387) and 2023 (374). However, most of this change had occurred by 2019 (376) with only a one-point (rounded) change since then.

Figure 6.6: Distribution of achievement across TIMSS cycles in Ireland, Second Year science



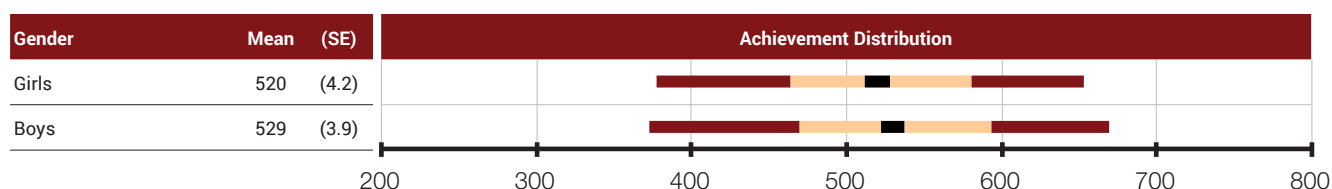
Note. See Figure 1.1 (Chapter 1) for guidance on how to interpret this graph.
Source: e-Appendix Table A6.8.

Distribution of achievement, by gender

As described above (Figure 6.3), boys significantly outperformed girls in science at Second Year, with a nine-point advantage on the TIMSS scale. Figure 6.7 presents the distribution of achievement for boys and girls in Ireland.

The distribution of achievement for science is somewhat narrower for girls (276) in Second Year compared to boys (296), largely driven by differences at the upper end of the distribution. At the 5th percentile, girls achieved a mean score that was four points higher than that of boys while at the 95th percentile, boys had a mean score that was 16 points higher than girls. This indicates that, while the lowest-achieving girls performed slightly better than the lowest-achieving boys, the highest-achieving boys performed better than the highest-achieving girls (although the difference at the 95th percentile is not significant).

Figure 6.7: Distribution of achievement by gender in Ireland, Second Year science



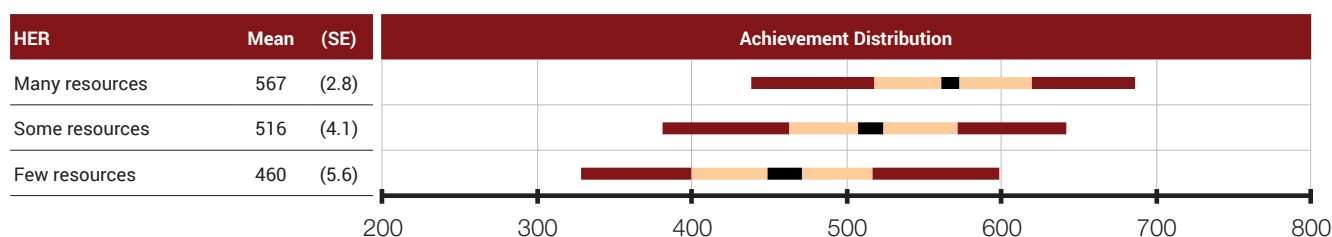
Note. See Figure 1.1 (Chapter 1) for guidance on how to interpret this graph.

Source: e-Appendix Table A6.9.

Distribution of achievement, by Home Educational Resources

Figure 6.8 shows the distribution on science achievement in relation to students' Home Educational Resources. At each point along the distribution, students with *few resources* and students with *some resources* achieved significantly lower scores on the science assessment than those with *many resources*. The difference at the 95th percentile between students with *many resources* (686) and those with *few resources* (599) is 87 score points. A larger difference (110 points) is evident among students at the 5th percentile, and both differences are statistically significant.

Figure 6.8: Distribution of achievement by Home Education Resources (HER) scale in Ireland, Second Year science



Note. See Figure 1.1 (Chapter 1) for guidance on how to interpret this graph.

Source: e-Appendix Table A6.10.

Performance at International Benchmarks for Second Year science

The International Benchmarks for Eighth Grade science describe students' understanding of scientific knowledge and the scientific skills they can demonstrate. This section presents the percentages of students reaching each of the four International Benchmarks for Ireland and selected reference countries. Within Ireland, performance at the International Benchmarks relative to previous cycles of TIMSS is examined, in addition to a comparison of gender differences in performance.

TIMSS International Benchmarks for Eighth Grade science

Table 6.3 outlines the typical skills displayed by students who successfully reach the Low, Intermediate, High, and Advanced Benchmarks.

In brief, students reaching the Low Benchmark can consistently demonstrate some knowledge of scientific facts, such as the characteristics of animals. Students at the Intermediate Benchmark can apply understanding of some concepts and can engage in some scientific practices, while those at the High Benchmark can engage in multiple scientific practices and apply knowledge from across the various content domains of science. Finally, students reaching the Advanced Benchmark can engage in more complex scientific practices and can demonstrate reasoning skills across content domains in a variety of contexts.

Table 6.3: International Benchmarks - Eighth Grade science

Benchmark	Scoring at least	Students typically can:
Advanced <i>Students can show, apply, and reason with knowledge of concepts related to biology, chemistry, physics, and earth science in various contexts, and they can engage in more complex scientific practices.</i>	625	Show knowledge of cellular respiration, photosynthesis, and natural disasters. Apply knowledge about the human immune system and reason about ancestry. Show and can apply knowledge of atoms, molecules, acids and bases, and chemical reactions, and can reason about separating mixtures. Show knowledge about unbalanced forces and can apply knowledge about friction and the properties of sound. Reason about shadows. Show knowledge about the composition of the Earth's oceans and atmosphere, the Earth's processes and history, and the Earth's resources and their uses. Describe one limitation of a model and design a fair test with multiple variables.

<p>High</p> <p><i>Students show and apply knowledge of concepts from biology, chemistry, physics, and earth science, and they engage in multiple scientific practices.</i></p>	<p>550</p> <p>Show and apply knowledge of plant and animal cells, know simple facts about inheritance, and reason about simple population dynamics in an ecosystem.</p> <p>Apply knowledge of the human body and of the effects of human behaviour on the environment.</p> <p>Show some knowledge of subatomic particles and of chemical notation and can reason about a chemical reaction.</p> <p>Apply knowledge of properties of matter, electromagnets, light absorption and reflection, and the direction of common forces.</p> <p>Demonstrate knowledge about the states of matter, the transfer of thermal energy, and energy transformation.</p> <p>Show knowledge about light from the sun and about Earth's resources.</p> <p>Apply knowledge about the relationship between climate and both weather and weathering.</p> <p>Interpret patterns in data, reason with data and graphical information, explore relationships between variables, and predict outcomes.</p>
<p>Intermediate</p> <p><i>Students can apply understanding of some concepts from biology, chemistry, physics, and earth science, and they engage in some scientific practices.</i></p>	<p>475</p> <p>Apply knowledge about health, energy flow in ecosystems, interactions among living things and with their environment, and reproduction and inheritance.</p> <p>Apply knowledge of some chemistry concepts, such as thermal and electrical conductivity, concentration of a solution, and chemical reactions.</p> <p>Show basic knowledge of states of matter, motion, and forces, and they apply knowledge of properties of materials and of light.</p> <p>Show some knowledge of the physical structure of the Earth, the Earth-moon-sun system, and the water cycle.</p> <p>Reason about the Earth's climate and demonstrate knowledge of ways to manage the Earth's natural resources.</p> <p>Create a simple experimental design and a basic mathematical model.</p> <p>Interpret tables, graphs, and pictures, and draw conclusions.</p>
<p>Low</p> <p><i>Students show and apply knowledge of some science facts.</i></p>	<p>400</p> <p>Show knowledge about cells, tissues, and organs and about some characteristics of animals.</p> <p>Apply some knowledge of ecosystems using models.</p> <p>Distinguish between physical and chemical changes, and show some knowledge related to dissolving.</p> <p>Show basic knowledge about the physical properties of matter and about the form of energy a common device uses.</p> <p>Know that ocean water contains salt and the sun provides light and heat.</p> <p>Describe an observation and interpret a model.</p>

Source: Adapted from Exhibit 2.2.3 in von Davier et al. (2024).

Achievement at the International Benchmarks

Table 6.4 presents the percentage of students in Ireland and the selected countries reaching each of the four International Benchmarks in science for Eighth Grade students. In Ireland, 91% of Second Year students reached at least the Low Benchmark, while 72% reached at least the Intermediate Benchmark. More than four in ten students (41%) reached at least the High Benchmark and 13% reached the Advanced Benchmark (the highest level of performance). Across each of the four benchmarks, the percentage of students in Ireland was higher than the international median.

