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TIMSS 2019

Ireland's results in mathematics and science

IEA TIMSS 2019

Foras Taighde ar Oideachas Educational Research Centre

Rachel Perkins and Aidan Clerkin

Educational Research
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and Aidan Clerkin

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Contents

Preface v

Acknowledgements vi

Acronyms and Abbreviations vii

Chapter 1: Introduction 1

Chapter 2: TIMSS in Ireland 9

Chapter 3: Mathematics and science: Main results 13

Chapter 4: Distribution of achievement 22

Chapter 5: Performance at International Benchmarks 28

Chapter 6: Performance in content and cognitive domains: Mathematics 41

Chapter 7: Performance in content and cognitive domains: Science 48

Chapter 8: Curriculum coverage in TIMSS 55

Chapter 9: Summary 65

References 73

Appendix A: National Advisory Committees 74

Appendix B: Percentiles of achievement 75

Appendix C: Standard errors for mean scores on content and cognitive subscales 77

Appendix D: Teacher reports of topic coverage 81

Preface

TIMSS (*Trends in International Mathematics and Science Study*) is one of the world's largest studies in education. The study, which is a project of the International Association for the Evaluation of Educational Achievement (IEA), began in 1995 and takes place every four years. It assesses the mathematical and scientific skills of students at Fourth and Eighth grades (Fourth Class and Second Year in Ireland). In 2019, 64 countries and eight benchmarking participants (i.e., subnational entities) took part in TIMSS 2019 at one or both grade levels. Ireland has taken part in four cycles of TIMSS: in 1995, 2015 and 2019 at both primary and post-primary levels and at primary level only in 2011. TIMSS 2019 was the first cycle of the study to offer the assessment on a digital platform. Half of countries that took part in TIMSS 2019 opted to deliver the assessment digitally while the other half, including Ireland, administered the paper-based version of the assessment.

In Ireland, 150 primary and 149 post-primary schools took part in the study in March and April 2019. In total, over 8,500 students took part in TIMSS 2019 in Ireland. As well as completing tests of mathematics and science, students were asked to fill out a questionnaire which asked them about their home background as well as their experience of school and their attitudes towards learning mathematics and science. Teachers were also asked to complete questionnaires about the students' mathematics and science lessons, while the principal of each participating school was asked about the school environment and resources. At Fourth Class, the parents of participating students were asked to complete a questionnaire about the home environment, which included questions about homework, early learning activities and parents' beliefs about their child's schooling.

This report presents the initial findings for Ireland from TIMSS 2019. The main achievement findings for students in Fourth Class and Second Year are described in comparison to their peers in other countries, as well as to the performance of Irish students in previous cycles of the study. To facilitate a clear presentation of findings, international comparisons are limited in some chapters to a small number of countries that are of particular interest. The full international results can be found in *TIMSS 2019 International Results in Mathematics and Science* (Mullis, Martin, Foy, Kelly & Fishbein, 2020).

Chapter 1 provides a general introduction to TIMSS 2019, while Chapter 2 focuses specifically on the implementation of TIMSS 2019 in Ireland. The main mathematics and science results for both grades are presented in Chapter 3, including comparisons between girls and boys, and comparisons over time from 1995 to 2019. Chapter 4 describes the performance of the 'highest-' and 'lowest-achieving' students on the assessment. Chapter 5 presents student achievement with reference to four internationally-defined Benchmarks of achievement, each of which describes the types of mathematical or scientific skills that students reaching that level can typically demonstrate. Chapter 6 presents performance across the content and cognitive domains for mathematics, highlighting relative strengths and weaknesses within countries. Chapter 7 presents similar information for science, based on the scientific content and cognitive subscales. Chapter 8 describes a Test-Curriculum Matching Analysis which compares the curricula in each country against the TIMSS assessment frameworks, and describes how performance across countries may differ if students were only presented with items that were covered on their relevant curricula. Finally, Chapter 9 provides a summary of the main findings.

In 2021, the Educational Research Centre will publish two follow-up reports, one for each grade level, which will examine the results for Ireland in more detail using contextual information provided by students, parents, principals and teachers. More information on TIMSS in Ireland, including access to national reports for previous cycles, is available at www.erc.ie/timss.

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Finally, we especially thank the many students, school principals, school coordinators, teachers, and parents who participated in TIMSS 2019 in Ireland. Without their willingness to participate and their continued support throughout the administration, this study and the findings arising from it would not be possible.

Acronyms and Abbreviations

DEIS	Delivering Equality of Opportunity in Schools
DE	Department of Education
ERC	Educational Research Centre
eTIMSS	electronic Trends in International Mathematics and Science Study
GDPR	General Data Protection Regulation
ICT	Information and Communication Technology
IEA	International Association for the Evaluation of Educational Achievement
ISCED	International Standard Classification of Education
NCCA	National Council for Curriculum and Assessment
PISA	Programme for International Student Assessment
PSI	Problem Solving and Inquiry
SD	Standard Deviation
SE	Standard Error
TCMA	Test-Curriculum Matching Analysis
TIMSS	Trends in International Mathematics and Science Study

Chapter 1: Introduction

***T**rends in **I**nternational **M**athematics and **S**cience **S**tudy* (*TIMSS*) assesses the mathematics and science skills of students in Fourth grade (Fourth Class) and Eighth grade (Second Year). Ireland was one of 64 countries to participate in TIMSS in 2019.

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.

Overview of TIMSS 2019

TIMSS 2019 is the seventh cycle of TIMSS to be completed. The study has been conducted every four years since 1995. It is overseen by the International Association for the Evaluation of Educational Achievement (IEA). The study is coordinated internationally by the International Study Centre at Boston College (USA), with support on sampling from Statistics Canada (Canada) and IEA-Hamburg (Germany), operational support and quality control from IEA-Amsterdam (Netherlands), and data processing and software support from IEA-Hamburg. Each participating country also nominates a national centre and national research coordinator to be responsible for implementing TIMSS locally.

Ireland has participated in the study on four occasions: in 1995, 2011 (at Fourth grade only), 2015, and 2019. TIMSS is one of the studies used by the Department of Education to inform and evaluate the outcomes of the *National Strategy: Literacy and Numeracy for Learning and Life 2011-2020* (Department of Education and Skills, 2011; 2017). In Ireland, the Educational Research Centre implements TIMSS on behalf of the Department of Education.

The primary purpose of TIMSS is to gather high-quality data on students' levels of achievement in two key domains of study – mathematics and science – at both primary (Fourth grade) and post-primary (Eighth grade) levels. Supporting this purpose are several additional aims, which include (a) reliably monitoring trends and changes over time; (b) assessing levels of achievement among both lower- and higher-performing students; (c) gathering contextual information from students, parents, teachers, and school principals in order to better understand the factors associated with learning; and (d) gathering information on national curricula and policies, which provide localised information on the context within which student achievement in each jurisdiction can be interpreted.

Who took part in TIMSS 2019?

As shown in Table 1.1, 64 countries and 8 benchmarking participants (72 participants in total) took part in TIMSS 2019. *Benchmarking participants* are sub-national regions or cities that follow the same sampling and administrative procedures as countries in order to attain robust information at that level. For example, students in Madrid are part of the overall Spanish national sample, but a separate sample of students in Madrid was also drawn to participate separately to produce scores for Madrid as a benchmarking entity. For brevity, this report will generally refer to country-level results unless there is reason to draw attention to benchmarking participants.

Countries could elect to take part in TIMSS at Fourth grade (students approximately aged 10 years old and in the fourth year of formal education[1]), Eighth grade (students aged approximately 14 years old and in the eighth year of formal education), or at both levels. In the 2019 assessment, 33 countries (including Ireland) and five benchmarking participants administered TIMSS at both grade levels. Twenty-five countries and one benchmarking participant took part only at Fourth grade, while six countries and two benchmarking participants took part only at Eighth grade. This means that, in total, 58 countries took part in TIMSS 2019 at Fourth grade and 39 countries took part at Eighth grade.

TIMSS 2019 is the first cycle to offer the TIMSS assessment via computer or tablet. Countries could choose between a paper-based or an electronic version of the assessment, known as eTIMSS. Equal numbers of countries assessed their students in each format (Table 1.1). Thirty-two countries administered the assessment electronically, while 32 countries (including Ireland) administered the assessment on paper. Of the eight benchmarking participants, six administered eTIMSS and two used the paper-based format.

eTIMSS included the same items used in the paper-based TIMSS mathematics and science assessments as well as additional interactive Problem Solving and Inquiry tasks (PSIs). Countries that administered eTIMSS also administered items in paper format in a smaller additional 'bridge' sample in order to assess any differences in item difficulty between the two formats. International reporting on the PSIs is forthcoming in 2021. The current report presents data based on the items common to TIMSS in both paper and online formats, which were placed on the same reporting scale and linked to previous TIMSS assessments for both sets of countries (see Martin, von Davier & Mullis [2020] for more information on the methods and procedures used to link paper TIMSS and eTIMSS assessments).

Internationally, approximately 672,000 students took part in TIMSS 2019 (384,000 in Fourth grade and 288,000 in Eighth grade), as well as their parents, teachers, and principals.

1 'Formal education' counting from the first year of ISCED Level 1 (Mullis & Martin, 2017). In Ireland, this corresponds to First Class.

Table 1.1: Participating countries and benchmarking participants in TIMSS 2019

Fourth grade and Eighth grade		Fourth grade only	Eighth grade only
Australia	**Russian Federation**	Albania	Egypt
Bahrain	Saudi Arabia	Armenia	**Israel**
Chile	**Singapore**	**Austria**	Jordan
Chinese Taipei	South Africa (G5 and G9)	Azerbaijan	Lebanon
Cyprus	**Sweden**	Belgium (Flemish)	**Malaysia**
England	**Turkey (G5)**	Bosnia and Herzegovina	Romania
Finland	**United Arab Emirates (UAE)**	Bulgaria	
France	**United States**	**Canada**	
Georgia		**Croatia**	
Hong Kong SAR		**Czech Republic**	
Hungary		**Denmark**	
Iran, Islamic Rep. of		**Germany**	
Ireland		Kosovo	
Italy		Latvia	
Japan		**Malta**	
Kazakhstan		Montenegro	
Korea, Rep. of		**Netherlands**	
Kuwait		North Macedonia	
Lithuania		Northern Ireland	
Morocco		Pakistan	
New Zealand		Philippines	
Norway (G5 and G9)		Poland	
Oman		Serbia	
Portugal		**Slovak Republic**	
Qatar		**Spain**	
Benchmarking participants			
Ontario (Canada)	**Abu Dhabi (UAE)**	**Madrid (Spain)**	Gauteng (South Africa) (G9)
Quebec (Canada)	**Dubai (UAE)**		Western Cape (South Africa) (G9)
Moscow (Russian Federation)			

Note: Countries in **bold** participated in the eTIMSS assessment.
G5 = Grade 5. G9 = Grade 9.

What does TIMSS assess?

TIMSS examines student performance in the two domains of mathematics and science, following the assessment frameworks described by Mullis and Martin (2017). The final Fourth grade assessment includes 171 mathematics items (questions) and 169 science items. The Eighth grade assessment includes 206 mathematics items and 211 items assessing science.

In both domains, each item is classified in the assessment framework under one *content domain* (i.e., a subdomain of mathematics or science) and one *cognitive domain* (i.e., the type of thinking needed to answer the question correctly). For both science and mathematics, at both levels, there are three cognitive domains – Knowing, Applying, and Reasoning – which are assessed in varying proportions

at each grade level (Table 1.2 and Table 1.3). Items assessing Knowing are relatively more common at Fourth grade, and items assessing Reasoning at Eighth grade.

The proportion of the assessment allocated to covering each content domain differs for Fourth grade and Eighth grade, although the content areas at both grades are related (Table 1.2 and Table 1.3). For example, the assessment framework specifies that 50% of the mathematics assessment at Fourth grade is devoted to items assessing Number, whereas the equivalent percentage at Eighth grade is 30%. Algebra is allocated 30% of the Eighth grade assessment but does not appear as a separate content area at Fourth grade (where some pre-algebra items are included under the Number content domain). Data (and Probability) items comprise 20% of the assessment at both grade levels, with the remainder devoted to (Measurement and) Geometry (30% at Fourth grade and 20% at Eighth grade).

Life Science makes up almost half (45%) of the Fourth grade science assessment. Biology, the corresponding content domain at Eighth grade, makes up about one-third (35%) of that assessment. Earth Science makes up 20% of the assessment at both grades. Earth Science includes topics such as climate, erosion, and the solar system, some of which would generally be covered in geography (rather than science) lessons in Ireland. Finally, Physical Science is allocated 35% of the assessment at Fourth grade. The corresponding areas, Physics and Chemistry, are presented separately at Eighth grade and are allocated 25% and 20%, respectively, of the item coverage.

The distribution of items included in the final TIMSS 2019 assessment was very close to the desired distributions specified in the assessment frameworks (Table 1.2 and Table 1.3). The final pool included new items written and piloted for TIMSS 2019, in addition to trend items carried forward from previous cycles.

Table 1.2: TIMSS 2019 assessment frameworks by target and final achieved percentage devoted to each content and cognitive domain – Fourth grade

	Content	Target %	Final %	Cognitive	Target %	Final %
Mathematics	Number	50	47	Knowing	40	33
	Measurement and Geometry	30	31	Applying	40	43
	Data	20	23	Reasoning	20	24
Science	Life Science	45	46	Knowing	40	43
	Physical Science	35	35	Applying	40	36
	Earth Science	20	19	Reasoning	20	21

Source: Mullis and Martin (2017) and Martin, von Davier and Mullis (2020).

Table 1.3: TIMSS 2019 assessment frameworks by target and final achieved percentage devoted to each content and cognitive domain – Eighth grade

	Content	Target %	Final %	Cognitive	Target %	Final %
Mathematics	Number	30	30	Knowing	35	30
	Algebra	30	29	Applying	40	45
	Geometry	20	21	Reasoning	25	25
	Data and Probability	20	20			
Science	Biology	35	35	Knowing	35	36
	Chemistry	20	20	Applying	35	37
	Physics	25	25	Reasoning	30	26
	Earth Science	20	20			

Source: Mullis and Martin (2017) and Martin, von Davier and Mullis (2020).

Each item was assigned to one of 14 'blocks' per domain per grade level. These blocks were combined into 14 test booklets in a rotated overlapping design. This means that some of the content of Booklet 1 was shared with Booklet 2, some of Booklet 2 was shared with Booklet 3, and so on. This enables direct linkages to be made across all the items covering the assessment framework, even though any individual student received only a subset of the items. All 14 test booklets contained two blocks of mathematics items and two blocks of science items.