Comparing science achievement across the selected countries, the percentage of students reaching at least the Low Benchmark in Ireland was lower than in the highest-achieving countries (such as 97% in Singapore and Japan), but similar to England (90%) and Finland (91%). The gap between Ireland and the highest-achieving countries widened at the higher benchmarks. For example, 41% of students in Ireland reached the High Benchmark compared to majorities (ranging from 50% to 74%) in Singapore, Chinese Taipei, Japan, and the Republic of Korea. In Singapore, 47% of students reached the Advanced Benchmark.

Table 6.4: Cumulative percentages of students reaching each International Benchmark in Ireland and selected countries, Eighth Grade science

	Mean	Low (400)	Intermediate (475)	High (550)	Advanced (625)
Singapore	606	97	89	74	47
Chinese Taipei	572	96	85	62	30
Japan	557	97	85	56	20
Korea, Rep. of	545	94	80	50	18
England	531	90	73	45	17
Finland	531	91	73	44	15
Ireland	525	91	72	41	13
Sweden	521	88	68	40	14
Australia	520	89	70	40	13
United States	513	87	66	37	12
TIMSS (median)	-	80	56	27	6

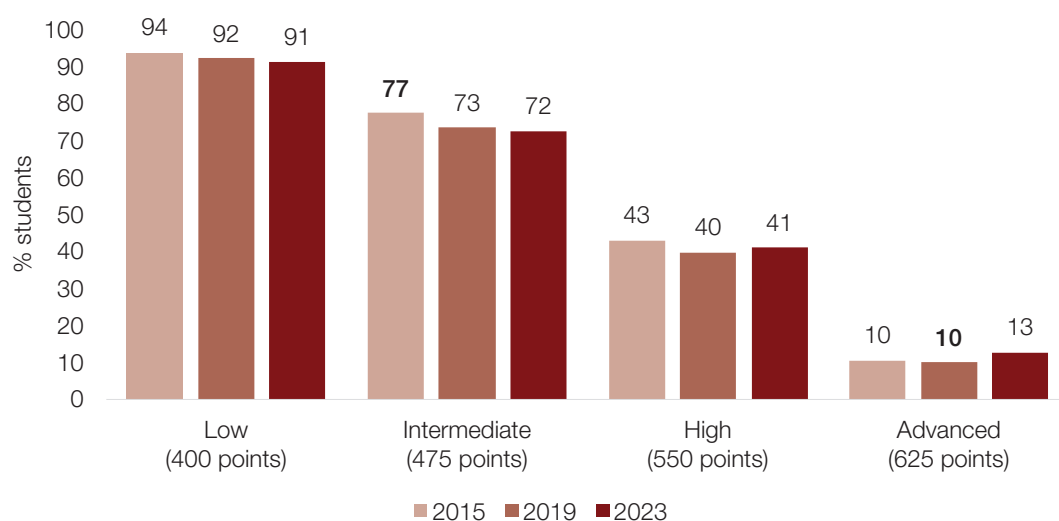
Note. The percentages of Second Year students within each International Benchmark of science (i.e., discrete categories) in Ireland are: 8.8% (Below Low); 18.9% (Low); 31.5% (Intermediate); 28.3% (High); 12.6% (Advanced).

Source: e-Appendix Table A6.11 and Exhibit 2.2.4 in von Davier et al. (2024).

Trends in performance at International Benchmarks

The percentage of Second Year students reaching the Low Benchmark in science has decreased slightly, although not significantly, over recent cycles of TIMSS (from 94% in 2015 to 91% in 2023) (Figure 5.9). While the percentage of students reaching the Intermediate Benchmark was similar in 2019 (73%) and 2023 (72%), the decrease from 2015 to 2023 is statistically significant (five percentage points). At the High Benchmark, the percentage has been similar over the past three cycles of TIMSS. However, at the Advanced Benchmark, the percentage of Second Year students reaching this level has increased slightly over the cycles, with a statistically significant increase of three percentage points between 2019 and 2023 (from 10% to 13%).

Figure 6.9: Cumulative percentages of students reaching each International Benchmark across TIMSS cycles in Ireland, Second Year science



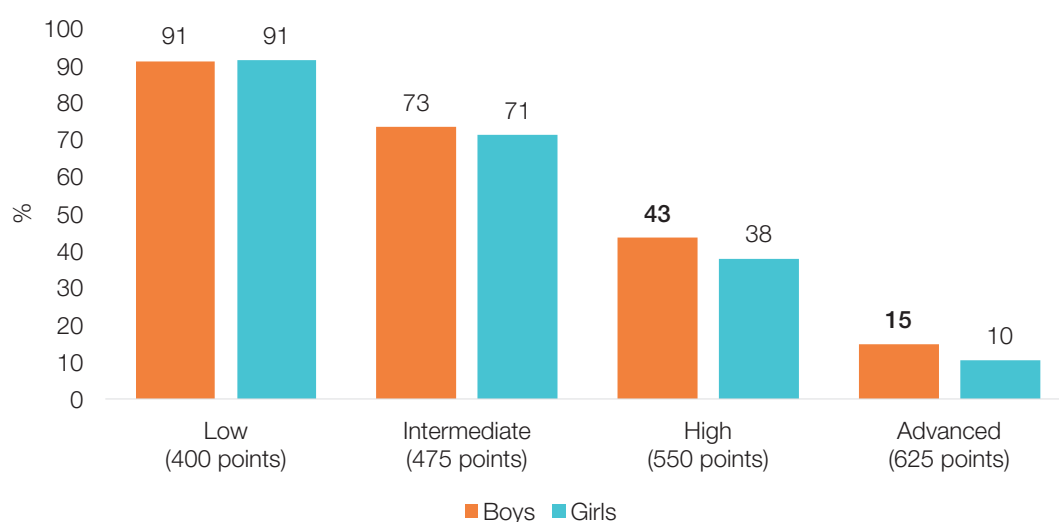
Note. Percentages in **bold** are significantly different to the equivalent in 2023.

Source: e-Appendix Table A6.12.

Performance at the International Benchmarks, by gender

The percentage of Second Year boys and girls reaching each of the four International Benchmarks for science is presented in Figure 6.10. There were no significant differences between the genders at the Low and Intermediate Benchmarks. There is a five-percentage point difference in favour of boys reaching the High Benchmark and this difference is statistically significant. Similarly, a significantly higher percentage of boys (15%) than girls (10%) reached the Advanced Benchmark for science at Second Year.

Figure 6.10: Cumulative percentages of girls and boys reaching each International Benchmark in Ireland, Second Year science



Note. Percentages in **bold** indicate a significant difference between boys and girls.

Source: e-Appendix Table A6.13.

Performance in content and cognitive domains for Second Year science

The TIMSS Assessment Framework is revised and updated each cycle to accurately reflect the curricula of participating countries (Mullis et al., 2021). This section presents the performance on the content and cognitive domains in Ireland and selected countries. Performance on these domains is compared to overall science performance at Eighth Grade for Ireland and the selected countries. Performance by boys and girls in Ireland is also examined along with comparisons to performance in 2019.

Performance on content domains

The Eighth Grade science assessment includes four content areas. Of these, 35% of the assessment was allocated to Biology topics; 20% to Chemistry; 25% to Physics; and 20% to Earth Science. Each content domain includes different topic areas. Biology included topics such as characteristics and life processes of organisms; cells and their functions; life cycles; ecosystems; and human health. Chemistry was split into three topic areas: composition of matter; properties of matter; and chemical change. Physics consisted of five topics: physical states and changes in matter; energy transformation and transfer; light and sound; electricity and magnetism; and motion and forces. Earth Science included topics such as the structure and physical features of Earth, including Earth's structural layers and the atmosphere, as well as processes, cycles, and patterns, including geological processes that have occurred over Earth's history.

Table 6.5 presents the relative strengths and weaknesses across these content areas when compared to overall science achievement. Second Year students in Ireland were found to have a relative strength on the Earth Science content domain (+11 points). In contrast, they showed a relative weakness in Biology (-6 points), which include such topics as cells and their functions, life cycles, reproduction, and heredity. For both the Chemistry and Physics content domains, Second Year students' performance was similar to their overall science achievement. This compares to 2019 when Second Year students showed a relative weakness in Chemistry and Physics, a relative strength in Earth Science and had a similar performance in Biology to their overall science score.

Earth Science was an area of relative strength for many of our selected countries while a number of countries (including Ireland) displayed a relative weakness in the Biology domain. In contrast, students in Singapore demonstrated a relative weakness in Earth Science and a relative strength in Biology, Chemistry, and Physics.

Table 6.5: Mean achievement scores on content domains in Ireland and selected countries, Eighth Grade science

	Mean	Biology	Chemistry	Physics	Earth Science
Singapore	606	622	618	614	572
Chinese Taipei	572	558	593	565	581
Japan	557	549	555	563	566
Korea, Rep. of	545	547	522	557	555
England	531	531	533	532	531
Finland	531	524	529	536	537
Ireland	525	519	528	521	536
Sweden	521	519	520	520	526
Australia	520	513	515	530	527
United States	513	516	505	517	511

Note. Light shading indicates that the subscale score is significantly lower than the country's overall science scale score. Dark shading indicates that the subscale score is significantly higher than the country's overall science scale score.

Source: Adapted from Exhibit 2.2.13 in von Davier et al. (2024).

No significant differences were observed between boys and girls in Ireland on the Biology or Chemistry content domains. However, there were significant differences on the Physics and Earth Science content domains in favour of boys.

Table 6.6: Mean achievement scores of girls and boys on content domains in Ireland, Second Year science

	Mean	Biology	Chemistry	Physics	Earth Science
Girls	520	514	532	511	529
Boys	529	522	524	530	542

Note. Shading indicates that the subscale score is significantly higher than for the other gender on that subscale.

Source: e-Appendix Table A6.14.

Performance on cognitive domains

Table 6.7 shows average achievement in the Knowing, Applying, and Reasoning cognitive domains relative to students' overall average science achievement. Students in Ireland had a relative strength on Reasoning (+6 points) and a relative weakness on Knowing (-6 points) which is similar to the pattern seen among Second Year students in 2019. Eighth Grade students in the Republic of Korea, Sweden, Australia, and the United States also have a similar pattern to students in Ireland. In just two of the selected countries (Japan and Finland), students had a similar performance across all cognitive domains. In the top two performing countries (Singapore and Chinese Taipei), the performance of students on the Knowing cognitive domain displayed a relative strength when compared to their overall science performance.

Table 6.7: Mean achievement scores on cognitive domains in Ireland and selected countries, Eighth Grade science

	Mean	Knowing	Applying	Reasoning
Singapore	606	610	605	608
Chinese Taipei	572	592	574	556
Japan	557	558	559	555
Korea, Rep. of	545	535	547	554
England	531	532	528	536
Finland	531	529	531	533
Ireland	525	519	524	531
Sweden	521	514	521	528
Australia	520	513	520	526
United States	513	503	514	521

Note. Light shading indicates that the subscale score is significantly lower than the country's overall science scale score. Dark shading indicates that the subscale score is significantly higher than the country's overall science scale score.

Source: Adapted from Exhibit 2.2.14 in von Davier et al. (2024).

Gender differences across the three cognitive domains in science are presented in Table 6.8. In Ireland, boys significantly outperformed girls on the Knowing and Applying cognitive domains, while both had similar scores on the Reasoning domain.

Table 6.8: Mean achievement scores of girls and boys on cognitive domains in Ireland, Second Year science

	Mean	Knowing	Applying	Reasoning
Girls	520	513	517	530
Boys	529	524	529	531

Note. Shading indicates that the subscale score is significantly higher than for the other gender on that subscale.

Source: e-Appendix Table A6.15.

Curriculum coverage for Second Year science

In TIMSS 2023 a TCMA was conducted to establish whether the topic of each item in the TIMSS assessment was likely to have been covered by the majority of Second Year students by the time of TIMSS testing in spring 2023. This section presents the results of the TCMA for Second Year science followed by findings from the Teacher Questionnaire where teachers reported the coverage of TIMSS topics.

Test-Curriculum Matching Analysis for Eighth Grade science

Table 6.9 presents the outcomes of the TCMA for Second Year science in Ireland. Overall, 87% of the assessment was considered to have been covered by Second Year students in Ireland. All students were deemed to have covered topics in Chemistry and 93% were estimated to have covered topics on the Earth Science domain. Approximately 89% of the Second Year Students were reckoned to have covered topics on the Biology domain and on the Physics domain 67% of the topics were estimated to have been covered by Second Year students by the time of the TIMSS testing in spring 2023.

Table 6.9: TCMA overall and by content domain – Eighth Grade science items

	Number of items	Number of items included in curriculum	% included in curriculum
Biology	76	68	89%
Chemistry	43	43	100%
Physics	48	32	67%
Earth Science	45	42	93%
Overall	212	185	87%

Exhibit C.4 in the TIMSS 2023 International Results in Mathematics and Science (von Davier et al., 2024) presents findings on the average scale scores for each country based on the science TCMA. Students in Ireland would have a mean achievement score of 526 if only the items considered to be part of the curriculum were included, which is the very similar to the actual achieved achievement score (525). Overall, across all the participating countries at Eighth Grade, most countries only observed small fluctuations between the mean score achieved and the score they would achieve if only the items considered to be part of the curriculum were included.

Teacher reports of topic coverage for Eighth Grade science

The final section of this chapter presents finding from the teacher questionnaire in relation to questions on whether specific science topics had been *mostly taught before this year*, *mostly taught this year*, or *not yet taught this year*. The latter category also includes topics that were not in the curriculum. Table 6.10 presents results for Ireland and the selected countries in terms of the percentages of students whose teachers reported that the topics had been mostly taught in the assessment year or in the year before.

In Ireland, reported coverage of the Earth Science topics (46%) in science lessons was substantially lower than that reported for the international average (69%).¹⁷ Similarly, coverage of Biology topics was also lower in Ireland (57%) than the international average (73%). The highest level of coverage in Ireland was in Chemistry, with 80% of students having teachers who reported that these topics were mostly taught before or in the assessment year. Coverage of this topic was higher than on average across all TIMSS countries (73%).

In England, where overall science achievement did not differ significantly from Ireland's (see Table 6.1), coverage of Biology, Physics, and Earth Science was higher than the coverage reported in Ireland. In the top two performing countries (Singapore and Chinese Taipei), coverage of Biology was higher than that reported for Ireland while coverage of the Earth Science topics was substantially lower in these countries compared to Ireland.

¹⁷ Second Year students may have received some additional exposure to Earth Science topics in geography lessons which are not captured in the questionnaires completed by science teachers.

Table 6.10: Percentages and standard errors of students taught the TIMSS topics – Eighth Grade science

	Biology (16 topics)		Chemistry (10 topics)		Physics (13 topics)		Earth Science (12 topics)	
	%	(SE)	%	(SE)	%	(SE)	%	(SE)
Singapore	73	(1.4)	79	(1.2)	68	(1.0)	20	(1.4)
Chinese Taipei	73	(3.5)	93	(0.8)	48	(1.2)	11	(1.9)
Japan	46	(0.8)	59	(1.2)	50	(1.0)	60	(1.4)
Korea, Rep. of	61	(1.6)	52	(1.7)	60	(1.2)	65	(1.6)
England	70	(2.2)	72	(2.4)	73	(2.7)	53	(3.2)
Finland	69	(0.8)	89	(0.9)	72	(1.3)	83	(0.9)
Ireland	57	(1.2)	80	(1.1)	58	(1.1)	46	(1.7)
Sweden	77	(1.0)	69	(1.5)	76	(1.1)	-	-
Australia	64	(1.6)	66	(1.4)	53	(1.5)	62	(2.1)
United States	89	(1.0)	77	(2.2)	82	(1.8)	89	(1.6)
TIMSS average (43)	73	(0.2)	73	(0.2)	66	(0.2)	69	(0.3)

Note. Percentages of students mostly taught before or in the assessment year, averaged across topics.

43 countries in the TIMSS average rather than 44 as Norway did not administer the Teacher Questionnaire.

See e-Appendix Table A6.16 for more detailed information on individual topics.

Chapter 7:

Transition from Paper to Digital Testing: National Mode Effect Study

This chapter focuses on Ireland's transition from paper to digital administration in TIMSS 2023 and presents initial findings from the national mode effect study.

TIMSS 2019 was the first cycle of the study to offer the assessment on a digital platform internationally. While half of the participating countries chose to administer the assessment digitally at that time, the other half, including Ireland, administered the paper-based version. The current cycle, TIMSS 2023, completed the transition to a fully digital administration for all countries, concluding the process that began in 2019 and marking Ireland's transition to a digital administration (see also Delaney et al., 2024). In addition to being easier to administer in some respects, with processes such as data entry and scoring being more efficient, the digital version of the TIMSS test, as mentioned in Chapter 1, facilitated the assessment of complex areas of the curriculum that are difficult to measure with the paper-based version by including animated, interactive PSI tasks. Besides extending measurement capabilities, these colourful and dynamic tasks were expected to enhance student engagement with the assessment and stimulate their motivation.