Items were presented to students in either *multiple-choice* or *constructed-response* format. Multiple-choice items ask students to select the correct answer from several possibilities. This often required selecting one of four response options, although some items allowed students to select multiple options from several provided. Constructed-response items require students to generate their own response to a question. Depending on the domain (mathematics or science) and the particular item, these responses can range from a single number to a full paragraph, or from a simple line or dot (in the correct location) to a more complex drawing.

For mathematics, at both grade levels, approximately equal numbers of multiple-choice and constructed-response items were included in the final assessment (Martin, von Davier & Mullis, 2020). For science, at both grades, multiple-choice items comprised about 60% of the assessment, with the remainder composed of constructed-response items.

As part of the eTIMSS assessment, students were also presented with a number of PSI (Problem-Solving Inquiry) tasks which included a wider choice of digital features and aimed to improve measurement of higher-order skills in mathematics and science. These tasks are not included in the TIMSS scores presented in this report. The results of the eTIMSS PSIs will be presented in a separate international report to be published in 2021.

Further, some countries with a majority of children still developing fundamental mathematics skills at Fourth grade participated in a 'less difficult' mathematics assessment as part of TIMSS 2019. These countries administered the same Fourth grade science assessment as in other countries, but administered a mathematics assessment that, while equivalent in scope, involved less complex numbers and situations (Martin, von Davier & Mullis, 2020). The regular and less difficult mathematics assessments at Fourth grade were placed on the same scale, allowing comparison of mathematics performance among these countries.

Contextual information

TIMSS collects a variety of contextual information in addition to estimates of achievement in science and mathematics (Table 1.4). The contexts for which data are gathered range from the national- or system-level (Curriculum Questionnaire, TIMSS Encyclopaedia, Test-Curriculum Matching Analysis) to the school level (School Questionnaire) to the class-level (Teacher Questionnaire) and the student-level (Student Questionnaire, Home Questionnaire). At the school, class, and student levels, questionnaire data can be linked directly to students' achievement.

Table 1.4: Summary of data gathered and data sources for TIMSS 2019

Type of data	Source	Instrument
Mathematics achievement	Student	Test (eTIMSS and paper)
Science achievement	Student	Test (eTIMSS and paper)
Problem Solving and Inquiry tasks (PSIs)	Student	Test (eTIMSS only)
Personal characteristics (e.g., attitudes)	Student	Student Questionnaire
Home background (*Fourth Class only*)	Parents	Early Learning Survey (Home Questionnaire)
Classroom environment and teaching practices	Teachers	Teacher Questionnaire
School environment and resources	Principals	School Questionnaire
Overlap between national curriculum and TIMSS assessment	Subject experts	Test-Curriculum Matching Analysis
Structure and policies of the national education system	DE / NCCA / ERC	Curriculum Questionnaire and Encyclopaedia country chapter

The TIMSS Encyclopaedia, which contains a chapter describing the educational system in each country (including Ireland) and a set of exhibits comparing national policies in key areas, can be viewed at https://timssandpirls.bc.edu/timss2019. The Irish national questionnaire data from school principals, teachers, students, and parents will be presented in follow-on reports, currently scheduled for publication by the Educational Research Centre in late 2021.

Although this initial report primarily focuses on the achievement outcomes at Fourth Class and Second Year, the findings of the Test-Curriculum Matching Analysis and a selected set of items from the teacher questionnaire related to curriculum coverage are presented in Chapter 8. This additional information is intended to provide useful curricular context to the results.

How to interpret the analyses in this report

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

- **Scale scores:** Student achievement is reported on a scale that was set to a centrepoint of 500 in 1995 (see below) and a *standard deviation* (SD) of 100. This means that in 1995 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). The scales for both domains were set to the centrepoint of 500 in the same way, but they are constructed independently and should be considered separate. 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 is relative to other students *within* a domain, but not *across* domains.

- **Centrepoint:** Performance in TIMSS is reported with reference to a scale that was set to have a *centrepoint* of 500. This represents the mean (average) international performance from the first TIMSS assessment, in 1995. 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, although it is no longer an international average, countries that take part in multiple cycles can monitor how their national performance changes over time with reference to this constant.

- **Subscales (content and cognitive domains):** As well as the overall mathematics and science results, subscales are calculated for each cognitive and content domain (Number, Earth Science, Reasoning, etc.). These subscales are created independently of the main scales by using only the subset of items that belong to that content or cognitive domain, and are also set to a centrepoint of 500.

- **Scale scores and uncertainty:** The tables in the following chapters report both mean scores (average performance) and *standard errors* (SE; a measure of uncertainty around the mean). TIMSS assesses a sample of students in each country, rather than all students, and each student only attempts a subset of test items. Therefore, estimates of achievement are prone to uncertainty arising from this sampling and measurement error. The reported mean scores that are based on the *sample's* performance should be regarded as estimates of the true *population* score that might be expected if all students had taken the test. A smaller standard error represents a better estimate, while a larger standard error represents more uncertainty (e.g., if there are relatively few students in a particular subgroup).

- **Confidence intervals:** A 95% *confidence interval* can be constructed for any mean score by multiplying the SE by 1.96 and then adding/subtracting the result to/from the mean score. For a quick approximation, the SE can be multiplied by 2. For example, the confidence interval around a mean score of 520 (SE = 3) is roughly 514-526. This means that, if we repeated the survey on many occasions under the same conditions, we would expect the true population score to fall within this range 95% of the time. Smaller SEs indicate a smaller confidence interval and an estimated mean more likely to be close to the true score.

- **Statistical significance:** We describe a difference in performance as *statistically significant* if the difference is large enough and reliable enough that we can be confident that the difference reported is unlikely to have occurred by chance. Statistical significance tests are reported at the 95% confidence level and measurement and sampling error are accounted for in the statistical comparisons. In general, if the confidence intervals around two means do not overlap (e.g., 514-525 vs 527-531), the difference between them is statistically significant. Where reference is made

to a significant difference (i.e., significantly lower or higher) in this report, a test of statistical significance has been conducted. Readers should note that statistical significance refers to the probability of an observed difference occurring by chance if no true difference exists. It does not necessarily imply that a difference is substantive or meaningful in terms of its implications for policy or practice: statistically significant differences can sometimes be very small in practical terms. Informed judgement should therefore be used in interpreting the results of the statistical tests presented here.

- **Median:** The median is a measure of central tendency. It refers to the midpoint in a distribution of values ordered from highest to lowest. Where a TIMSS median value is referred to in this report it means that half of countries had a value above this figure and half of countries had a value below it.

A note on measuring trends

A concurrent calibration methodology is used by the International Study Centre in order to estimate changes in national achievement scores between assessment cycles – for example, between TIMSS 2015 and TIMSS 2019. In simplified terms, concurrent calibration makes use of items common to the previous and current assessments and information on those items (i.e., students' responses) from countries involved in both assessments. This allows more accurate estimates of scale scores and, importantly, minimises error in trend measurement. The calibration is done on a rolling basis across cycles so that, for example, the 1995 assessment is linked directly to the 1999 assessment, 1999 is linked directly to 2003, and so on, up to the current (2019) assessment. In this way, long-term trends can be established between 1995 and 2019 even though all individual items in the 1995 assessment had been replaced by the time of the 2019 assessment.

The scaling of the TIMSS 2019 data involved, firstly, combining paper-based data from TIMSS 2015 and TIMSS 2019 from trend countries that administered the assessment in paper in 2019 and from specially-collected 'Bridge' data from eTIMSS countries. Next, the (digital) eTIMSS data and the (paper-based) Bridge data from the eTIMSS countries were scaled jointly. In this way, the paper-TIMSS and eTIMSS data could be linked and placed on the TIMSS 2015 scale.

Chapter 2: TIMSS in Ireland

In Ireland, Fourth Class and Second Year students took part in the TIMSS main study in March and April 2019. The study was preceded by a field trial in Spring 2018, in which the study materials and procedures were trialled in a smaller number of schools. The implementation of TIMSS in Ireland was assisted by a National Advisory Committee at each grade level (see Appendix A).

Who took part in TIMSS 2019 in Ireland?

The Fourth Class and Second Year samples for TIMSS 2019 were drawn by Statistics Canada and the IEA, in consultation with the Educational Research Centre. The sampling at each grade level took place in two stages. First, 150 primary[2] and 152 post-primary[3] 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 (urban band 1, urban band 2, rural and non-DEIS), language of instruction and gender mix (all girls, all boys and mixed). Post-primary schools were stratified by school sector (secondary, vocational and community/comprehensive), gender mix (all girls, all boys and mixed) and socioeconomic status based on the percentage of students in a school eligible for the Junior Certificate fee waiver (low, medium and high SES). The samples for both grade levels were drawn in such a way as to minimise overlap with schools that participated in the TIMSS field trial in 2018 and also (at post-primary level) schools that had been selected to take part in the PISA autumn testing study.[4]

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 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. Post-primary schools provided the number of Second Year base class groups (i.e., the class groups that students are in for lessons such as P.E. or religion) in their school and depending on the size of the school either one (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 at both Fourth Class and Second Year took part, giving weighted class response rates of 100% at both grade levels.

All students in selected classes were encouraged to participate and special accommodations were made where necessary and if possible. However, a small number of students were excluded from the assessment due to functional or intellectual disabilities or limited English proficiency at both grade levels (Table 2.1).

2 151 primary schools were sampled, but one had closed permanently before the TIMSS administration began. Therefore, the weighted school response rate for Fourth grade in Ireland is 100%.

3 152 post-primary schools were sampled. Three schools were unable to participate and two of these were replaced. Two schools that participated in TIMSS at Second Year were not included in the final dataset due to low response rates (i.e., <50%). Therefore, 149 post-primary schools are included in the final dataset giving a weighted school response rate of 98.2%.

4 The PISA (Programme for International Student Assessment) autumn testing study is a study that took place in Ireland in 2018 to compare an autumn administration of PISA to a spring administration.

Table 2.1: Percentages of students excluded from TIMSS at Fourth Class and Second Year

	Fourth Class (Total sampled=5104)		Second Year (Total sampled=4722)	
	N	%	N	%
Functional disabilities	2	<0.1	3	<0.1
Intellectual disabilities	32	0.6	29	0.6
Limited English proficiency	9	0.4	12	0.3

After exclusions, 5051 Fourth Class pupils and 4678 Second Year[5] students were eligible to participate in the assessments. Of these, parental permission to take part in the study was denied for 233 pupils (4.6%) at Fourth Class and 82 (1.8%) students at Second Year.[6] This marks a large increase from the 11 parental withdrawals at Fourth Class (0.2%) and 41 students (0.8%) at Second Year observed in the previous TIMSS cycle (Clerkin, Perkins & Cunningham, 2016). Parents' comments provided with some of the withdrawal forms, and anecdotal observations from ERC staff and teachers, indicated that some parents were unwilling to share information and that this was a key factor in the increased withdrawal rate. The TIMSS 2019 implementation took place amid much public discussion of data privacy in the context of the introduction of the European Union's General Data Protection Regulation (GDPR) legislation in 2018.

In addition, 237 Fourth Class pupils were absent on the day of testing. At Second Year, 478 students were absent on the test day.

Table 2.2 presents the final (weighted) response rates to the tests and questionnaires, after accounting for student absences and parental withdrawals. In total, 4582 Fourth Class pupils (91% after weighting) completed at least part of one of the test booklets.[7] Almost equal proportions of boys (50.3%) and girls (49.7%) took part.

Table 2.2: Weighted response rates to tests and questionnaires at Fourth Class in Ireland (*Total eligible after exclusions = 5051*)

	N	Weighted %
TIMSS test	4582	91.0
Pupil questionnaire*	4580	99.7
Home questionnaire (Early Learning Survey)*	4325	90.7
Teacher questionnaire*	4541	99.3
School questionnaire*	4582	100.0

*Response rates are presented in terms of the number of pupils who completed a test and whose teachers, principals or parents completed questionnaires.

5 Five Second Year students who were excluded from the TIMSS assessment were also incorrectly classified as no longer being in the school/classroom and therefore not included in the exclusion rates reported in Appendix B.9 in the TIMSS 2019 International Report. Appendix B.9 (Mullis et al., 2020) states that 39 students were excluded at Eighth grade in Ireland and 46 students were no longer in the school/classroom. Instead, 44 students were excluded (as presented in Table 2.1 above) and 41 were no longer in the school/classroom. This error has only a marginal effect on Ireland's exclusion rate and does not affect the cognitive or contextual data for Ireland in TIMSS 2019.

6 At Fourth Class, parental withdrawal forms were also returned for 13 pupils who had already been excluded by their teachers and comments on the parental withdrawal form indicated concern that their child would not be able to participate in the assessment without distress. At Second Year, five parental withdrawal forms were also received for students who had already been assigned an exclusion code by their teacher. These 13 Fourth Class pupils and five Second Year students are included in the figures presented in Table 2.1.

7 Nineteen of these Fourth Class pupils participated with a special accommodation (e.g., a magnified booklet to accommodate visual impairment).

Of the 4582 pupils who participated in the assessment, almost all (99.7%) returned a Pupil Questionnaire. The return rate for the Home Questionnaires was also high, albeit lower than the pupils' return rate, at 90.7%. Again, anecdotal evidence suggests that reluctance to provide personal details was a factor in some parents choosing not to return a questionnaire. The principals of all participating schools (100%) and the teachers of almost all pupils (99.3%) in the assessment at Fourth Class also returned their respective questionnaires.

Table 2.3 presents the weighted response rates for the tests and questionnaires at Second Year. After accounting for absences and parental withdrawals, 4118[8] Second Year students completed the tests, with almost equal proportions of boys (51.2%) and girls (48.8%). This gives a weighted student participation rate of 88%.[9]

Of the students who completed a test 4066 (98.7%) also completed a Student Questionnaire and the principals of 3981 students returned a School Questionnaire (96.8%). Students' mathematics and science teachers were also asked to complete questionnaires about their lessons with the TIMSS students.[10] Of the TIMSS students who studied science, 95.6% had teachers who returned a science teacher questionnaire, while mathematics teacher questionnaires were returned for 93.5% of students.[11]

Table 2.3: Weighted response rates to tests and questionnaires at Second Year in Ireland (*Total eligible after exclusions = 4678*)

	N	Weighted %
TIMSS test	4118	88.0
Student questionnaire*	4066	98.7
Mathematics teacher questionnaire*#	3853	93.5
Science teacher questionnaire*^	3742	95.6
School questionnaire*	3981	96.8

*Response rates are presented in terms of the number of students who completed a test

4117 students had at least one mathematics teacher who received a questionnaire.

^ 3935 students had at least one science teacher who received a questionnaire.

How was testing conducted?