The digital TIMSS test was designed to maintain continuity with previous paper-based cycles, allowing countries that chose the digital option to preserve their trend measurements. Based on an item equivalence pilot study conducted in 2017 (Fishbein et al., 2018) that revealed a modest effect of administration mode (i.e., on paper or digitally), countries administering the digital version for the first time had the option to examine possible mode differences during the transition cycle, with Ireland choosing to do so.¹⁸ This involved administering eight of the 14 item blocks per subject in paper format to samples of at least 1,500 students at each grade level (additional to the main TIMSS samples described above). These eight blocks were selected as they contained the trend items (i.e., items that had been used in previous TIMSS cycles). Given that students were randomly assigned to either the digital or paper mode, they were expected to have the same underlying skills and knowledge. The only difference between the groups should be the mode to which they were assigned, making them otherwise equivalent. This approach is based on the principle of randomisation, a cornerstone of experimental design.

At Fourth Class, 62 schools were selected to participate in the national mode effect study. Of these, one school was ineligible to participate due to amalgamation with another school, 16 schools participated in both the main study (i.e., digital version) and the national mode effect study (i.e., on paper), and 45 schools participated in the national mode effect study only. Within these schools, 1,714 pupils in 83 classes were eligible to participate in the national mode effect study, with 1,615 pupils actually participating. At Second Year, 60 schools were selected to participate in the national mode effect study. Of these, one school was unable to participate and was replaced, 52 schools participated in both the main study and the national mode effect study, and eight schools participated in the national mode effect study only. Within these schools, 1,462 students in 61 classes were eligible to participate in the national mode effect study, with 1,231 students actually participating.

The administration of the national mode effect study in Ireland at both primary and post-primary levels adhered to the same procedures as those used for the digital version, as described in Chapter 2. The only difference between the two modes was that the test and the Student Questionnaire were exclusively paper-based for classes participating in the national mode effect study and exclusively digital for classes participating in the main study.

¹⁸ Among countries administering the digital version for the first time in 2023, three other countries – Azerbaijan, Bahrain, and Belgium (Flemish) – also opted to examine possible mode differences.

National mode effect study

The data from the national mode effect study, presented next, are specifically designed to examine potential differences between the digital and the paper versions of the assessment in Ireland in order to ensure the validity and comparability of results as Ireland transitions to a fully digital administration for future cycles of TIMSS. It is important to note that these data are separate from the main study (digital) TIMSS data and do not contribute to Ireland's performance as reported in Chapters 3-6. Instead, the national mode effect study provides critical insights into how the mode of administration may shape student achievement and differences in the distribution of achievement, thereby allowing for more accurate and nuanced interpretations of the main study findings. This ensures that Ireland's main study results remain valid and reliable, representing genuine trends in student achievement rather than artifacts of the assessment format.

As a consequence of the linking approach used in the achievement scaling for the digital and paper versions of the TIMSS achievement test (Martin et al., 2020), the digital and paper scale scores are on the same TIMSS 2023 achievement scales and can be directly compared. However, it should be noted that the digital scale scores are based on all of the 2023 achievement items (described in Chapter 1), while the paper scale scores are (i) based on only the subset of trend items carried forward from TIMSS 2019 (eight of the 14 item blocks per subject) and (ii) have been estimated from student samples that are approximately one-third in size compared to the samples involved in the main study (digital version), as described above.

Mode effects: Overall

Table 7.1 presents the mean mathematics and science scores for students in Ireland by grade level and by the mode of test administration. A key finding is that none of the differences in mean scores by mode of administration were statistically significant. This indicates that the administration mode did not have a substantial impact on students' overall mathematics and science achievement in Ireland, at either primary or post-primary level.

Table 7.1: Mean mathematics and science scores for Ireland, by grade level and administration mode

	Fourth Class				Second Year			
	Mathematics		Science		Mathematics		Science	
	Mean	(SE)	Mean	(SE)	Mean	(SE)	Mean	(SE)
Paper	544	(5.3)	529	(6.0)	528	(4.1)	528	(4.4)
Digital	546	(2.9)	532	(3.2)	522	(2.7)	525	(3.5)

Note. None of the differences in mean mathematics and science scores by mode of administration were statistically significant.
Source: e-Appendix Tables A7.1, A7.2, A7.3, A7.4.

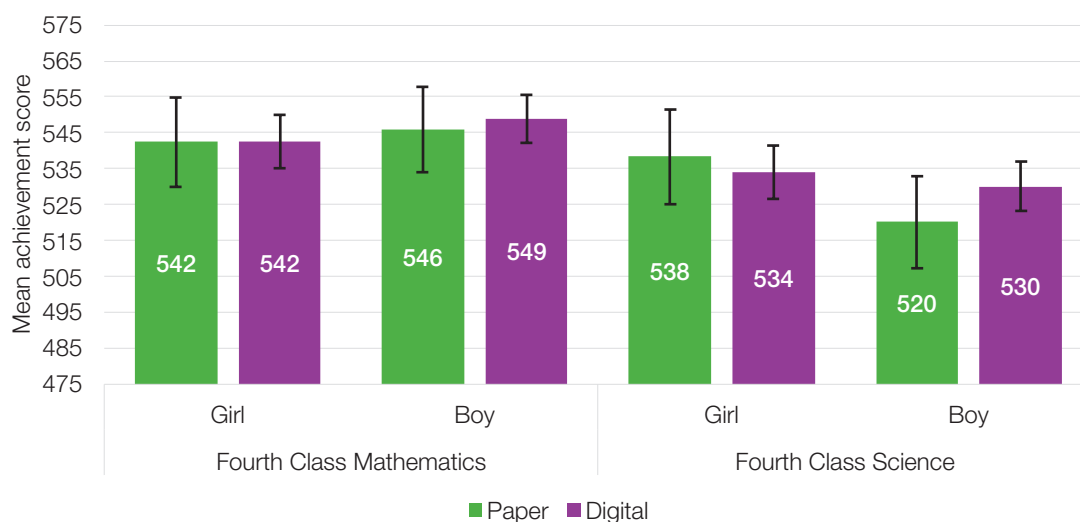
Mode effects: By gender

Figure 7.1 presents gender differences with respect to possible mode effects at Fourth Class, describing the mean mathematics and science scores for girls and boys in Ireland by the mode of test administration.

Fourth Class girls who took the paper-based version of the TIMSS mathematics test achieved the same mean score as those who took the digital version. In science, there was no statistically significant difference between girls who took the paper-based and digital versions of the TIMSS science test. Similarly, while Fourth Class boys showed a tendency to perform better on the digital version of both the mathematics and science tests, these differences were not statistically significant.

Overall, these results suggest that, for both girls and boys, the administration mode (paper or digital) did not have a substantial impact on their overall mathematics and science achievement, indicating that neither group was notably disadvantaged (or advantaged) by the mode of test administration.

Figure 7.1: Mean mathematics and science scores among girls and boys in Ireland, by administration mode, Fourth Class



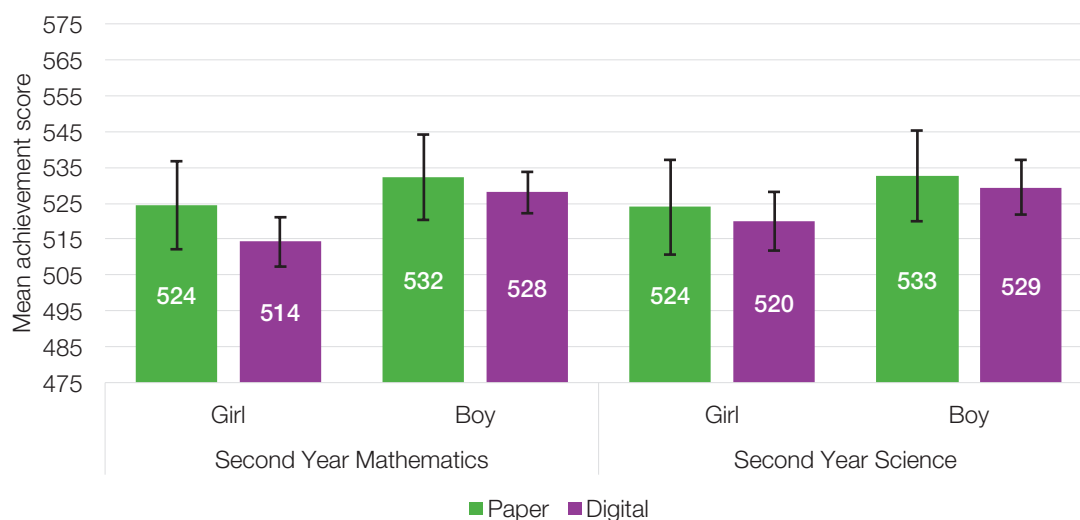
Note. Mean scores are presented with a 95% confidence interval around the estimate. None of the gender differences in mean scores by mode of administration were statistically significant.

Source: e-Appendix Tables A7.5, A7.6, A7.7, A7.8.

Figure 7.2 presents the mean mathematics and science scores for Second Year girls and boys in Ireland by the mode of test administration. At Second Year, both boys and girls showed a tendency to perform better on the paper-based version of the TIMSS mathematics and science tests compared to the digital version. However, none of these differences were statistically significant.

As was found at Fourth Class, these results suggest that the administration mode (paper or digital) did not have a substantial impact on the overall mathematics and science achievement of either girls or boys, indicating that neither group was notably disadvantaged (or advantaged) by the mode of test administration.

Figure 7.2: Mean mathematics and science scores among girls and boys in Ireland, by administration mode, Second Year



Note. Mean scores are presented with a 95% confidence interval around the estimate. None of the gender differences in mean scores by mode of administration were statistically significant.
Source: e-Appendix Tables A7.9, A7.10, A7.11, A7.12.

Chapter 8:

Summary and Discussion

This chapter draws together the main findings described in the preceding chapters. First, key findings relating to the achievement of Fourth Class and Second Year students in mathematics and science are summarised. This is followed by a summary of findings from the national mode effects study that was carried out as an addition to TIMSS 2023 in Ireland in order to monitor any changes to achievement associated with the transition from paper-based to digital assessment.

The next section looks across both grade levels and both subjects to identify high-level observations of common patterns and points of difference, important changes and points of consistency relative to previous cycles of TIMSS, and recurring challenges relating to student learning in mathematics and science. The chapter concludes by describing plans for further analysis of the TIMSS 2023 data.

Summary of key findings

The following sections summarise the main achievement-related findings for Ireland from TIMSS 2023. Table 8.1 provides a high-level snapshot of key points of note, which are described more fully in the accompanying text.

Overall achievement in mathematics and science in TIMSS 2023

Fourth Class

Fourth Class pupils achieved a mean score of 546 in mathematics and 532 in science. In both subjects, pupils in Ireland achieved scores that were significantly above the respective international averages (503 and 494).

In mathematics, seven countries (including one EU country: Lithuania) achieved mean scores higher than Ireland's, while four countries (including Poland and Romania within the EU) achieved similar scores. The score in Ireland was significantly higher than that of 46 countries.

In science, ten countries (including two EU countries: Poland and Finland) achieved a significantly higher mean score than Ireland's. Eleven countries had a similar mean score to Ireland, while 36 countries had a significantly lower score than Ireland at Fourth Grade.

Second Year

Second Year students achieved a mean score of 522 in mathematics and 525 in science. The scores of students in Ireland were significantly higher than the international averages (478 for both subjects).

In mathematics, students in five countries – all outside the EU – achieved significantly higher mean scores than those in Ireland. Four countries (including Czech Republic, Sweden, and Lithuania) achieved similar mean scores to Ireland's, while 34 countries had mean scores that were significantly lower.

In science, four countries – again, all outside the EU – achieved significantly higher scores than Ireland, with nine countries achieving similar mean scores. Thirty countries had mean scores that were significantly below Ireland's in Eighth Grade science.

Table 8.1: Summary of selected key findings for Ireland in mathematics and science from TIMSS 2023

	Fourth Class		Second Year	
	Mathematics	Science	Mathematics	Science
Mean score				
Score	546	532	522	525
Countries sig. above IRL	7	10	5	4
Countries similar to IRL	4	11	4	9
Countries sig. below IRL	46	36	34	30
International Benchmarks				
Low (400)	95	93	93	91
Intermediate (475)	81	78	73	72
High (550)	52	45	38	41
Advanced (625)	16	10	9	13
Distribution of achievement				
5th percentile	401	384	385	374
95th percentile	667	650	646	662
Content domains				
Relative strength	-	-	Number, Data & Probability	Earth Science
Similar to overall	Number, Data	Life Science, Earth Science	-	Chemistry, Physics
Relative weakness	Measurement & Geometry	Physical Science	Algebra, Geometry & Measurement	Biology
Cognitive domains				
Relative strength	Knowing	-	Applying	Reasoning
Similar to overall	Applying	Knowing, Applying, Reasoning	Knowing	Applying
Relative weakness	Reasoning	-	Reasoning	Knowing
Sig. gender difference?				
Mean score	No	No	Yes (528 boys vs 514 girls)	Yes (529 boys vs 520 girls)
International Benchmarks	More boys at Advanced	No	More boys at Intermediate, High, Advanced	More boys at High, Advanced
Differences by socioeconomic status				
	Substantive at school level (DEIS Urban vs non-DEIS) and at individual level	Substantive at school level (DEIS Urban vs non-DEIS) and at individual level	Substantive at school level (DEIS vs non-DEIS) and at individual level	Substantive at school level (DEIS vs non-DEIS) and at individual level
Mode effects				
Sig. difference in paper vs digital?	No	No	No	No

Note. For scale scores and percentages, **bold** indicates a significant increase from the equivalent in 2019.

Trends in achievement in Ireland

Fourth Class

Overall, performance in TIMSS has remained very stable since 2015. There were no significant changes in either mathematics or science achievement at Fourth Class in TIMSS 2023, relative to either of the two previous cycles, with only small and non-significant differences (-3 points in mathematics and +4 points in science) observed since 2019.

Second Year

As at primary level, the performance of Second Year students in TIMSS has remained stable, with no significant differences seen since 2015. This is especially apparent for mathematics, where the mean scores in 2015 (523), 2019 (524), and 2023 (522) show very little change. Similarly, in science, the change in mean score from 2019 (523) to 2023 (525) is very small.

Distribution of achievement (performance of lowest- and highest-achieving students)

Fourth Class

The distribution of pupil achievement at Fourth Class was wider in TIMSS 2023 than in any recent previous cycle, for both mathematics and science. In both subjects, the overall pattern indicates a narrowing of the distribution of achievement between 2011 and 2015, followed by gradual widening in subsequent cycles.

In mathematics, the difference in achievement between the highest-performing pupils (those at the 95th percentile) and the lowest-performing pupils (at the 5th percentile) in TIMSS 2023 was 266 score points. In previous cycles, the corresponding difference was 258 points (in 2011), 239 points (in 2015), and 250 points (in 2019). In science, the difference between scores at the 5th and 95th percentiles was 266 points in TIMSS 2023, compared to 257 (in 2011), 230 (in 2015), and 250 (in 2019).

Comparing specific markers along the distribution, the differences in mean scores at the 5th and 95th percentiles between 2019 and 2023 were not significant in either mathematics or science. However, compared to TIMSS 2015, the lowest-performing pupils in 2023 achieved significantly lower scores in both subjects. Conversely, performance in science among the highest-achieving pupils was significantly higher in 2023 than in 2015 (accompanied by a non-significant increase in mathematics).

Second Year

At post-primary level, a broadly similar pattern is seen. The range of achievement from the 5th to the 95th percentile in mathematics among Second Year students was 260 score points in TIMSS 2023, marking an increase from 2015 (242 points) and 2019 (241 points). Similarly, in science, the range widened in 2023 to 288 score points, after previously being recorded at 262 (in 2015) and 274 (in 2019). As at Fourth Class, a consistent gradual widening of the distribution has been seen in both subjects since 2015.

In mathematics, a statistically significant nine-point increase in achievement among higher-achieving students (at the 95th percentile) was observed in 2023, relative to 2019. Differences at the 5th percentile were not significant. In science, changes in mean scores at the 5th and 95th percentiles relative to TIMSS 2019 or TIMSS 2015 were not statistically significant.

International Benchmarks

Fourth Class

The vast majority of Fourth Class pupils reached at least the Low Benchmarks for mathematics (95%) and science (93%), and about four-fifths reached the Intermediate Benchmarks in either subject (81% and 78%, respectively). However, somewhat fewer pupils could demonstrate the skills and knowledge needed to reach the High and Advanced Benchmarks in science (45% and 10%, respectively) compared to mathematics (52% and 16%).