Schools were asked to complete the TIMSS assessment in March and April 2019. The assessment was administered by teachers in participating schools. Students at Fourth grade were allowed 72 minutes to complete the test, while 90 minutes were allocated to testing at Eighth grade. A short break was given in the middle of the tests at both grade levels. After the test, and generally on the same day, students were asked to complete a 30-minute questionnaire that asked about their home background as well as their experience of and attitudes towards school and learning mathematics and science.

TIMSS uses a rotated booklet design which means that each student only received a subset of the entire pool of items. There were 14 test booklets in total and each student completed just one booklet. As described in Chapter 1, items are repeated across booklets so that students' performance across

8 Of the 4118 Second Year students who completed a test, 11 did so with a special accommodation (e.g., in some cases a larger version of the test booklet was provided to a student).

9 The overall weighted response rate at Second Year, taking into consideration the school (98.2%), class (100%) and student (88.0%) response rates, is 86.4%

10 Of the Second Year students who completed at least part of a TIMSS test, 95.6% studied science.

11 Some Second Year students in Ireland did not have a science and/or mathematics teacher. Further, some students had more than one science and/or mathematics teacher. The response rates presented here refer to the weighted percentage of students whose teachers returned a questionnaire.

booklets can be linked. Each booklet was made up of both mathematics and science items, with an equal amount of testing time allowed for each subject.

At primary level, 18 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. Two schools requested the test materials only in Irish, two schools requested the tests only in English, and the remaining 14 schools received both Irish and English versions for teachers to select one version. In total, 6.3% of Fourth Class pupils completed the assessment in Irish.

At post-primary level, six of the sampled schools taught all or some students completely through the medium of Irish and across these six schools, nine classes were selected to participate. Both English and Irish materials were requested for six of the nine class groups and students in these classes had the option to complete the assessment in either language. Ninety-six (2.6%) Second Year students completed the test in Irish.

Quality monitoring

Quality monitoring is carried out in each participating country to ensure that the same testing procedures are applied within and across countries. International quality control monitors, employed by the IEA, visited at least 10% of selected schools on their testing day. In Ireland, 15 schools were visited by international quality monitors at both primary and post-primary levels. A further 15 schools (10%) at each grade level in Ireland were visited by national quality monitors who were members of the Department of Education Inspectorate.

The role of quality monitors, both national and international, 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., communication from 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.

In addition, during testing, students were asked to provide self-generated written responses to some test questions. These responses were scored, using an international scoring guide, by trained coders at the ERC. Approximately 25% of these items were scored independently by two coders to assess the *level of agreement across coders*. Similarly, coders in all countries were required to score a common set of English-language responses (from the TIMSS 2015 assessment) to assess *cross-country scoring reliability*. Finally, the *reliability of scoring across cycles of the study* was also assessed. Countries that had participated in TIMSS 2015, including Ireland, were required to score a number of responses that had been collected in their country in 2015 in order to ensure that student responses were being scored in a consistent manner in both cycles.

Chapter 3: Mathematics and science: Main results

This chapter presents the overall performance on the mathematics and science tests for students in each country and benchmarking entity that took part in TIMSS 2019. The performance of students in Ireland is compared to performance in previous cycles of TIMSS, and differences between boys and girls in terms of their average mathematics and science scores are also presented.

As noted in Chapter 1, student performance is reported on a separate scale for each domain and at each grade level. Each scale was set to have a centrepoint of 500 and a standard deviation of 100 when the first cycle of TIMSS took place in 1995. This centrepoint represents the mean score across all countries that took part at each grade level in 1995 and can be used as a fixed point of reference against which the scale of changes in performance in subsequent cycles can be measured. As the number of countries that take part in TIMSS changes from cycle to cycle, the international averages for each cycle cannot be compared in a meaningful way.

Mathematics and science performance at Fourth Class

Table 3.1 presents the mean mathematics and science scores of Fourth Class pupils in Ireland and the corresponding mean scores for pupils in other countries. Table 3.2 presents the mean scores for Fourth grade students in the six benchmarking participants.

Pupils in Ireland achieved a mean score of 548 in mathematics, which was significantly above the TIMSS scale centrepoint (500). This score was significantly lower than the average scores achieved in seven other countries – Singapore (at 625, the highest-scoring country), Hong Kong, the Republic of Korea, Chinese Taipei, Japan, the Russian Federation, and Northern Ireland. Pupils in four countries (England, Latvia, Norway, and Lithuania) achieved similar – not statistically different – mean scores to pupils in Ireland. Finally, 46 countries (including United States, Finland, Sweden, Germany, Australia, New Zealand and France) achieved significantly lower mean mathematics scores than Ireland. Of the 22 EU countries that participated at Fourth grade, two (Latvia and Lithuania) had similar mathematics performance to Ireland while 19 performed significantly less well than Ireland. No EU country had a higher mean mathematics score than Ireland at Fourth grade.

In science, Fourth Class pupils achieved a mean score of 528, which was significantly above the scale centrepoint (500). This was significantly below the mean scores achieved in 12 countries (Singapore, the Republic of Korea, the Russian Federation, Japan, Chinese Taipei, Finland, Latvia, Norway, the United States, Lithuania, Sweden, and England), and similar to the mean scores achieved in another 12 countries (including Australia, Hong Kong, Poland, Canada and Denmark). In 33 countries (including Northern Ireland, Netherlands, Germany, and New Zealand), performance on the science assessment was significantly lower than in Ireland. Four EU countries (Finland, Latvia, Lithuania and Sweden) had significantly higher mean science scores than Ireland, while the science performance of eight EU countries was similar to Ireland's science performance and nine EU countries performed significantly less well than Ireland.

TIMSS is designed to facilitate reliable comparisons of within-country trends over time. In both domains, the Irish performance in 2019 was very similar to that seen in TIMSS 2015. The mean mathematics score in 2019 (548) is one point higher than in 2015 (547), while the 2019 mean science score (528) is one

point lower than in 2015 (529). Neither of these differences are statistically significant or substantively meaningful. This indicates that, on average, there has been no change in Fourth Class pupils' proficiency in either mathematics or science over the last four years. Mean achievement in both domains remains significantly higher than was found in 2011 (mathematics: 527; science: 516) and 1995 (mathematics: 523; science: 515).

For comparison, of the 45 countries that participated at Fourth grade in TIMSS in both 2015 and 2019, 14 countries showed improvements in mean mathematics performance and eight showed deteriorating mean performance over that period. In science, ten countries recorded significant improvements over the last four years, and ten countries showed significant declines.

Five countries – Singapore, the Republic of Korea, Chinese Taipei, Japan, and the Russian Federation – achieved significantly higher mean scores than Ireland in both domains. Of the two other countries that outperformed Ireland in mathematics, Hong Kong achieved a similar score to Ireland in science, while pupils in Northern Ireland achieved a significantly lower science score.

Table 3.1: Mean country scores and standard errors for the TIMSS 2019 Fourth grade assessments, with significant differences relative to Ireland's mean score

Mathematics			Science		
Country	**Mean**	**(*SE*)**	**Country**	**Mean**	**(*SE*)**
Singapore	625	(3.9)	Singapore	595	(3.4)
Hong Kong SAR	602	(3.3)	Korea, Rep. of	588	(2.1)
Korea, Rep. of	600	(2.2)	Russian Federation	567	(3.0)
Chinese Taipei	599	(1.9)	Japan	562	(1.8)
Japan	593	(1.8)	Chinese Taipei	558	(1.8)
Russian Federation	567	(3.3)	Finland	555	(2.6)
Northern Ireland	566	(2.7)	Latvia	542	(2.4)
England	556	(3.0)	Norway (5)	539	(2.2)
Ireland	**548**	**(2.5)**	United States	539	(2.7)
Latvia	546	(2.6)	Lithuania	538	(2.5)
Norway (5)	543	(2.2)	Sweden	537	(3.3)
Lithuania	542	(2.8)	England	537	(2.7)
Austria	539	(2.0)	Czech Republic	534	(2.6)
Netherlands	538	(2.2)	Australia	533	(2.4)
United States	535	(2.5)	Hong Kong SAR	531	(3.3)
Czech Republic	533	(2.5)	Poland	531	(2.6)
Belgium (Flemish)	532	(1.9)	Hungary	529	(2.7)
Cyprus	532	(2.9)	**Ireland**	**528**	**(3.2)**
Finland	532	(2.3)	Turkey (5)	526	(4.2)
Portugal	525	(2.6)	Croatia	524	(2.2)
Denmark	525	(1.9)	Canada	523	(1.9)
Hungary	523	(2.6)	Denmark	522	(2.4)
Turkey (5)	523	(4.4)	Austria	522	(2.6)
Sweden	521	(2.8)	Bulgaria	521	(4.9)
Germany	521	(2.3)	Slovak Republic	521	(3.7)
Poland	520	(2.7)	Northern Ireland	518	(2.3)
Australia	516	(2.8)	Netherlands	518	(2.9)
Azerbaijan	515	(2.7)	Germany	518	(2.2)
Bulgaria	515	(4.3)	Serbia	517	(3.5)
Italy	515	(2.4)	Cyprus	511	(3.0)
Kazakhstan	512	(2.5)	Spain	511	(2.0)
Canada	512	(1.9)	Italy	510	(3.0)
Slovak Republic	510	(3.5)	Portugal	504	(2.6)
Croatia	509	(2.2)	New Zealand	503	(2.3)
Malta	509	(1.4)	Belgium (Flemish)	501	(2.1)
Serbia	508	(3.2)	Malta	496	(1.3)
Spain	502	(2.1)	Kazakhstan	494	(3.1)
Armenia	498	(2.5)	Bahrain	493	(3.4)
Albania	494	(3.4)	Albania	489	(3.5)
New Zealand	487	(2.6)	France	488	(3.0)
France	485	(3.0)	United Arab Emirates	473	(2.1)
Georgia	482	(3.7)	Chile	469	(2.6)
United Arab Emirates	481	(1.7)	Armenia	466	(3.4)
Bahrain	480	(2.6)	Bosnia and Herzegovina	459	(2.9)
North Macedonia	472	(5.3)	Georgia	454	(3.9)
Montenegro	453	(2.0)	Montenegro	453	(2.5)
Bosnia and Herzegovina	452	(2.4)	Qatar	449	(3.9)
Qatar	449	(3.4)	Iran, Islamic Rep. of	441	(4.1)
Kosovo	444	(3.0)	Oman	435	(4.1)
Iran, Islamic Rep. of	443	(3.9)	Azerbaijan	427	(3.3)
Chile	441	(2.7)	North Macedonia	426	(6.2)
Oman	431	(3.7)	Kosovo	413	(3.7)
Saudi Arabia	398	(3.6)	Saudi Arabia	402	(4.1)
Morocco	383	(4.3)	Kuwait	392	(6.1)
Kuwait	383	(4.7)	Morocco	374	(5.8)
South Africa (5)	374	(3.6)	South Africa (5)	324	(4.9)
Pakistan	328	(12.0)	Pakistan	290	(13.4)
Philippines	297	(6.4)	Philippines	249	(7.5)

Average achievement significantly higher than Ireland

Average achievement significantly lower than Ireland

Note: Norway, Turkey, and South Africa assessed students at Grade 5 rather than Grade 4.

Table 3.2: Mean scores and standard errors of benchmarking participants on the TIMSS 2019 Fourth grade assessments, with significant differences relative to Ireland's mean score

Mathematics			Science		
Region	**Mean**	**(*SE*)**	**Region**	**Mean**	**(*SE*)**
Moscow City, Russian Fed.	593	(2.2)	Moscow City, Russian Fed.	595	(2.2)
Dubai, UAE	544	(1.6)	Dubai, UAE	545	(1.7)
Quebec, Canada	532	(2.3)	Ontario, Canada	524	(3.2)
Madrid, Spain	518	(2.2)	Madrid, Spain	523	(2.0)
Ontario, Canada	512	(3.3)	Quebec, Canada	522	(2.5)
Abu Dhabi, UAE	441	(2.2)	Abu Dhabi, UAE	418	(2.8)
Average achievement significantly higher than Ireland			Average achievement significantly lower than Ireland		

Figure 3.1 shows gender differences in mean mathematics achievement at Fourth Class in TIMSS 2019 and in previous cycles. Although boys (552) achieved a higher average score than girls (545), this difference was not statistically significant.

Internationally, gender differences were small, with girls scoring 499 on average across all TIMSS countries and boys scoring an average of 503. Ireland was one of 27 countries where no statistically significant gender difference was observed in mean mathematics performance. Another 27 countries (including Canada, France, Spain, the United States, Singapore, and Denmark) recorded a significant advantage for boys, ranging in magnitude from five to 19 points. In nine of these countries, significant gender differences have appeared since 2015. There were four countries – Philippines, Saudi Arabia, South Africa, and Oman – where girls achieved a significantly higher mean score than boys, ranging from 14 to 35 points.

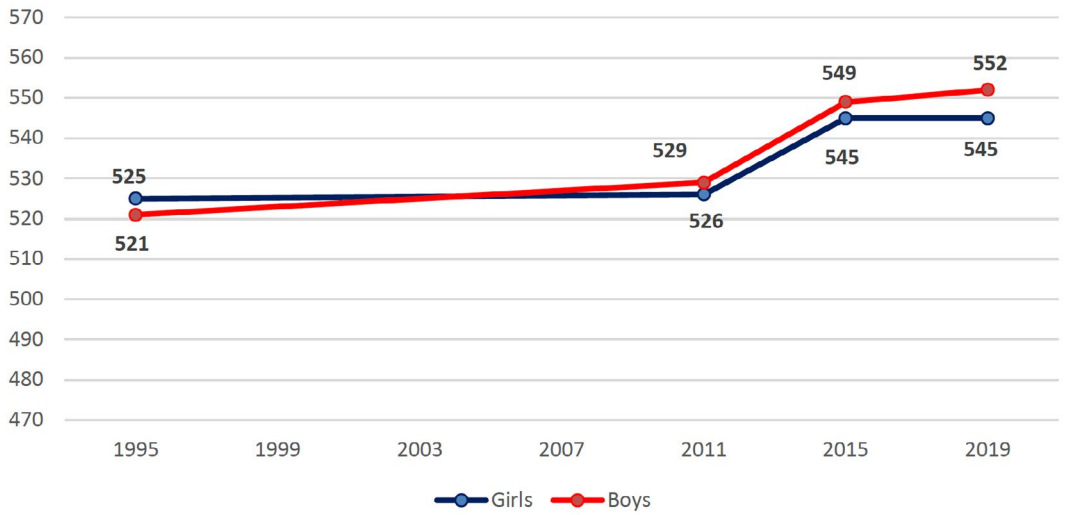

Figure 3.1: Mean scores on the TIMSS 1995, 2011, 2015, and 2019 Fourth Class mathematics assessment, among boys and girls in Ireland

In science (Figure 3.2), the difference between boys (530) and girls (526) in Ireland was not statistically significant. Both boys and girls achieved almost identical mean scores to those recorded in 2015.