Some changes can be seen in Fourth Class pupils' performance at the International Benchmarks compared to previous cycles of TIMSS. In mathematics, the proportion of pupils reaching at least the Low Benchmark was slightly, but statistically significantly, lower in 2023 than in 2015. At the other mathematics benchmarks, performance in 2023 remained similar to that seen in 2015 or 2019, and also remains significantly above the levels seen in 2011. In science, as for mathematics, a significantly lower proportion of pupils achieved the Low Benchmark in 2023 compared to 2015. However, significantly high proportions reached the Intermediate (compared to 2011), High (compared to 2011 and 2015), and Advanced Benchmarks (compared to 2011 and 2015). There were no significant changes since 2019 at any International Benchmark level in either subject.

Second Year

Most Second Year students successfully achieved at least the Low Benchmarks in mathematics (93%) and science (91%), while slightly fewer than three-quarters of students reached the Intermediate Benchmarks (73% and 72%, respectively). In contrast to the pattern seen at Fourth Class, students at Second Year performed slightly better at the High and Advanced Benchmarks in science compared to mathematics. In both subjects, approximately four-fifths of students reached the High Benchmark (38% mathematics; 41% science), while 9% reached the Advanced Benchmark for mathematics and 13% did so for science. In general, relatively fewer students at Second Year reached each of the benchmarks than for the corresponding levels at Fourth Class.

Comparing back to student performance in TIMSS 2015 or TIMSS 2019, few changes can be seen at Second Year. In mathematics, a two-percentage point increase represents a slightly (but statistically significantly) greater proportion of students reaching the Advanced Benchmark in 2023 compared to 2015. In science, significantly fewer students in 2023 successfully achieved the Intermediate Benchmark relative to 2015. Conversely, significantly more students achieved the Advanced Benchmark in 2023 than in 2019. No other significant changes were seen in either subject.

Performance by content domains

Fourth Class

In mathematics, Fourth Class pupils demonstrated a relative weakness (relative to their high overall performance) in Measurement & Geometry. Performance on the other two content domains – Number and Data – were similar to the overall national performance. The identification of Measurement & Geometry as an area of relative weakness is a finding that persists from previous cycles of TIMSS in 2019 (Perkins & Clerkin, 2020), 2015 (Clerkin et al., 2016), and 2011 (Eivers & Clerkin, 2012). However, while each of the previous cycles identified Number as an area of relative strength, this was no longer the case in 2023.

In science, Physical Science was an area of relative weakness for Fourth Class pupils. Performance on items assessing Life Science and Earth Science was in line with pupils' overall performance. Physical Science

was also identified as a relative weakness in TIMSS 2019 (Perkins & Clerkin, 2020) and TIMSS 2015 (Clerkin et al., 2016), while Earth Science had been a relative strength in these previous cycles.

Second Year

As was found at Fourth Class, Geometry & Measurement was an area of relative weakness for Second Year students in TIMSS 2023, as was Algebra. Conversely, Number and Data & Probability were both areas of relative strength. The exact same pattern of strengths and weaknesses was also found previously in both 2019 (Perkins & Clerkin, 2020) and 2015 (Clerkin et al., 2016).

In science, Biology was a relative weakness for students in 2023, while Earth Science was a relative strength. Performance on both Chemistry and Physics was in line with students' overall achievement. Earth Science has consistently been identified as a relative strength for Second Year students in both previous cycles of TIMSS (2015 and 2019). However, it is noteworthy that Chemistry and Physics were both identified as relative weaknesses in previous cycles but not in the current cycle. Another change is that Biology has gradually moved from being a relative strength in 2015 (Clerkin et al., 2016) to neither a strength nor a weakness in 2019 (Perkins & Clerkin, 2020) and to a relative weakness in 2023.

Performance by cognitive domains

Fourth Class

In mathematics, Knowing was found to be a relative strength, while Reasoning was a relative weakness for Fourth Class pupils. Achievement on items assessing Applying skills was similar to overall performance. Reasoning in mathematics has been identified as an area of relative weakness for Fourth Class pupils in each cycle of TIMSS since 2011 (Clerkin et al., 2016; Eivers & Clerkin, 2012; Perkins & Clerkin, 2020). Similarly, Knowing has generally been found to be a relative strength, with the exception of 2019 (when it was in line with overall performance).

In science, the patterns are somewhat different and generally indicate a more even level of pupil performance across cognitive domains. In TIMSS 2023, performance on all three cognitive domains was in line with overall performance, with none emerging as either a relative strength or weakness. The same pattern was also observed in 2015. One exception to this tendency was observed in each of TIMSS 2011 (when Reasoning was a relative weakness) and TIMSS 2019 (when Knowing was a relative strength).

Second Year

Looking across both mathematics and science, student performance on the cognitive domains at Second Year is more difficult to interpret. In the current cycle, Reasoning was found to be a relative weakness for students in mathematics but a relative strength in science. Applying was a relative strength in mathematics but similar to overall performance in science, while the opposite pattern was found for Knowing.

Nonetheless, this remains largely consistent with the findings of TIMSS 2019, when reasoning in mathematics was also a relative weakness while reasoning in science was a relative strength (Perkins & Clerkin, 2020). The only difference in patterns of cognitive performance between TIMSS 2019 and TIMSS 2023 is that Knowing was a relative strength for mathematics in 2019 but is no longer so; otherwise, for both domains, the pattern described above remains consistent.

Curriculum coverage

Fourth Class

The Test-Curriculum Matching Analysis indicated that the vast majority of items on the TIMSS Fourth Grade assessment were covered by the Irish curriculum, albeit to a greater extent for mathematics (96% coverage) than for science (87%). Coverage of content domains ranged from 95% (Data) to 97% (Number) for mathematics, and from 64% (Earth Science) to 95% (Physical Science) for science.

Teacher reports also indicated that most Fourth Class pupils had been taught the topics included in the TIMSS assessment by the time testing took place. In mathematics, teachers reported that coverage of topics across content domains ranged from 79% of pupils for Measurement & Geometry to 91% for Number. The corresponding percentages were lower for science, ranging from 60% for Physical Science to 80% for Life Science.

Second Year

The TCMA analysis indicated that most TIMSS items on the Eighth Grade mathematics assessment (89%) were judged to be included on the Irish curriculum. This was true to a greater extent for Number (98%) and Data & Probability (89%) than for Geometry & Measurement (83%) or Algebra (81%). For science, overall coverage of items on the Irish curriculum (87%) was similar to mathematics. However, coverage of items relating to Physics (67%) was noticeably lower than for the other three content domains (ranging from 89% for Biology to 100% for Chemistry).

Teachers of Second Year mathematics reported that almost all students would have been taught the topics relating to Number (97%) by the time of TIMSS testing, with about three-quarters of students expected to have been exposed to topics in Data & Probability (76%) and Algebra (72%). Coverage of Geometry & Measurement topics in classrooms was lower (59%). Teachers of science reported lower coverage of the topics assessed in TIMSS, with close to half of Second Year students being taught the topics in Earth Science (46%), Biology (57%), and Physics (58%). Students received greater exposure to the topics assessed by TIMSS under Chemistry (80%).

Differences in achievement by gender

Fourth Class

Overall, boys and girls in Fourth Class achieved similar scores in both mathematics and science, with no significant differences emerging. However, a significantly higher proportion of boys successfully reached the Advanced Benchmark for mathematics performance (18% boys vs 13% girls). There were no other significant gender differences across the other benchmarks for mathematics or science.

Across the distribution of achievement, there were no significant differences at the 5th or 95th percentiles between boys and girls in Fourth Class for either mathematics or science. However, the range of achievement between the 5th and 95th percentiles was wider for boys (274 score points for both subjects) than for girls (257 for both subjects).

Among the content and cognitive domains, boys achieved a significantly higher score than girls on the Data subscale for mathematics, and also on Knowing and Reasoning in mathematics. Conversely, girls achieved a significantly higher score than boys on the Life Science content domain and on Reasoning in science.

Second Year

Significant differences between boys and girls were seen at Second Year for both mathematics and science. In mathematics, boys' mean score (528) was 14 points higher than girls' (514). In science, boys' mean score (529) was nine points higher than that of girls (520). The observation of significant gender differences in TIMSS 2023 marks a change from previous cycles of TIMSS, where Second Year boys and girls had achieved similar performance on average in both mathematics and science (Clerkin et al., 2016; Perkins & Clerkin, 2020).