Internationally, the average gender difference was small, with girls scoring an average of 493 across all TIMSS countries and boys scoring an average of 489. In 33 countries, a majority, no gender differences in science achievement were found. There were seven countries (including the Republic of Korea, the Czech Republic, Singapore, and the United States) where, on average, boys outperformed girls in

science by a small margin, ranging from five to nine points. On the other hand, in 18 countries (including Saudi Arabia, Pakistan, South Africa, Kosovo, and Japan) girls achieved significantly higher average scores than boys, ranging from six to 60 points.

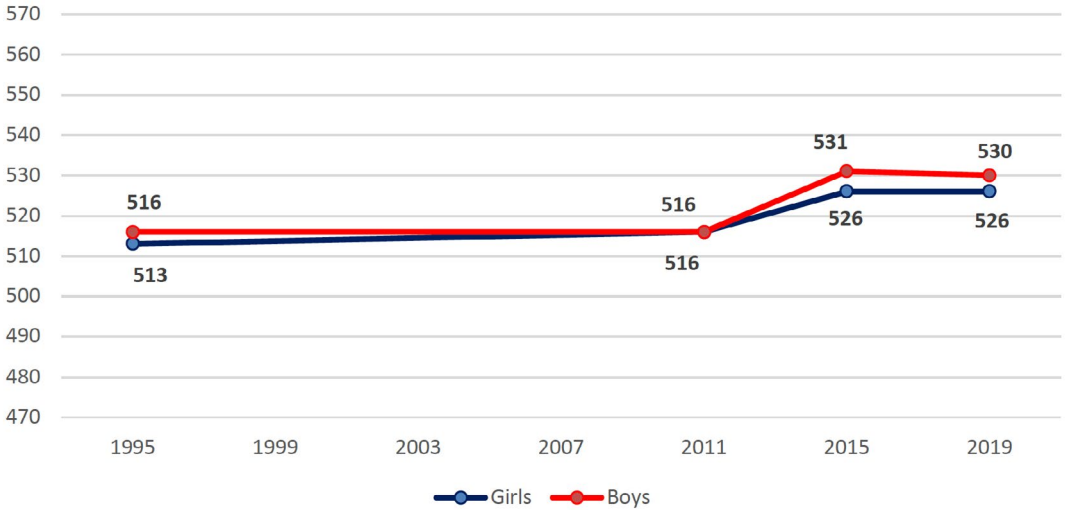

Figure 3.2: Mean scores on the TIMSS 1995, 2011, 2015, and 2019 Fourth Class science assessment, among boys and girls in Ireland

Mathematics and science performance at Second Year

The mean mathematics and science scores of Second Year students in Ireland, as well as those of their peers in other countries, are presented in Table 3.3. The corresponding mean scores for the seven benchmarking participants that took part at Eighth grade are shown in Table 3.4. The highest mean scores in both mathematics (616) and science (608) were achieved by students in Singapore. For both subject areas, the four highest performing countries were Singapore, Chinese Taipei, the Republic of Korea and Japan.

Students in Ireland achieved a mean score of 524 in mathematics, which was significantly above the TIMSS scale centrepoint (500). Six countries (Singapore, Chinese Taipei, the Republic of Korea, Japan, Hong Kong and the Russian Federation) achieved mean mathematics scores that were significantly higher than Ireland's score. The mean scores of a further six countries (Lithuania, Israel, Australia, Hungary, the United States and England) did not differ significantly from Ireland's mean score, while students in Ireland significantly outperformed students in 26 countries (including Finland, Norway, Sweden, France and New Zealand). There has been no significant change in Ireland's mean mathematics performance since 2015 (523) or 1995 (519). Of the ten EU countries that participated at Eighth grade, two (Lithuania and Hungary) had similar mean mathematics scores to Ireland, while seven performed significantly less well than Ireland. No EU country had higher mean mathematics achievement than Ireland at Eighth grade.

The mean science score achieved by students in Ireland was 523, which was significantly above the TIMSS centrepoint (500). Seven countries (Singapore, Chinese Taipei, Japan, the Republic of Korea, the Russian Federation, Finland and Lithuania) had significantly higher mean science scores than Ireland, while eight countries (including Australia, the United States and England) achieved mean science scores which were not significantly different from Ireland's score. Students in Ireland significantly outperformed students in 23 countries, including New Zealand, Norway and France. Although not statistically significant, the mean science score for Ireland has lowered by seven points since 2015. While Ireland saw a significant increase of 12 points in mean science performance between 1995 and 2015, a drop of seven points since 2015, although not statistically significant, means that Ireland's

performance in 2019 does not differ significantly from that in either 2015 or 1995. Two EU countries (Finland and Lithuania) significantly outperformed Ireland in science, while three EU countries (Hungary, Sweden and Portugal) achieved similar mean science scores to Ireland. Four EU countries (Italy, France, Cyprus and Romania) performed significantly less well than Ireland in science.

Of the 33 countries that took part in 2015 and 2019 at Eighth grade, 13 saw significant improvements in their mean mathematics scores since 2015 while mean mathematics performance dropped significantly in four countries. For science, 11 countries experienced a significant increase in their mean science score between 2015 and 2019, while science performance declined significantly in five countries.

Of the six countries that significantly outperformed Ireland in mathematics, five also had significantly higher mean science scores than Ireland. In addition, five of the six countries that had similar mean mathematics scores to Ireland's also performed similarly to Ireland in science. On the other hand, Hong Kong had a significantly higher mean mathematics score but a significantly lower mean science score compared to Ireland, while Finland performed significantly less well than Ireland in mathematics but significantly better in science.

Table 3.3: Mean country scores and standard errors for the TIMSS 2019 Eighth grade assessments, with significant differences relative to Ireland's mean score

Mathematics			Science		
Country	**Mean**	**(*SE*)**	**Country**	**Mean**	**(*SE*)**
Singapore	616	(4.0)	Singapore	608	(3.9)
Chinese Taipei	612	(2.7)	Chinese Taipei	574	(1.9)
Korea, Rep. of	607	(2.8)	Japan	570	(2.1)
Japan	594	(2.7)	Korea, Rep. of	561	(2.1)
Hong Kong SAR	578	(4.1)	Russian Federation	543	(4.2)
Russian Federation	543	(4.5)	Finland	543	(3.1)
Ireland	**524**	**(2.6)**	Lithuania	534	(3.0)
Lithuania	520	(2.9)	Hungary	530	(2.6)
Israel	519	(4.3)	Australia	528	(3.2)
Australia	517	(3.8)	**Ireland**	**523**	**(2.9)**
Hungary	517	(2.9)	United States	522	(4.7)
United States	515	(4.8)	Sweden	521	(3.2)
England	515	(5.3)	Portugal	519	(2.9)
Finland	509	(2.6)	England	517	(4.8)
Norway (G9)	503	(2.4)	Turkey	515	(3.7)
Sweden	503	(2.5)	Israel	513	(4.2)
Cyprus	501	(1.6)	Hong Kong SAR	504	(5.2)
Portugal	500	(3.2)	Italy	500	(2.6)
Italy	497	(2.7)	New Zealand	499	(3.5)
Turkey	496	(4.3)	Norway (G9)	495	(3.1)
Kazakhstan	488	(3.3)	France	489	(2.7)
France	483	(2.5)	Bahrain	486	(1.9)
New Zealand	482	(3.4)	Cyprus	484	(1.9)
Bahrain	481	(1.7)	Kazakhstan	478	(3.1)
Romania	479	(4.3)	Qatar	475	(4.4)
United Arab Emirates	473	(1.9)	United Arab Emirates	473	(2.2)
Georgia	461	(4.3)	Romania	470	(4.2)
Malaysia	461	(3.2)	Chile	462	(2.9)
Iran, Islamic Rep. of	446	(3.7)	Malaysia	460	(3.5)
Qatar	443	(4.0)	Oman	457	(2.9)
Chile	441	(2.8)	Jordan	452	(4.7)
Lebanon	429	(2.9)	Iran, Islamic Rep. of	449	(3.6)
Jordan	420	(4.3)	Georgia	447	(3.9)
Egypt	413	(5.2)	Kuwait	444	(5.7)
Oman	411	(2.8)	Saudi Arabia	431	(2.6)
Kuwait	403	(5.0)	Morocco	394	(2.7)
Saudi Arabia	394	(2.5)	Egypt	389	(5.4)
South Africa (G9)	389	(2.3)	Lebanon	377	(4.6)
Morocco	388	(2.3)	South Africa (G9)	370	(3.1)

Average achievement significantly higher than Ireland

Average achievement significantly lower than Ireland

Table 3.4: Mean scores and standard errors of benchmarking participants on the TIMSS 2019 Eight grade assessments, with significant differences relative to Ireland's mean score

Mathematics			Science		
Region	**Mean**	**(*SE*)**	**Region**	**Mean**	**(*SE*)**
Moscow City, Russian Fed.	575	(*4.2*)	Moscow City, Russian Fed.	567	(*2.9*)
Quebec, Canada	543	(*3.7*)	Dubai, UAE	548	(*2.0*)
Dubai, UAE	537	(*2.0*)	Quebec, Canada	537	(*3.6*)
Ontario, Canada	530	(*4.3*)	Ontario, Canada	522	(*3.0*)
Western Cape, SA (G9)	441	(*4.4*)	Western Cape, SA (G9)	439	(*5.1*)
Abu Dhabi, UAE	436	(*2.9*)	Gauteng, SA (G9)	422	(*3.9*)
Gauteng, SA (G9)	421	(*3.0*)	Abu Dhabi, UAE	420	(*3.6*)
Average achievement significantly higher than Ireland			Average achievement significantly lower than Ireland		

Note: Western Cape and Gauteng assessed students at Grade 9 rather than Grade 8.

The average mathematics performance of girls and boys was very similar in Ireland, with girls scoring, on average, just one point higher than boys (Figure 3.3). The performance of boys in Ireland in mathematics has remained relatively stable since 1995; the mean mathematics score for boys in 2019 was 523 compared to 526 in 2015 and 525 in 1995. On the other hand, the mean mathematics performance of girls increased from 512 to 524 between 1995 and 2019.

On average across all TIMSS countries, girls achieved a slightly higher mean mathematics score (491) than boys (488). In most countries, differences between boys and girls in mean mathematics performance were not significant, including Ireland. On average, girls significantly outperformed boys in mathematics in seven countries (South Africa, Malaysia, Romania, Saudi Arabia, Bahrain, Jordan and Oman) with differences ranging from six to 41 points. On the other hand, the average mathematics score for boys was significantly higher than that of girls in six countries (Morocco, France, Portugal, Israel, Italy and Hungary) with differences ranging from five to 14 points.

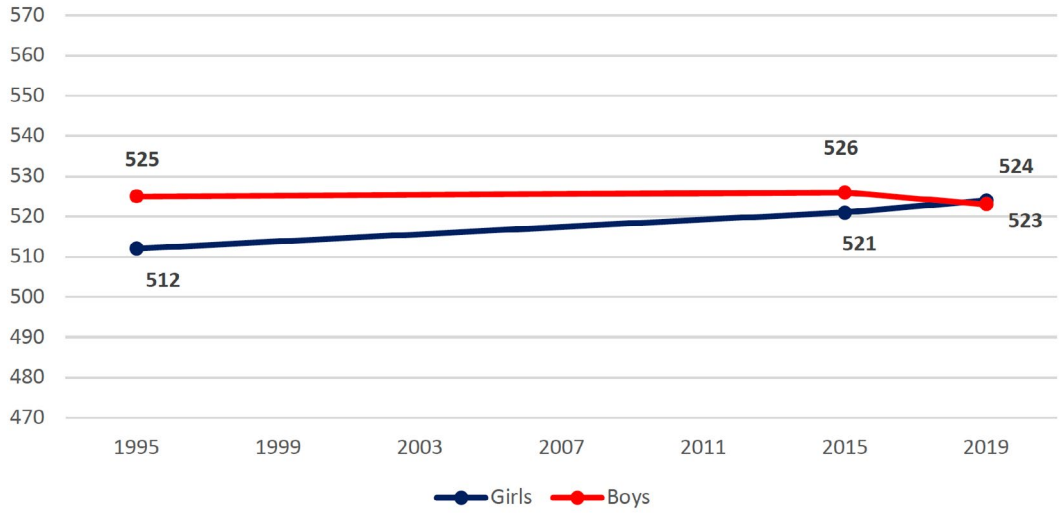

Figure 3.3: Mean scores on the TIMSS 1995, 2015, and 2019 Second Year mathematics assessment, among boys and girls in Ireland

Girls in Ireland scored, on average, five points higher than boys in science, although this difference was not statistically significant (Figure 3.4). The science performance of boys in Ireland remained stable between 1995 and 2015 (527 and 529, respectively) while there was a large increase, from 510 to 531, in the mean science scores for girls between 1995 and 2015. Between 2015 and 2019, the average science score for Ireland dropped by almost five points for girls, to 526, and eight points for boys, to 521.

At the international average, girls achieved a mean science score that was 10 points higher than that of boys (495 and 485, respectively). Differences in mean science performance between boys and girls were not significant in many countries. However, girls achieved significantly higher mean science scores than boys in 15 countries (including Oman, Jordan, Bahrain, Finland and Sweden) while boys significantly outperformed girls in six countries (Hungary, Chile, the Republic of Korea, Japan, Italy and Portugal).