Second Year girls and boys had a similar range of achievement in mathematics, with differences of 260 and 261 score points (respectively) between students at the 5th and 95th percentiles. Although the 16-point advantage in favour of boys at the 5th percentile was not statistically significant, boys at the 95th percentile achieved a significantly higher score, by 17 points, than girls. In science, the range for boys (296) was wider than for girls (276), although scores at either end of the distribution were statistically similar. The difference at the 5th percentile was relatively small, at four score points, with a difference of 16 score points at the 95th percentile.

In TIMSS 2023, greater proportions of boys than girls in Second Year also reached the Intermediate, High, and Advanced Benchmarks for mathematics, and the High and Advanced Benchmarks for science. At the level of content and cognitive domains, boys demonstrated a statistically significant advantage over girls in two mathematics content domains (Number, and Geometry & Measurement) and two science content domains (Physics and Earth Science). Boys also achieved significantly higher scores than girls on the Knowing, Applying, and Reasoning cognitive subscales for mathematics, and on Knowing and Applying for science.

Differences in achievement by socioeconomic status

Fourth Class

Examined by schools' DEIS status, pupils in non-DEIS primary schools achieved mean scores in both mathematics and science that were significantly – and substantively – higher than the scores of pupils in DEIS Urban Band 1 or Band 2 schools. Although the mean scores of pupils in DEIS Rural schools was somewhat lower than that of pupils in non-DEIS schools, these differences were not statistically significant.

Using a new international individual-level indicator of SES, pupils in Ireland who were classified within the *higher SES* category achieved significantly higher mean scores than pupils in the *middle SES* or *lower SES* categories in both subjects. These differences were substantial in magnitude, with *higher SES* pupils exhibiting an advantage of 102 score points in mathematics (one full standard deviation on the international TIMSS scale) and 97 score points in science over *lower SES* pupils.

Second Year

Differences in mean achievement between DEIS and non-DEIS post-primary schools were both significant and substantial in both subjects. In mathematics, the mean score of students in non-DEIS schools was 49 points higher than that of students in DEIS schools, approximately equivalent to half a standard deviation on the international TIMSS scale. The difference for science was similar (52 points).

At the individual level, the difference in mathematics achievement between Second Year students with *many resources* at home and those with *few resources* was very large, equal to one standard deviation on the scale (100 score points). In science, the difference was even greater (107 score points). Both differences were statistically significant.

National mode effect study

TIMSS 2023 marked Ireland’s transition from paper-based to digital assessment, following the earlier transition by about half of participating TIMSS countries in 2019. While mode effects – differences in student performance due to administration of the test in either paper or digital modes – were examined and controlled for at an international level in TIMSS 2019, there was no corresponding cross-national study of mode effects for countries transitioning in TIMSS 2023.

However, Ireland elected to administer paper versions of the test booklets to a separate “bridge” sample of students, under equivalent conditions to the main digital TIMSS assessment, in order to examine the potential for mode effects in this cycle. Understanding any differences in student achievement across modes of administration is crucial for interpreting the trend information provided by TIMSS and providing assurance that the scores achieved by students in 2023 can be considered a valid extension of the existing trendline, without being unduly affected (positively or negatively) by the move to digital assessment. The administration and findings of this national mode effect study are described in Chapter 7.

In brief, the study finds no evidence of statistically significant differences in students’ scores – in either mathematics or science, at either Fourth Class or Second Year – that were related to the mode of administration. A second stage of this analysis also examined patterns of achievement by gender to assess the degree to which boys’ or girls’ performance may have been affected by the move to digital testing. As at the overall national level, no significant mean score differences related to the mode of administration were found between boys and girls in either subject, at either grade level.

The results of the mode effect study indicate that, on average, the students in Ireland who participated in TIMSS 2023 were not notably advantaged or disadvantaged by the transition to digital assessment (at least in terms of their observed achievement). This provides some assurance that national trend comparisons back to previous cycles of TIMSS, and forward to future cycles, can continue to be made reliably to inform educational practice and policymaking. Secondary analysis of these data in future, together with analysis of accompanying data on students’ test-taking behaviour in either paper or digital format, may shed further light on differences in student behaviour, attitudes, and achievement that may be related to the ways in which students interact with tests.

Discussion of key findings

A strength of TIMSS is the richness of the data collected – covering two key subjects at both primary and post-primary levels, with reliable trends dating back over many years. The breadth of these data provides an opportunity to draw some high-level conclusions about the status of mathematics and science achievement among Fourth Class and Second Year students in 2023.

Stability in average mathematics and science achievement over the pandemic years

A notable feature of TIMSS 2019 was the remarkable level of stability in student achievement outcomes at both grade levels and in both subjects, relative to the performance of students in 2015 (Perkins & Clerkin, 2020). That stability has continued to 2023, with no significant changes in Ireland’s mean scores observed in the current cycle. The evidence provided by the national mode effect study accompanying the current cycle of TIMSS means that we can be confident that these trends are a reliable reflection of students’ performance.

The lack of any significant difference in achievement in Ireland between the 2023 cohort of students and their predecessors is particularly noteworthy in the context of the COVID-19 pandemic, which caused unprecedented disruption to learning and life both in and out of school in the intervening years.¹⁹ Some similar findings of broad consistency in student performance in Ireland over the period of the pandemic have been reported (albeit moreso at primary level) in other recent large-scale assessments such as PIRLS, PISA, and NAMER (Delaney et al., 2023; Donohue et al., 2023; Kiniry et al., 2023). Stability in student performance may also be seen as a relatively positive outcome in light of international findings of significant declines in performance in many countries over a similar period (Crato & Patrinos, 2024; Jakubowski et al., 2024).

Increasing differences between lowest- and highest-achieving students

Despite the overall stability of performance when considered at the average level, the current data indicate that differences in performance between the lowest- and highest-achieving students have continued to widen from 2015, through 2019, to 2023. This indicates that, although there are signs that higher-achieving students are performing better in 2023, lower-achieving students are performing at a lower level, leading to increasing differences in student outcomes. This is the case for both mathematics and science, at both Fourth Class and Second Year.

The changes in performance at particular percentiles of achievement, or at particular benchmarks of performance, are not always statistically significant and should not be overstated. Nonetheless, the trends tend to point in the same direction for both subjects and at both grades and, in some cases, significant differences over time can be observed. These include significant declines in the percentage of pupils reaching the Low Benchmark – a minimal level of proficiency – in both mathematics and science at Fourth Class since 2015. This has been accompanied by a significant increase in the percentage of Fourth Class pupils reaching the High and Advanced Benchmarks for science, though not mathematics, since 2015. Similarly, at Second Year, significantly fewer students achieved the Intermediate Benchmark for science in 2023 (compared to 2015), while a significantly greater proportion successfully reached the Advanced Benchmarks in both mathematics and science (compared to 2019). Also at Second Year, the mean score achieved by students at the 95th percentile in mathematics was significantly higher in 2023 than in 2019.

Improvements in student performance at the higher levels of achievement are welcome – particularly in light of the historical relative underperformance of higher-achieving students in Ireland, compared to their peers internationally, as highlighted in reporting on previous cycles of TIMSS (Clerkin et al., 2016; McHugh et al., 2024; Perkins & Clerkin, 2020). However, while continuing to support and stretch higher-achieving students to reach their full potential, it will be important also to ensure that students across the full range of the distribution of achievement, including those at the lower end, remain supported and enabled to fulfil their potential as fully as possible.

Gender differences at Second Year

Previous cycles of TIMSS have tended to find similar mean outcomes for boys and girls in both of the assessed subjects (Clerkin et al., 2016; Eivers & Clerkin, 2012; Perkins & Clerkin, 2020). This remains the case in TIMSS 2023 for pupils in Fourth Class on average and at most benchmarks, although one noteworthy finding from the current cycle is the appearance of a significant difference in the proportions of boys (18%) and girls (13%) reaching the Advanced Benchmark for mathematics.

¹⁹ Recall that Fourth Class pupils in TIMSS 2023 would have been in First Class when school closures began in 2020, while Second Year students in TIMSS 2023 would have been in Fifth Class.

However, for the first time in recent years, a significant gender difference in average performance among Second Year students in TIMSS has been observed, with boys significantly outperforming girls in both mathematics and science. Although boys' mean score in both subjects increased slightly, though not statistically significantly, in 2023, the mean score of Second Year girls in TIMSS has decreased significantly over time in mathematics (since 2019) and in science (since 2015).

As well as these differences at the national average, boys in Second Year demonstrated an advantage over girls at the highest levels of achievement in both subjects. In mathematics, boys at the 95th percentile achieved a significantly higher mean score than girls. In both mathematics and science, for the first time in recent cycles, a significantly greater proportion of boys than girls reached both the High and Advanced Benchmarks. (Boys also outperformed girls at the Intermediate Benchmark in mathematics, replicating a similar difference seen in TIMSS 2019.)

Significant gender differences in mathematics – although not in science – were also observed among 15-year-old students in the PISA 2022 study, with boys similarly reaching the highest levels of proficiency in greater proportions (Donohue et al., 2023). Taken in conjunction with the evidence of increasing gender differences at Second Year in this cycle of TIMSS, where few had previously been found, the data suggest that a renewed focus is needed to maintain high levels of performance in mathematics and science among all students regardless of gender, particularly so at post-primary level. Further analysis of the TIMSS 2023 data will seek to shed further light on this issue by examining students' attitudes towards learning mathematics and science in more detail, including with regard to differences by gender.

Consistent patterns of relative strengths and weaknesses across time

At the level of the content and cognitive domains that make up the TIMSS assessment, some familiar patterns can be seen in the TIMSS 2023 data.

In mathematics, students in Ireland at both grade levels performed more poorly (albeit still at a higher level than students in most other countries) on items assessing aspects of measurement and geometry. This relative weakness has been persistently identified in all recent cycles of TIMSS. Notably, teachers' reports indicated that, at both Fourth Class and Second Year, topics related to measurement and geometry tend to receive less coverage in Irish classrooms relative to other mathematics content domains. In addition, Algebra remains a relative weakness for Second Year students, as in previous cycles, while Number remains an area of relative strength.

In science, Physical Science remains a relative weakness for Fourth Class pupils, as in previous cycles. In this regard, a noteworthy finding from the TCMA and the accompanying analysis of teachers' reports presented in this report is that, although 95% of the Physical Science topics were judged to be included on the Irish primary curriculum, only 60% of students were reported by their teachers to have been taught those topics by the time of testing. In general, Fourth Class teachers reported that coverage of science topics across most content areas tended to be lower than coverage of mathematics topics. At Second Year, Earth Science remains a relative strength, as found in previous cycles of TIMSS. However, student achievement in Physics and Chemistry, which had been relative weaknesses in previous cycles, was in line with overall performance in science in the current cycle.

At both grade levels, students in Ireland demonstrated a relative weakness in Reasoning in mathematics, while Fourth Class pupils retained a relative strength in Knowing. Similar findings for both cognitive domains have been reported in all previous cycles of TIMSS since 2011. Conversely, yet consistent with TIMSS 2019, Second Year students demonstrated a relative strength in Reasoning in science. Despite these promising indications of students' reasoning ability in a scientific context, the TIMSS 2023 data suggest that continued efforts should be made to engage students in mathematical reasoning and to enhance their skills in this regard.

Readers who are interested in the performance of students in Ireland across the various content domains in mathematics and science are referred to McHugh et al. (2024) for a more detailed examination using TIMSS 2019 data, including comparisons of performance at the lower levels of the constituent subdomains, topics, and individual items of each content domain, and with reference to the relevant Irish curricula.

Substantial differences in achievement by socioeconomic status

The TIMSS 2023 data indicate that large, and important, differences in performance between students learning in differing socioeconomic contexts persist in Ireland. This can be seen both when examined by school-level indicators of disadvantage (DEIS status) and individual-level indicators (based on student or parent/guardian reports). Although a relatively small proportion of students were classified within the *lower SES* (Fourth Class) or *few resources* (Second Year) categories in Ireland, relative to many other countries, the differences in achievement between this group of students and the larger group of *higher SES* or *many resources* students were particularly striking.

This suggests that consideration could be given to ways in which supports are provided for individual learners experiencing the greatest degree of educational disadvantage, including those attending non-DEIS schools. Future research could contribute in this regard by seeking to better understand the dynamic interactions between learning outcomes and learners' experiences as they relate to home backgrounds, socioeconomic status, and the supports and resources available in a student's school (whether DEIS or non-DEIS).

STEM Education Policy Statement (2017-2026) and Literacy, Numeracy and Digital Literacy Strategy (2024-2033)

The TIMSS 2023 data reported here provide targeted insights that policymakers, as well as those involved in initial teacher education and professional development, can use to inform their efforts in the coming years.

One policy of relevance is the *STEM Education Policy Statement (2017-2026)* (Department of Education and Skills, 2017b) and its accompanying *STEM Education Implementation Plan to 2026* (Government of Ireland, 2023), which make reference to TIMSS as a source of information with which student achievement in mathematics and scientific subjects can be benchmarked. The current TIMSS data are particularly timely as they correspond to the beginning of the third of the *Policy Statement's* three phases, running from 2023-2026, which focuses on "realising the vision of providing the highest quality STEM education experience for learners" (Department of Education and Skills, 2017b, p. 21). The *Policy Statement* includes the following goals for students in Irish schools with regard to STEM subjects, including mathematics and science:

- › *All learners will have an excellent understanding of STEM disciplines, methods and processes, and a positive attitude towards STEM education.*
- › *All learner achievement in DEIS schools will increase, thus addressing the gap in achievement in STEM disciplines between students in DEIS schools and students in all schools.*
- › *The performance of Irish STEM learners across the education system will steadily improve and our ranking in cross country studies will rise.*

As shown by the findings of TIMSS 2023, work remains to be done to achieve these aims. Notwithstanding the continued strong performance of students in Ireland (relative to most other participating countries) in 2023, the data show no increase in mathematics or science performance, on average, over the lifetime of the *Policy Statement* to date. Similarly, substantial gaps remain to be addressed both in terms of socioeconomic background (including schools' DEIS status) and by other factors, such as gender. The next cycle of TIMSS in

2027 will collect data slightly after the end of the current *Policy Statement*, but will nonetheless provide another opportunity to examine the extent of progress towards these goals following the completion of its third phase.

In addition, these initial findings from TIMSS 2023 are relevant to several indicators that are set out in the Department of Education's (2024) recent *Literacy, Numeracy and Digital Literacy Strategy (2024-2033)*. Most notably, the *Strategy* includes the following goals:

- › *Reduced numbers of learners at primary and post-primary schools at the lowest level of achievement in [...] mathematics.*
- › *Increased numbers of learners at primary and post-primary schools at the highest levels of achievement in [...] mathematics.*
- › *Increased performance in mathematics at primary and post-primary levels with a focus on both male and female achievement.*
- › *Improved performance of learners in primary and post-primary schools in mathematics with particular focus on shape and space, and data.*
- › *Improved performance by learners in DEIS schools in mathematics [...].*

The TIMSS 2023 data are the most recent from a nationally representative large-scale assessment that were collected prior to the publication of the current *Strategy* and, therefore, can be considered as providing baseline data (for relevant subjects and grade levels) against which progress over the next decade of the *Strategy* can be monitored. The findings reported here suggest that these indicators are well-chosen in the sense that they reflect both new and recurring challenges to be addressed over the next decade. These include the need to ensure the highest standards of learning for all students, regardless of gender; supporting learners of mathematics particularly in areas such as shape and space, measurement and geometry; and providing continued and enhanced support to learners from all socioeconomic backgrounds according to their needs.

Beyond the initial achievement-related findings presented here, there remains scope for more detailed analysis of the TIMSS data on students' performance in both subjects, including gender differences and students' attitudes to and confidence in science and mathematics, that would yield insights for further policymaking and practice in these areas. Looking ahead, TIMSS 2027 will provide comparable data with which to examine trends in achievement and other outcomes over the early years of the *Strategy*.

Forthcoming reporting on TIMSS 2023 in Ireland

This report presents initial findings and trend comparisons for Ireland from TIMSS 2023. As well as the achievement-related findings which have been the main focus here, TIMSS also represents a rich source of data on students' home, classroom, and school contexts by drawing on a variety of data sources. Further analysis of these data is planned in order to provide further insights for students, parents, educators, researchers, and policymakers. Topics currently planned for more detailed investigation include:

- › Students' attitudes towards, and perspectives on, mathematics and science.
- › Examination of characteristics, resources, and practices in schools and classrooms at primary and post-primary levels.
- › Features of students' home learning environments.
- › Further examination of data arising from the national mode effect study, including students' experiences of and attitudes towards taking a test on paper versus in digital format.

The potential for secondary analysis combining insights from TIMSS with other large-scale assessments will also be examined. Publications arising from all of this work can be accessed as they become available from www.erc.ie/TIMSS.

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