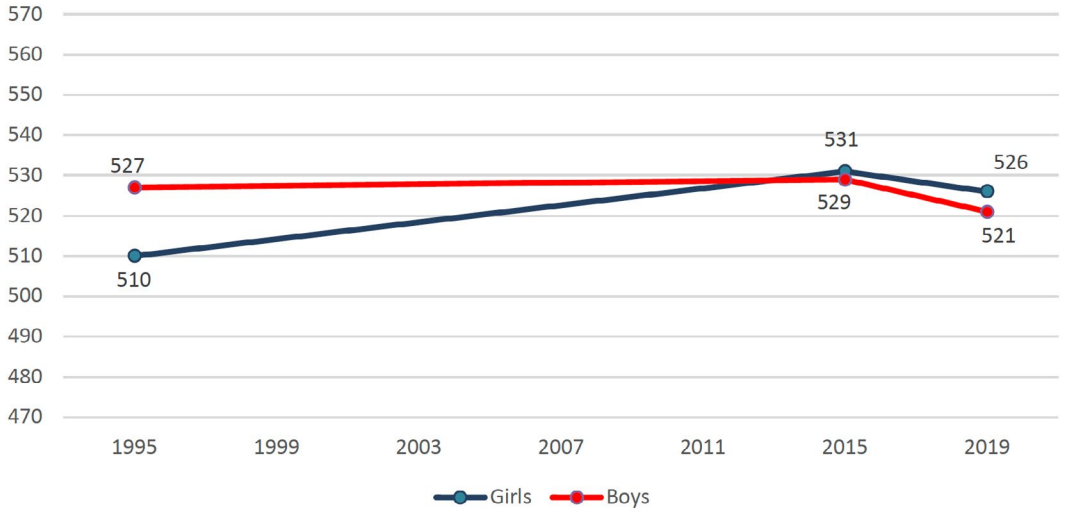

Figure 3.4: Mean scores on the TIMSS 1995, 2015, and 2019 Second Year science assessment, among boys and girls in Ireland

Chapter 4: Distribution of achievement

As well as describing students' overall achievement in mathematics and science, performance in TIMSS can be examined in terms of the distribution of achievement (i.e., the difference in performance between the lowest- and highest-achieving students). This chapter presents the mathematics and science scores for students in Ireland at various percentile points and compares them to the corresponding scores in a subset of countries that were selected on the basis of high performance on TIMSS 2019 or due to their cultural and/or linguistic similarities to Ireland. The selected comparison countries are Australia, Chinese Taipei, England,[12] Finland, Japan, New Zealand,[13] the Republic of Korea, Singapore[14] and the United States[15] for both Fourth grade and Eighth grade, as well as Northern Ireland[16] which participated at Fourth Grade only. Countries are presented in descending order based on their overall mean score in each domain and at each grade level.

The distributions of performance for each domain and grade level are presented graphically (see Figure 4.1). The black band in the centre of each distribution represents the confidence interval around the mean score for a country (i.e., the mean ±2 standard errors) which takes account of sampling and measurement error. The dark grey bands at either end of the distribution represent students in the 'below-average' range of achievement (i.e., between the 5th and 25th percentile) and the 'above-average' range of achievement (i.e., between the 75th and 95th percentile). All other students (i.e., those closer to the mean) are represented by the light grey bands. In this chapter, students scoring at the 5th percentile are referred to as the lowest-achieving/performing students, while those at the 95th percentile are referred to as the highest-achieving/performing. The specific mathematics and science scores of students at various percentile points are presented for Ireland and our selected comparison countries in Appendix B.

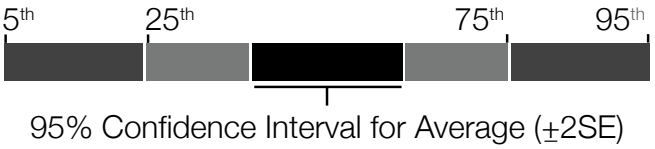

Figure 4.1: Percentiles of performance (adapted from international reports)

The countries presented in the figures in this chapter are categorised according to whether their mean achievement is significantly higher than, similar to, or lower than Ireland's mean achievement scores (see Table 4.1).

12 The national defined population at Fourth grade in England covers 90% to 95% of the national target population.

13 The national defined population at Fourth grade in New Zealand covers 90% to 95% of the national target population. At Eighth grade the guidelines for sample participation were met only after replacement schools were included.

14 The national defined population at Fourth grade in Singapore covers 77% to 90% of the national target population. At Eighth grade, the national defined population covers 90% - 95% of the national target population.

15 The national defined population at Fourth grade in the United States covers 90% - 95% of the national target population. At both grades, the guidelines for sample participation rates were met only after replacement schools were included.

16 Northern Ireland met the guidelines for sample participation rates only after replacement schools were included.

Table 4.1: Achievement levels relative to Ireland's mean performance

Colour		Achievement level
Fourth grade	Eighth grade	
		Average achievement significantly higher than Ireland
		Average achievement does not differ significantly from Ireland
		Average achievement significantly lower than Ireland

Distribution of achievement – Fourth Class, mathematics

Figure 4.2 shows the distribution of pupil achievement in mathematics at Fourth grade for Ireland and selected comparison countries. The general pattern, as might be expected, is that performance at the 95th and 5th percentiles tends to be higher in countries with a higher average score. However, there are nuances within that general pattern.

For example, pupil achievement at the 5th percentile was very slightly lower in Northern Ireland (410) and in England (411) compared to Ireland (414), but the highest-achieving students (95th percentile) in both jurisdictions achieved substantially higher scores (699 and 693, respectively) than the highest-achieving pupils in Ireland (665). Therefore, although the average mathematics score was similar in England and Ireland, the distribution of achievement was narrower in Ireland, particularly at the upper end. The opposite pattern can be seen in the United States, where the performance of the highest-achieving pupils (as indicated by the 95th percentile score, 663) was similar to those in Ireland, but the lowest-achieving pupils in the United States (as indicated by the 5th percentile, 383) achieved a substantially lower score than in Ireland.

The mean score in Ireland (548) was similar to the score among pupils at the 75th percentile in New Zealand (549). At the same time, the mean score in the Republic of Korea (600) and Chinese Taipei (599) was similar to the 75th percentile in Ireland (601).

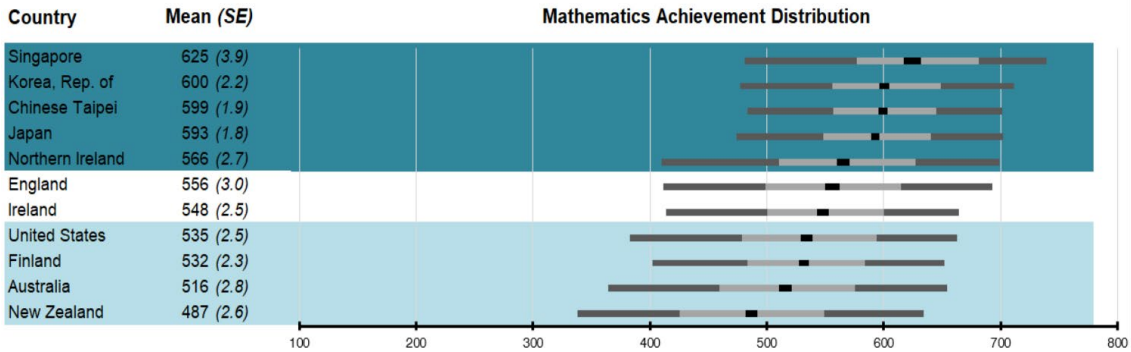

Figure 4.2: Distribution of mathematics achievement, Ireland and comparison countries – Fourth grade

The distribution of mathematics achievement in Fourth Class was very similar in 2019 to that observed in 2015 (Figure 4.3). The mean score and the scores at the 25th and 75th percentile overlap almost completely in both cycles. However, pupils at the 5th percentile achieved a slightly lower, although not significantly different, score in 2019 (414) than in 2015 (420), and pupils at the 95th percentile achieved a slightly higher score (665 compared to 658), although this was also not statistically significant. This means that the distribution has widened to a small degree at both ends since 2015.

Mathematics performance at all points along the distribution was higher in 2019 than in either 2011 or 1995.

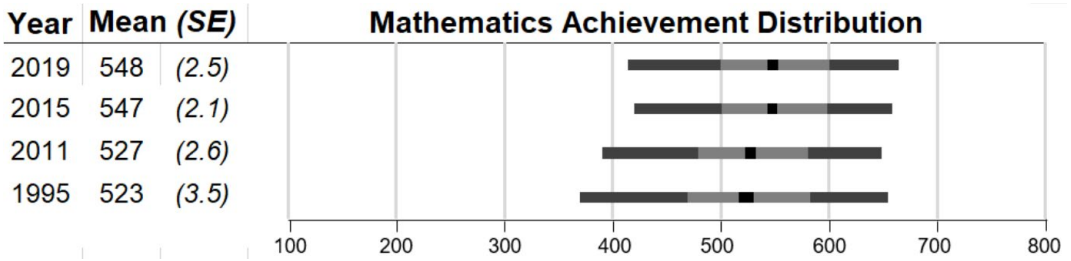

Figure 4.3: Trends in the distribution of mathematics achievement in Ireland – Fourth Class

Distribution of achievement – Fourth Class, science

In science (Figure 4.4), the distribution of achievement among Fourth Class pupils is slightly narrower, at both tails, than among Fourth grade pupils in Australia (whose average achievement was similar). This means that the lowest-performing pupils in Ireland (393) achieved a slightly higher score than their peers in Australia (389), and the highest-achieving pupils in Ireland (643) achieved a lower score than their counterparts in Australia (653).

Pupils in Northern Ireland (392) achieved a similar score to pupils in Ireland at the 5th percentile, but Fourth Class pupils in Ireland achieved higher scores than their peers in Northern Ireland at higher points along the distribution, particularly at the 95th percentile (627 in Northern Ireland). Compared to England (649), the 95th percentile score in Ireland (643) was slightly lower, but the 5th percentile score in England was substantively higher (413) than that in Ireland (393).

The distribution in Singapore was substantially broader at both ends than in the Republic of Korea, although the mean scores in the two countries were not far apart. Pupils at the 75th percentile in Singapore (649) achieved a score that was slightly higher than the highest-achieving pupils (95th percentile) in Ireland (643).

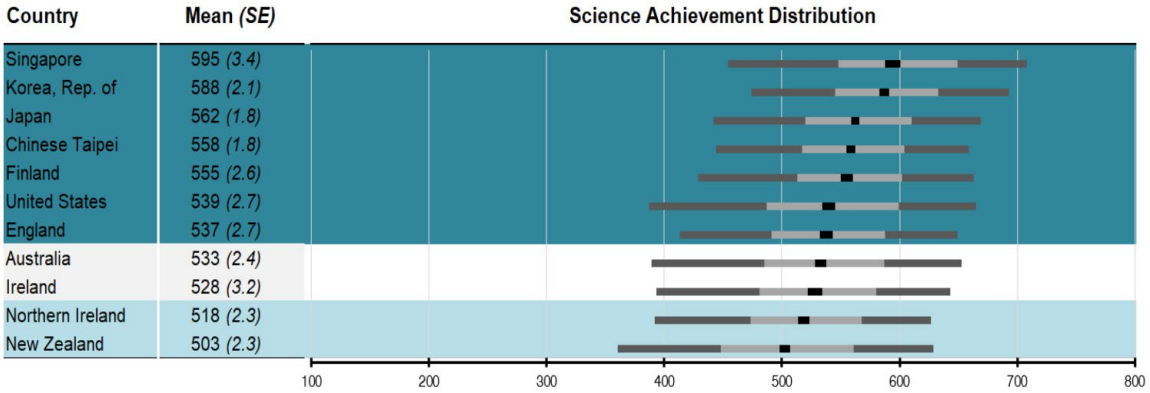

Figure 4.4: Distribution of science achievement, Ireland and comparison countries – Fourth grade

As was the case for mathematics, the distribution of science achievement in TIMSS 2019 at Fourth Class was broadly similar to that seen in 2015, but somewhat wider at both tails (Figure 4.5). The lower scores among pupils at the 5th percentile in 2019 (393), compared to 2015 (405), are more pronounced for science than was the case for mathematics (described above). At the 95th percentile, pupils in 2019 (643) achieved a higher score than their peers in 2015 (635).

Compared to earlier cycles in 2011 and 1995, pupils in 2019 achieved higher scores at all points along the distribution, with the exception of pupils at the 95th percentile in 1995, who achieved a very similar score (644).

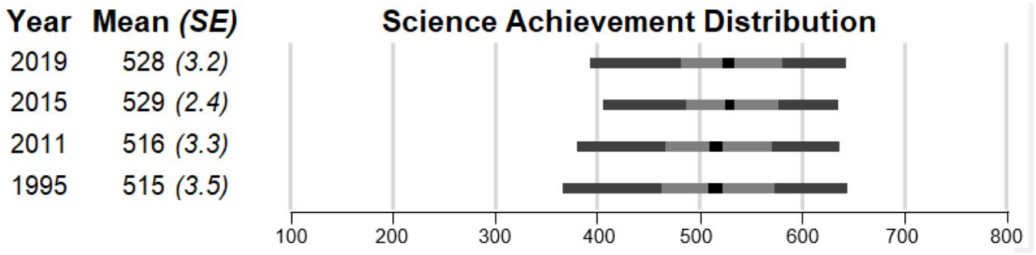

Figure 4.5: Trends in the distribution of science achievement in Ireland – Fourth Class

Distribution of achievement – Second Year, mathematics

The distribution of mathematics achievement among Eighth grade students is narrower in Ireland than in many of our comparison countries (Figure 4.6). The mathematics performance of students in Ireland at the 5th percentile (395) is about 50 points lower than the corresponding score in Singapore (445), the highest performing country. However, at the other end of the distribution (i.e., the 95th percentile), students in Ireland score over 100 points lower than their counterparts in Singapore (636 compared to 740). In fact, the mathematics score of students in Ireland at the 95th percentile is below the scores of students at the 75th percentile in Singapore, Chinese Taipei, the Republic of Korea and Japan.

Despite having a similar mean mathematics score to students in Australia, the United States and England, the performance of students at the 5th percentile in Ireland (395) is considerably higher than in these countries (369, 348 and 363, respectively). Conversely, Ireland's highest-achieving students (636) are performing less well relative to their peers in these countries (666 in Australia, 671 in the United States and 660 in England). Indeed, the mathematics score of students at the 95th percentile in Ireland is closer to the corresponding students in Finland (624) and New Zealand (629), countries with significantly lower mean mathematics performance than Ireland. Ireland's performance at the 75th percentile (574) is very similar to the corresponding score in Australia (578) and England (575), indicating that Ireland's underperformance at the higher end of the mathematics achievement distribution relative to these countries is among the very highest-performing students.

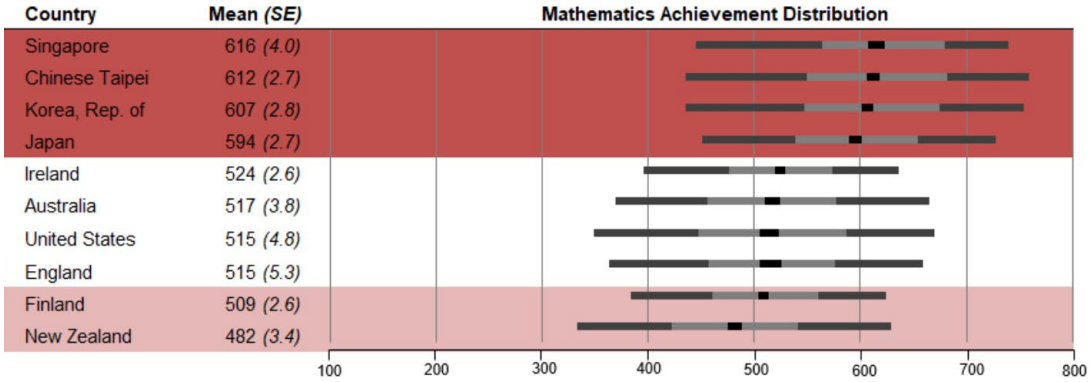

Figure 4.6: Distribution of mathematics achievement, Ireland and comparison countries – Eighth grade

Figure 4.7 presents the distribution of mathematics achievement for Second Year students in 1995, 2015 and 2019. There has been a marked improvement of about 25 points at the 5th percentile since 1995 and most of this improvement (about 21 points) occurred between 1995 and 2015. At the other end of the distribution, the 95th percentile score has remained stable between 2015 and 2019 (634 and 636, respectively), although the 95th percentile score is about seven points lower in 2019 than in 1995 (643).

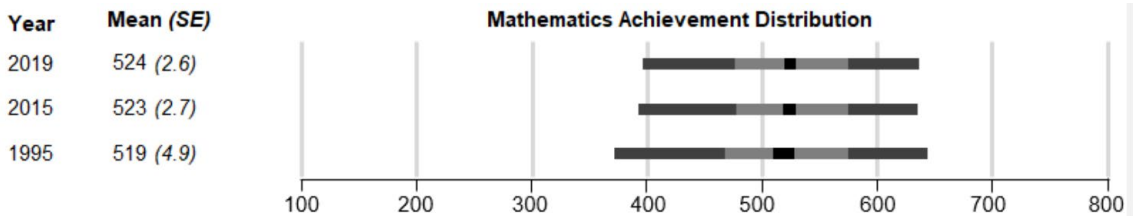

Figure 4.7: Trends in the distribution of mathematics achievement in Ireland – Second Year

Distribution of achievement – Second Year, science

The science performance of the lowest-achieving students in Ireland (as indicated by the score at the 5th percentile, 376) is substantially lower than the corresponding students in Singapore (439), the highest-performing country. The difference is even greater among the highest-achieving students, with those at the 95th percentile in Ireland (649) achieving a score that is 82 points lower than that of their peers in Singapore (731) (Figure 4.8).

When compared to the scores of students in our comparison countries with similar overall science performance, the score of the lowest-achieving students in Ireland (indicated by the 5th percentile score) is either very similar (in the case of Australia, with a corresponding score of 373) or considerably higher (in the cases of the United States and England, whose scores are at least 20 points lower). On the other hand, the score of students at the 95th percentile is somewhat lower in Ireland than in these countries, by 10 points in the case of England, and 21 points in the case of the United States.

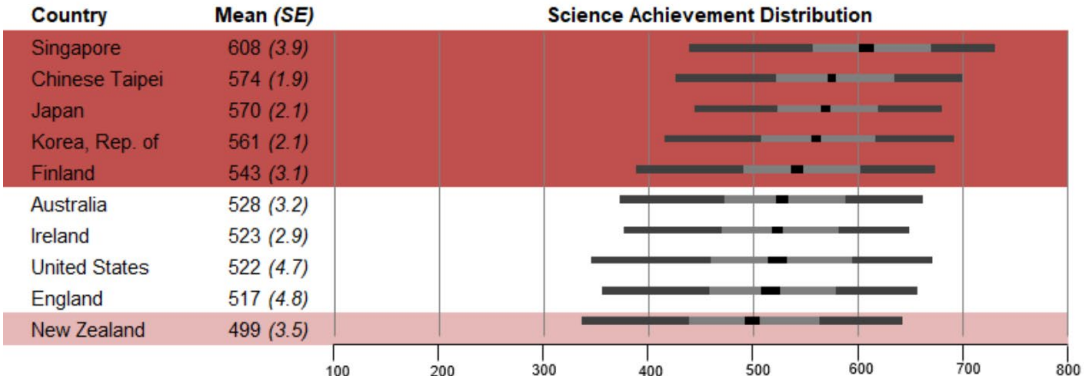

Figure 4.8: Distribution of science achievement, Ireland and comparison countries – Eighth grade

There were large improvements of over 20 points in the science performance of students at the 5th and 25th percentiles in Ireland between 1995 and 2015 (Figure 4.9). However, between 2015 and 2019 the science scores of students at these percentiles decreased by about 12 points, and significantly so at the 25th percentile. At the other end of the science achievement distribution, performance has remained stable between 2015 and 2019. The scores at the 95th percentiles in both these years (650 and 649, respectively) are almost eight points lower than in 1995 (657).

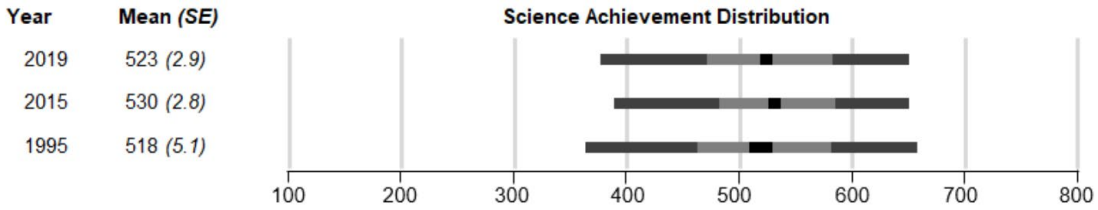

Figure 4.9: Trends in the distribution of science achievement in Ireland – Second Year

Chapter 5: Performance at International Benchmarks

While previous chapters have presented student achievement results in a continuous (scale) format, it can also be useful to describe the types of skills and knowledge that students at different levels of achievement can demonstrate. In this chapter, achievement data are presented with reference to four International Benchmarks. Each TIMSS Benchmark represents a set of skills and knowledge that students who reach that Benchmark can demonstrate consistently.

International Benchmarks

The International Benchmarks are designed to provide an intuitive method of interpreting country-level performance on the mathematics and science assessments. The Benchmarks describe student achievement with reference to the specific skills and knowledge that students at a particular level of performance are typically able to demonstrate.

Each participating student is categorised, based on their performance on the test, as reaching one of four Benchmark levels of achievement. The Benchmarks are defined relative to specified cutpoints (or thresholds) on the continuous achievement scale (see Figure 5.1). For example, a student achieving 460 points on the mathematics test can be said to have reached the Low Benchmark of mathematics performance. Another student scoring 549 points will have reached the Intermediate Benchmark. A student scoring below 400 (i.e., more than one standard deviation below the scale centrepoint of 500) is described as 'not reaching the Low Benchmark.' The skills and knowledge of students below the Low Benchmark cannot be reliably assessed by the items in the TIMSS assessments.[17]

The thresholds that are used to differentiate one Benchmark from the next were determined by international subject experts for mathematics and for science, by drawing on detailed analyses of students' performance and particular items that are used to 'anchor' each benchmark. *Anchoring items* are those 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 – therefore define the types of skills that students at the 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 Benchmark can, by definition, demonstrate the skills expected at the Low and Intermediate Benchmarks as well as the additional skills that are specific to the High Benchmark.

Further technical details on the construction of the International Benchmarks, anchoring items, and the specified cutpoints, is provided in Martin, von Davier and Mullis (2020).

The following sections describe the mathematical and scientific knowledge and skills that are associated with each Benchmark. The percentage of students reaching each Benchmark in Ireland, in our comparison countries, and at the TIMSS median are also presented. The Benchmarks for mathematics and science at Fourth grade are described first, followed by their equivalents at Eighth grade.

17 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.

Figure 5.1: Benchmarks reached by students scoring *at or above* each scale score cutpoint

Benchmark performance – Fourth Class, mathematics

The International Benchmarks for mathematics at Fourth Grade are described in Table 5.1.[18] As shown, pupils reaching the Low Benchmark can consistently demonstrate some basic mathematical skills (e.g., reading simple bar graphs and tables; multiplying and dividing one- and two-digit whole numbers). There is increasing evidence of mathematical proficiency among pupils at the Intermediate Benchmark. At the High Benchmark and, in particular, the Advanced Benchmark, pupils are engaging in more complex operations, such as interpreting data presented in tables or graphs to engage in problem-solving.

Table 5.1: International Benchmarks – Fourth grade mathematics

Benchmark	Scoring at least	Pupils typically can:
Advanced *Pupils can apply their understanding and knowledge in a variety of relatively complex situations, and explain their reasoning.*	625	✓ Solve multi-step word problems involving whole numbers. ✓ Show an understanding of fractions and decimals. ✓ Apply knowledge of two- and three- dimensional shapes in a variety of situations. ✓ Interpret and represent data to solve multi-step problems.
High *Pupils can apply conceptual understanding to solve problems.*	550	✓ Apply conceptual understanding of whole numbers to solve two-step word problems. ✓ Show understanding of the number line, multiples, factors, and rounding numbers. ✓ Show understanding of operations with fractions and decimals. ✓ Solve simple measurement problems. ✓ Demonstrate understanding of geometric properties of shapes and angles. ✓ Interpret and use data in tables and a variety of graphs to solve problems.
Intermediate *Pupils can apply basic mathematical knowledge in simple situations*	475	✓ Compute with three- and four-digit whole numbers in a variety of situations. ✓ Identify and draw shapes with simple properties. ✓ Read, label, and interpret information in graphs and tables.
Low *Pupils have some basic mathematical knowledge.*	400	✓ Add, subtract, multiply, and divide one- and two- digit whole numbers. ✓ Solve simple word problems. ✓ Have some knowledge of unit fractions and common geometric shapes. ✓ Read and complete simple bar graphs and tables.

Adapted from Mullis, Martin, Foy, Kelly, & Fishbein (2020).

18 The percentage of pupils reaching each benchmark is presented here in cumulative format on the basis that each Benchmark represents a cumulative demonstration of increasing knowledge and skill, in accordance with the presentation provided in the international TIMSS report (Mullis, Martin, Foy, Kelly & Fishbein, 2020). Alternatively, each Benchmark can be treated as a discrete category, showing the percentage of pupils within each Benchmark. The percentages of students *within* each Benchmark in Ireland are presented in footnotes accompanying the corresponding cumulative data.

The percentage of Fourth Class pupils who reached each Benchmark was higher in Ireland than was found internationally at the TIMSS median (Table 5.2). The vast majority of pupils in Ireland (97%) reached at least the Low Benchmark, with most (84%) achieving at least an Intermediate level of proficiency. More than half of Fourth Class pupils (52%) were classified as reaching the High Benchmark for mathematics. A smaller proportion – about one in seven pupils (15%) – reached the Advanced mathematical Benchmark.

In several of our comparison countries (Singapore, Republic of Korea, Chinese Taipei, Japan), achievement of the Low and Intermediate Benchmarks was almost universal. More than half of Singaporean pupils reached the Advanced Benchmark, as did at least one-third of pupils in Republic of Korea, Chinese Taipei, and Japan. In Northern Ireland and England, the percentage of pupils reaching the Low, Intermediate, and (in England) High Benchmarks was similar to Ireland's. However, both jurisdictions had higher percentages of pupils reaching the most advanced level (26% in Northern Ireland and 21% in England, compared to 15% in Ireland). Benchmark performance in the United States, Finland, Australia, and New Zealand was lower than in Ireland.

Table 5.2: Percentages (*SE*) of pupils reaching each International Benchmark, Ireland and comparison countries – Fourth grade mathematics[19]

	Mean score	Percent of pupils (cumulative) (*SE*)			
		Low	Intermediate	High	Advanced
Singapore	625	99 (*0.3*)	96 (*0.7*)	84 (*1.5*)	54 (*2.2*)
Korea, Rep. of	600	99 (*0.2*)	95 (*0.5*)	77 (*1.2*)	37 (*1.4*)
Chinese Taipei	599	100 (*0.2*)	96 (*0.5*)	78 (*1.1*)	37 (*1.3*)
Japan	593	99 (*0.2*)	95 (*0.4*)	74 (*0.9*)	33 (*1.3*)
Northern Ireland	566	96 (*0.6*)	85 (*1.1*)	60 (*1.4*)	26 (*1.4*)
England	556	96 (*0.5*)	83 (*1.2*)	53 (*1.5*)	21 (*1.4*)
Ireland	**548**	**97 (*0.5*)**	**84 (*1.0*)**	**52 (*1.4*)**	**15 (*1.0*)**
United States	535	93 (*0.6*)	77 (*1.1*)	46 (*1.3*)	14 (*0.8*)
Finland	532	95 (*0.6*)	78 (*1.2*)	42 (*1.3*)	11 (*0.8*)
Australia	516	90 (*1.0*)	70 (*1.3*)	36 (*1.2*)	10 (*0.9*)
New Zealand	487	83 (*0.9*)	56 (*1.3*)	25 (*1.2*)	6 (*0.5*)
TIMSS (median)	-	92 (-)	71 (-)	34 (-)	7 (-)

Average achievement significantly higher than Ireland

Average achievement significantly lower than Ireland

There were no statistically significant differences between the percentages of pupils reaching the various Benchmarks in Ireland between TIMSS 2015 and TIMSS 2019 (Table 5.3). However, as was the case in 2015, Irish achievement in TIMSS 2019 was significantly higher than in 1995 or 2011 at all levels.

19 The percentages of Fourth Class pupils within each mathematics Benchmark (i.e., discrete categories) in Ireland are: 3.4% (Below Low); 13.0% (Low); 31.9% (Intermediate); 36.4% (High); 15.3% (Advanced).

Table 5.3: Overall mean score, and percentage of Fourth Class pupils reaching the mathematics International Benchmarks in TIMSS 2019 and previous cycles

	Mean	Low (400)	Intermediate (475)	High (550)	Advanced (625)
Ireland: 2019	548	97	84	52	15
Ireland: 2015	547	97	84	51	14
Ireland: 2011	527	**94**	**77**	**41**	**9**
Ireland: 1995	523	**91**	**73**	**40**	**10**

Percentages in **bold** are significantly lower than the equivalent in 2019.

In Ireland, similar percentages of boys and girls reached the Low and Intermediate mathematics Benchmarks (Table 5.4), and a slightly higher percentage of boys reached the High and Advanced Benchmarks. However, the differences in the percentages of boys and girls reaching each Benchmark were not statistically significant.

Table 5.4: Percentages (*SE*) of boys and girls reaching each Benchmark – Fourth Class mathematics

	Mean	Low (400)	Intermediate (475)	High (550)	Advanced (625)
Boys	552	97 (*0.6*)	84 (*1.4*)	53 (*1.8*)	17 (*1.4*)
Girls	545	96 (*0.6*)	83 (*1.3*)	50 (*1.9*)	14 (*1.4*)

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

Benchmark performance – Fourth Class, science

Table 5.5 presents the International Benchmarks for science at the Fourth grade. Pupils reaching the Low Benchmark can demonstrate some limited knowledge of scientific facts, while pupils at the Intermediate Benchmark can show some understanding of the physical characteristics of Earth and knowledge of several aspects of the physical and life sciences. At the High and Advanced Benchmarks, pupils can demonstrate more complex understanding and apply their knowledge, as well as showing increasing ability to communicate their understanding of scientific facts and processes.

Table 5.5: International Benchmarks – Fourth grade science

Benchmark	Scoring at least	Pupils typically can:
Advanced *Pupils communicate understanding of life, physical, and Earth sciences, and demonstrate some knowledge of the process of scientific inquiry.*	625	✓ Demonstrate knowledge of characteristics and life processes of a variety of organisms. ✓ Communicate understanding of relationships in ecosystems and interactions between organisms and their environment. ✓ Communicate understanding of properties and states of matter and physical and chemical changes. ✓ Communicate understanding of Earth's physical characteristics, processes, and history, and show knowledge of earth's revolution and rotation.
High *Pupils communicate and apply knowledge of life, physical, and Earth sciences.*	550	✓ Communicate knowledge of characteristics of plants, animals, and their life cycles. ✓ Apply knowledge of ecosystems and of humans' and organisms' interactions with their environment. ✓ Demonstrate knowledge of states and properties of matter, and of energy transfer in practical contexts, and show some understanding of forces and motion. ✓ Know various facts about the Earth's physical characteristics and show basic understanding of the Earth-Moon-Sun system.
Intermediate *Pupils show knowledge and understanding of some aspects of science.*	475	✓ Demonstrate some basic knowledge of plants and animals. ✓ Demonstrate knowledge about some properties of matter and about some facts related to electricity. ✓ Apply elementary knowledge of forces and motion. ✓ Show some understanding of Earth's physical characteristics.
Low *Pupils show limited knowledge of science facts*	400	✓ Limited knowledge demonstrated consistently.

Adapted from Mullis, Martin, Foy, Kelly, & Fishbein (2020).

In Ireland, most Fourth Class pupils could reach the Low (94%) and Intermediate (77%) Benchmarks (Table 5.6). About two-in-five pupils (41%) reached the High Benchmark for science, and about one-in-ten (9%) were classified at the Advanced Benchmark. Comparison to the TIMSS median indicates that performance on the science Benchmarks in Ireland was higher than was found internationally, although only slightly so at the Low and Advanced Benchmarks. Among our comparison countries, only Northern Ireland (at the Intermediate, High, and Advanced levels) and New Zealand had lower percentages of students reaching each Benchmark. In Singapore and the Republic of Korea, substantial minorities of students (38% and 29%) successfully reached the Advanced Benchmark.

Table 5.6: Percentages (*SE*) of pupils reaching each International Benchmark, Ireland and comparison countries – Fourth grade science[20]

	Mean score	Percent of pupils (cumulative) (*SE*)			
		Low	Intermediate	High	Advanced
Singapore	595	98 (*0.4*)	93 (*0.9*)	74 (*1.7*)	38 (*1.9*)
Korea, Rep. of	588	99 (*0.2*)	95 (*0.6*)	73 (*1.3*)	29 (*1.2*)
Japan	562	98 (*0.4*)	90 (*0.7*)	59 (*1.2*)	17 (*0.8*)
Chinese Taipei	558	99 (*0.3*)	89 (*0.9*)	57 (*1.1*)	15 (*0.9*)
Finland	555	97 (*0.5*)	87 (*1.0*)	56 (*1.4*)	15 (*1.1*)
United States	539	94 (*0.6*)	79 (*1.1*)	48 (*1.3*)	15 (*0.8*)
England	537	94 (*0.6*)	81 (*1.2*)	44 (*1.7*)	10 (*1.1*)
Australia	533	94 (*0.7*)	78 (*1.2*)	44 (*1.5*)	11 (*0.9*)
Ireland	**528**	**94 (*0.8*)**	**77 (*1.7*)**	**41 (*1.6*)**	**9 (*0.6*)**
Northern Ireland	518	94 (*0.7*)	74 (*1.5*)	35 (*1.4*)	5 (*0.7*)
New Zealand	503	88 (*0.8*)	64 (*1.2*)	30 (*1.3*)	6 (*0.5*)
TIMSS (median)	-	92 (-)	71 (-)	32 (-)	6 (-)

Average achievement significantly higher than Ireland

Average achievement significantly lower than Ireland

In Ireland, there were no significant changes in science achievement, as measured by the Benchmarks, between 2015 and 2019 (Table 5.7). A significantly greater percentage of Fourth Class pupils in 2019 reached the Intermediate and High Benchmarks than in either 1995 or 2011. In addition, a significantly higher percentage reached at least the Low Benchmark in 2019 than in 1995. However, there has been no substantive change in the proportion of pupils reaching the most Advanced level in science across any of the cycles of TIMSS in which Ireland has participated since 1995.

Table 5.7: Overall mean score, and percentage of Fourth Class pupils reaching the science International Benchmarks in TIMSS 2019 and previous cycles

	Mean	Low (400)	Intermediate (475)	High (550)	Advanced (625)
Ireland: 2019	528	94	77	41	9
Ireland: 2015	529	96	79	40	7
Ireland: 2011	516	92	**72**	**35**	7
Ireland: 1995	515	**91**	**70**	**36**	8

Percentages in **bold** are significantly lower than the equivalent in 2019.

Similar percentages of boys and girls reached each of the four Benchmarks in Ireland, although slightly more boys reached the High Benchmark (Table 5.8). There were no significant differences in the percentage of boys or girls reaching any of the Benchmarks.

20 The percentages of Fourth Class pupils within each science Benchmark (i.e., discrete categories) in Ireland are: 5.8% (Below Low); 16.8% (Low); 36.5% (Intermediate); 32.3% (High); 8.6% (Advanced).

Table 5.8: Percentages (*SE*) of boys and girls reaching each Benchmark – Fourth Class science

	Mean	Low (400)	Intermediate (475)	High (550)	Advanced (625)
Boys	530	94 (*1.0*)	78 (*1.6*)	42 (*1.7*)	9 (*0.9*)
Girls	526	94 (*0.9*)	77 (*2.3*)	40 (*2.1*)	8 (*0.8*)

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

Benchmark performance – Second Year, mathematics

The mathematics skills and knowledge associated with each of the International Benchmarks at Eighth grade are outlined in Table 5.9. Students achieving at the Low Benchmark can display some knowledge of whole numbers and basic graphs and are able to match tables to bar graphs and pictographs, while those at the Intermediate Benchmark are able to apply basic mathematical knowledge in different situations. At the High Benchmark, students can apply their mathematical knowledge in a range of complex situations, while students reaching the Advanced Benchmark demonstrate a greater understanding of mathematical concepts, such as knowledge of geometric figures and how changing data points can affect the mean, and they can apply and reason in a variety of problem situations.

Table 5.9: International Benchmarks – Eighth grade mathematics

Benchmark	Scoring at least	Pupils typically can:
Advanced *Students can apply and reason in a variety of problem situations, solve linear equations and make generalisations.*	625	✓ Solve a variety of fraction, proportion, and percent problems and can justify their conclusions. ✓ Understand linear functions and algebraic expressions. ✓ Use their knowledge of geometric figures to solve a wide range of problems involving angles, area and surface area. ✓ Calculate means and medians and understand how changing data points can affect the mean. ✓ Interpret a wide variety of data displays to draw and justify conclusions and solve multi-step problems. ✓ Solve problems involving expected values.
High *Students can apply their understanding and knowledge in a variety of relatively complex situations.*	550	✓ Solve problems with fractions, decimals, ratios and proportions. ✓ Show basic procedural knowledge related to algebraic expressions and equations. ✓ Solve a variety of problems with angles including those involving triangles, parallel lines, rectangles, and congruent and similar figures. ✓ Interpret data in a variety of graphs and solve simple problems involving outcomes and probabilities.
Intermediate *Students can apply basic mathematical knowledge in a variety of situations.*	475	✓ Solve problems involving whole numbers, negative numbers, fractions, decimals, and ratios. ✓ Show some basic knowledge about properties of two-dimensional shapes. ✓ Read and interpret data in graphs. ✓ Show some basic knowledge of probability.
Low *Students have some knowledge of whole numbers and basic graphs.*	400	✓ Match tables to bar graphs and pictographs.

Adapted from Mullis, Martin, Foy, Kelly, & Fishbein (2020).

The percentage of students in Ireland and selected comparison countries reaching each of the four mathematics Benchmarks are presented in Table 5.10. In Ireland, 94% of Second Year students reached at least the Low Benchmark, while 76% achieved at least the Intermediate Benchmark, 38% reached at least the High Benchmark and 7% obtained a score at the Advanced Benchmark. The corresponding international median percentages for the Low Benchmark (87%), Intermediate (56%) and High (25%) Benchmarks were well below those achieved in Ireland, while at the Advanced Benchmark, the international median percentage (5%) was just slightly below Ireland's percentage.

The percentage of students reaching the Low Benchmark in Ireland is slightly below the corresponding percentages in the highest-achieving countries (i.e., 98% in Singapore and Chinese Taipei) and slightly above Australia and England (both 90%), countries with similar overall performance to Ireland's. While Finland's mean mathematics score is significantly lower than Ireland's, the percentage of students reaching the Low Benchmark is very similar in the two countries (94% in Ireland and 93% in Finland). On the other hand, about half of students in Singapore and Chinese Taipei achieved the Advanced Benchmark, while the corresponding percentages in Australia and England were slightly above the percentage in Ireland.

Table 5.10: Percentages (*SE*) of students reaching each International Benchmark, Ireland and comparison countries – Eighth grade mathematics[21]

	Mean score	Percent of pupils (cumulative) (*SE*)			
		Low	Intermediate	High	Advanced
Singapore	616	98 (*0.4*)	92 (*1.1*)	79 (*2.0*)	51 (*2.2*)
Chinese Taipei	612	98 (*0.3*)	90 (*0.6*)	75 (*0.9*)	49 (*1.3*)
Korea, Rep. of	607	97 (*0.4*)	90 (*0.8*)	74 (*0.9*)	45 (*1.3*)
Japan	594	99 (*0.2*)	92 (*0.6*)	71 (*1.1*)	37 (*1.4*)
Ireland	**524**	**94 (*0.8*)**	**76 (*1.3*)**	**38 (*1.6*)**	**7 (*0.8*)**
Australia	517	90 (*0.8*)	68 (*1.5*)	36 (*1.8*)	11 (*1.4*)
United States	515	87 (*1.4*)	66 (*1.9*)	38 (*1.9*)	14 (*1.2*)
England	515	90 (*1.6*)	69 (*2.2*)	35 (*2.3*)	11 (*1.5*)
Finland	509	93 (*0.9*)	69 (*1.4*)	29 (*1.2*)	5 (*0.5*)
New Zealand	482	82 (*1.4*)	53 (*1.6*)	22 (*1.1*)	6 (*0.5*)
TIMSS (median)	-	87 (-)	56 (-)	25 (-)	5 (-)

Average achievement significantly higher than Ireland

Average achievement significantly lower than Ireland

Although not statistically significant, there were slight increases in the percentages reaching the Low and Intermediate Benchmarks in Ireland between 1995 and 2015 (from 91% to 94% at the Low Benchmark and from 73% to 76% at the Intermediate Benchmark). However, there were no changes in the percentages reaching these Benchmarks between 2015 and 2019. The percentages reaching the High and Advanced Benchmarks have remained stable since 1995 with no statistically significant changes in the percentages at these Benchmarks across the three cycles (Table 5.11).

Table 5.11: Overall mean score, and percentage of Second Year students reaching the mathematics International Benchmarks in TIMSS 2019 and previous cycles

	Mean	Low (400)	Intermediate (475)	High (550)	Advanced (625)
Ireland: 2019	524	94	76	38	7
Ireland: 2015	523	94	76	38	7
Ireland: 1995	519	91	73	37	8

Percentages in **bold** are significantly different to the equivalent in 2019.

In Ireland, a significantly higher percentage of girls than boys reached the Intermediate Benchmark in mathematics, while there were no significant differences between the percentages of Second Year girls and boys reaching any of the other mathematics Benchmark in 2019 (Table 5.12).

21 The percentages of Second Year students within each mathematics Benchmark (i.e., discrete categories) in Ireland are: 5.6% (Below Low); 18.9% (Low); 37.6% (Intermediate); 30.7% (High); 7.3% (Advanced).

Table 5.12: Percentages (*SE*) of boys and girls reaching at each Benchmark – Second Year mathematics

	Mean	Low (400)	Intermediate (475)	High (550)	Advanced (625)
Boys	523	94 (*1.0*)	**74 (*1.8*)**	39 (*2.0*)	8 (*1.1*)
Girls	524	95 (*0.8*)	77 (*1.4*)	37 (*2.0*)	6 (*0.9*)

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

Benchmark performance – Second Year, science

Science performance is also categorised into four International Benchmarks, each of which describe increasing levels of scientific knowledge and understanding (Table 5.13). Students who achieve at the Low Benchmark have a basic understanding of scientific principles and concepts and a limited knowledge of science facts. Students at the Intermediate Benchmark can demonstrate and apply some knowledge of biology (such as characteristics of animals) and physical science (such as properties of matter and chemical changes) while those at the High Benchmark can understand and apply concepts from biology, chemistry, physics and Earth science. Students reaching the Advanced Benchmark can communicate their understanding of more complex scientific concepts in a variety of contexts, such as recognising the interdependence of populations of organisms in an ecosystem; demonstrating knowledge of the composition of matter and the periodic table of element; recognising evidence that a chemical change has occurred; and communicating understanding of Earth's structure, physical features and processes.

Table 5.13: International Benchmarks – Second Year science

Benchmark	Scoring at least	Pupils typically can:
Advanced *Students communicate understanding of concepts related to biology, chemistry, physics and Earth science in a variety of contexts.*	625	✓ Classify animals into taxonomic groups. ✓ Apply knowledge of cells and their functions. ✓ Show some understanding of diversity, adaptation and natural selection. ✓ Recognise the interdependence of populations of organisms in an ecosystem. ✓ Demonstrate knowledge of the composition of matter and the periodic table of elements. ✓ Use physical properties of matter to sort, classify and compare substances and materials. ✓ Recognise evidence that a chemical change has occurred. ✓ Communicate understanding of particle spacing and motion in different physical states. ✓ Apply knowledge of energy transfer and electrical circuits, relate the properties of light and sound to common phenomena, and demonstrate understanding of forces in everyday contexts. ✓ Communicate understanding of Earth's structure, physical features and processes. ✓ Demonstrate knowledge of the Earth's resources and their conservation.
High *Students apply understanding of concepts from biology, chemistry, physics and Earth science.*	550	✓ Apply knowledge of the characteristics of groups of animals, life processes in humans, cells and their function, genetic inheritance, ecosystems, and nutrition. ✓ Show some knowledge and understanding of the composition and properties of matter and chemical reactions. ✓ Apply basic knowledge of energy transformation and transfer, electrical circuits, properties of magnets, light, sound and forces. ✓ Apply knowledge of Earth's physical features, processes, cycles, and history, and show some understanding of Earth's resources and their use.
Intermediate *Students show and apply some knowledge of biology and physical science.*	475	✓ Demonstrate some knowledge of characteristics of animals. ✓ Apply knowledge of ecosystems. ✓ Show some knowledge of the properties of matter, chemical changes, and a few physics concepts.
Low *Students show limited understanding of scientific principles and concepts and limited knowledge of science facts.*	400	✓ Read a food web. ✓ Identify some materials that are attracted to magnets. ✓ Know that salt must be removed from clean ocean water to make it safe to drink.

Adapted from Mullis, Martin, Foy, Kelly, & Fishbein (2020).

Table 5.14 presents the percentages of students reaching each Benchmark in Ireland and selected comparison countries. The majority of students in Ireland (92%) reached at least the Low Benchmark in science, while 73% reached at least the Intermediate Benchmark, 40% reached at least the High benchmark and 10% achieved the Advanced Benchmark. The percentages reaching each Benchmark

were higher in Ireland than the corresponding international median percentages, although just slightly so at the Advanced Benchmark (7% compared to 10% in Ireland).

The percentage of students reaching the Low Benchmark is somewhat lower in Ireland than in Singapore, the highest achieving country, where 98% of students reached this Benchmark. The gap in performance between Ireland and Singapore widens at the higher Benchmarks, with almost five times as many as students reaching the Advanced Benchmark in Singapore compared to Ireland (48% versus 10%). Of the selected comparison countries with similar overall science performance to Ireland, Australia had a similar percentage reaching the Low Benchmark as Ireland, while the United States and England had slightly fewer students reaching this Benchmark. On the other hand, these three countries had slightly more students reaching the Advanced Benchmark, although only just so in England.

Table 5.14: Percentages (*SE*) of students reaching each International Benchmark, Ireland and comparison countries – Second Year science[22]

	Mean score	Percent of students (cumulative) (*SE*)			
		Low	Intermediate	High	Advanced
Singapore	608	98 (*0.5*)	91 (*1.2*)	77 (*2.0*)	48 (*1.9*)
Chinese Taipei	574	97 (*0.3*)	88 (*0.7*)	64 (*1.0*)	29 (*1.0*)
Japan	570	99 (*0.3*)	90 (*0.6*)	63 (*1.1*)	22 (*1.4*)
Korea, Rep. of	561	96 (*0.4*)	86 (*0.8*)	56 (*1.1*)	22 (*0.9*)
Finland	543	94 (*0.7*)	80 (*1.4*)	50 (*1.5*)	16 (*1.0*)
Australia	528	92 (*0.7*)	74 (*1.2*)	43 (*1.6*)	13 (*1.2*)
Ireland	**523**	**92 (*0.9*)**	**73 (*1.5*)**	**40 (*1.4*)**	**10 (*0.8*)**
United States	522	88 (*1.4*)	70 (*1.8*)	43 (*1.8*)	15 (*1.1*)
England	517	89 (*1.4*)	69 (*2.1*)	38 (*2.1*)	11 (*1.3*)
New Zealand	499	85 (*1.2*)	63 (*1.6*)	30 (*1.4*)	8 (*0.6*)
TIMSS (median)	-	85 (-)	61 (-)	29 (-)	7 (-)

Average achievement significantly higher than Ireland

Average achievement significantly lower than Ireland

In Ireland, the percentages reaching the Low, Intermediate and High Benchmarks increased somewhat between 1995 and 2015 but have decreased between 2015 and 2019, significantly so at the Intermediate Benchmark. On the other hand, the percentage reaching the Advanced Benchmark has remained stable since 1995.

Table 5.15: Overall mean score, and percentage of Second Year students reaching the science International Benchmarks in TIMSS 2019 and previous cycles

	Mean	Low (400)	Intermediate (475)	High (550)	Advanced (625)
Ireland: 2019	523	92	73	40	10
Ireland: 2015	530	94	**77**	43	10
Ireland: 1995	518	90	70	38	11

Percentages in **bold** are significantly higher than the equivalent in 2019.

22 The percentages of Second Year students within each science Benchmark (i.e., discrete categories) in Ireland are: 8.0% (Below Low); 18.7% (Low); 33.7% (Intermediate); 29.8% (High); 9.8% (Advanced).

In Ireland, significantly more girls than boys reached at least the Low Benchmark in science, while there were no significant differences in the percentages of girls and boys reaching the Intermediate, High or Advanced Benchmarks (Table 5.16).

Table 5.16: Percentages (*SE*) of boys and girls reaching each Benchmark – Second Year science

	Mean	Low (400)	Intermediate (475)	High (550)	Advanced (625)
Boys	521	**91 (*1.3*)**	71 (*1.9*)	39 (*1.9*)	10 (*0.9*)
Girls	526	94 (*0.8*)	75 (*1.5*)	40 (*1.9*)	9 (*1.1*)

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

Chapter 6: Performance in content and cognitive domains: Mathematics

The design and content of the TIMSS mathematics assessment is informed by the TIMSS 2019 mathematics framework (Mullis & Martin, 2017), which is broadly similar to the assessment framework used in 2015 but includes minor updates to some topics to better reflect the curricula of participating countries. In addition, with the transition to eTIMSS in 2019, the framework was updated to reflect both paper and digital assessment formats.

The 2019 mathematics framework is organised around a number of domains that assess different areas or subject matter (content domains) and different thinking processes (cognitive domains). Each item in the assessment is classified according to the main content area that underlies the problem and the main cognitive process that is required to solve the problem.

At Fourth grade, three content domains were included in the assessment:

- **Number** (includes whole numbers; expressions, simple equations and relationships; and fractions and decimals);
- **Measurement & Geometry** (includes solving problems involving length, mass, volume, time, perimeters of polygons, area of triangles and partial squares; lines and angles; and two- and three-dimensional shapes); and
- **Data** (includes reading, interpreting and representing data; and using data to solve problems).

At Eighth grade, four content domains were assessed:

- **Number** (includes integers; fractions and decimals; ratio, proportion and percent);
- **Algebra** (includes expressions, operations and equations; and relationships and functions);
- **Geometry** (includes angles and lines, solving problems using the Cartesian plane; calculating perimeter, circumference and area; using the Pythagorean Theorem; recognising geometric transformations, and using the geometric properties of three-dimensional shapes to solve problems); and
- **Data & Probability** (includes reading and interpreting data; calculating, using and interpreting statistics; and theoretical and empirical probability).

As noted in Chapter 1, the relative emphasis placed on each content domain differs across the two grade levels, reflecting the mathematics that is generally taught at each grade.

Three cognitive domains were also assessed at both Fourth grade and Eighth grade and each of the content domains included items that addressed each of the three cognitive domains. The three cognitive domains were:

- **Knowing** (refers to the facts, concepts, and procedures students need to know);
- **Applying** (covers students' ability to apply knowledge and conceptual understanding to solve problems or answer questions); and
- **Reasoning** (involves solving problems in unfamiliar situations, complex contexts, and includes multistep problems).

The following sections describe performance across the different content and cognitive domains in TIMSS 2019 mathematics. Areas of relative strength or weakness are identified for students in Ireland and selected comparison countries.

> Statistical comparisons in this chapter are made *within countries*, not between them. The highlighted strengths and weaknesses are relative to a country's overall performance. This means that a country could have a relative weakness in one area (e.g., Measurement & Geometry in Singapore is relatively weak compared to overall Singaporean mathematics achievement) yet still achieve a higher score in that area than other countries.

Fourth Class – content domains

Table 6.1 displays the relative strengths and weaknesses observed in Ireland and selected comparison countries in the three content domains of the Fourth grade mathematics assessment. Fourth Class pupils displayed a relative strength in Number, with a Number subscale score (555) that was six points (before rounding) higher than the overall scale score (548). Pupils in Ireland were relatively weaker in Measurement & Geometry (-8 points) and Data (-6 points).

Internationally, almost all countries showed a relative difference in at least one area. Only one country – Albania – showed no relative strengths or weaknesses. Among our comparison countries (Table 6.1), a similar profile of strengths and weaknesses to Ireland's was seen in Singapore. Examples of strengths and weakness can be seen for each content domain, with no clear pattern related to overall achievement. For example, both Japan and New Zealand had relative weakness in Number and relative strengths in Data, despite very different levels of overall achievement.

Ireland's performance on each of the content domains has not changed significantly since 2015, but is significantly higher than in 2011 (+ 22 points for Number; +20 points for Measurement and Geometry; +20 points for Data).

Table 6.1: Scale scores (*SE*) on mathematics content domains, Ireland and comparison countries – Fourth grade

	Overall	Number	Measurement & Geometry	Data
Singapore	625	635 (*4.0*)	620 (*3.9*)	613 (*3.8*)
Korea, Rep. of	600	593 (*2.4*)	608 (*2.6*)	602 (*2.5*)
Chinese Taipei	599	599 (*1.7*)	607 (*1.8*)	590 (*2.4*)
Japan	593	586 (*1.8*)	601 (*2.7*)	606 (*2.1*)
Northern Ireland	566	572 (*3.1*)	556 (*3.0*)	564 (*2.5*)
England	556	559 (*3.3*)	545 (*3.3*)	565 (*3.1*)
Ireland	**548**	**555 (*2.7*)**	**540 (*2.7*)**	**543 (*3.0*)**
United States	535	542 (*2.6*)	520 (*2.6*)	533 (*3.0*)
Finland	532	528 (*2.3*)	538 (*3.0*)	534 (*2.8*)
Australia	516	506 (*3.1*)	516 (*3.3*)	534 (*3.4*)
New Zealand	487	478 (*2.9*)	481 (*2.7*)	504 (*3.1*)

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.

There were no significant gender differences in any of the content subscales in Ireland (Table 6.2), meaning that boys and girls in Fourth Class performed at a similar level in each area. A similar pattern was observed in Chinese Taipei, Northern Ireland, and Finland. Boys achieved a higher score than girls in four of our comparison countries on Number, in five countries on Measurement & Geometry, and in one country on Data. In Japan, girls significantly outperformed boys on Data. In the United States boys scored higher than girls on each content domain.

Table 6.2: Mean scores of girls and boys on mathematics content domains, Ireland and comparison countries – Fourth grade

	Number		Measurement & Geometry		Data	
	Girls	Boys	Girls	Boys	Girls	Boys
Singapore	631	639	615	625	611	616
Korea, Rep. of	589	597	605	610	605	600
Chinese Taipei	597	602	606	609	588	592
Japan	585	587	602	601	608	603
Northern Ireland	571	574	551	560	564	564
England	556	562	540	550	561	568
Ireland	**551**	**558**	**538**	**543**	**540**	**545**
United States	537	547	513	526	527	539
Finland	525	530	537	540	534	534
Australia	501	511	509	523	531	537
New Zealand	476	481	476	486	503	504

Shading indicates that the subscale score is significantly higher than for the other gender on that subscale.
Standard errors for the data in this table can be found in Table C1 in Appendix C.

Fourth Class – cognitive domains

In Ireland, Fourth Class pupils showed a relative strength in the Applying cognitive domain (+3 points) and a relative weakness in Reasoning (-7 points) (Table 6.3). This marks a change from TIMSS 2015, when Knowing (but not Applying) emerged as a relative strength (Clerkin et al., 2016), although Ireland's performance on each of the cognitive domains has not changed significantly since 2015. However, scores on each domain were significantly higher in 2019 than in 2011 (+11 points for Knowing; +23 points for Applying; +32 points for Reasoning).

Most of our comparison countries, including all of the highest-scoring countries, had a relative strength in Knowing and a relative weakness in Reasoning. Australia and New Zealand recorded the opposite pattern, with strengths in Reasoning and weakness in Knowing. Ireland was one of two countries in Table 6.3 with a relative strength in Applying (the other being the United States) or no relative difference in Knowing (the other being Finland). Among all TIMSS countries, only three (Hungary, Croatia and Malta) showed no relative differences in any cognitive domain.

Table 6.3: Scale scores (*SE*) on mathematics cognitive domains, Ireland and comparison countries – Fourth grade

	Overall	Knowing	Applying	Reasoning
Singapore	625	640 (*3.9*)	626 (*3.9*)	614 (*4.0*)
Korea, Rep. of	600	612 (*3.6*)	594 (*2.5*)	596 (*2.9*)
Chinese Taipei	599	622 (*1.9*)	600 (*1.5*)	576 (*1.8*)
Japan	593	597 (*2.0*)	593 (*2.0*)	589 (*2.2*)
Northern Ireland	566	574 (*3.3*)	565 (*2.8*)	558 (*2.9*)
England	556	563 (*3.3*)	553 (*3.3*)	554 (*3.4*)
Ireland	**548**	**550 (*3.0*)**	**551 (*2.7*)**	**542 (*2.5*)**
United States	535	536 (*2.6*)	537 (*2.6*)	524 (*2.5*)
Finland	532	531 (*2.4*)	531 (*2.4*)	535 (*2.5*)
Australia	516	509 (*3.3*)	516 (*2.9*)	522 (*3.0*)
New Zealand	487	476 (*2.7*)	487 (*2.4*)	501 (*2.7*)

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.

There were no gender differences in the cognitive domains in Ireland (Table 6.4). This was also the case in Japan, Northern Ireland, and Finland. Boys showed a relative advantage compared to girls in Knowing in five of the comparison countries; in one country for the Applying domain, and in five countries on the Reasoning domain. Boys had significantly higher mean scores in each cognitive domain in the United States.

Table 6.4: Mean scores of girls and boys on mathematics cognitive domains, Ireland and comparison countries – Fourth grade

	Knowing		Applying		Reasoning	
	Girls	Boys	Girls	Boys	Girls	Boys
Singapore	634	646	623	628	609	619
Korea, Rep. of	608	616	594	595	591	601
Chinese Taipei	619	624	599	601	570	581
Japan	597	598	594	591	588	590
Northern Ireland	570	579	565	564	556	561
England	555	570	552	555	550	558
Ireland	**546**	**554**	**548**	**554**	**538**	**546**
United States	528	544	534	541	516	531
Finland	528	534	532	530	533	538
Australia	499	519	513	519	517	528
New Zealand	469	482	487	488	499	503

Shading indicates that the subscale score is significantly higher than for the other gender on that subscale.
Standard errors for the data in this table can be found in Table C2 in Appendix C.

Second Year – content domains

Relative strengths among the mathematical content areas within Ireland and selected comparison countries are presented in Table 6.5. When compared to their overall mathematics performance, Second Year students in Ireland showed relative strengths in the Number (+17 points) and Data & Probability (+17 points) content areas, and relative weaknesses on the Algebra (-18 points) and Geometry (-18 points) content areas. Similar patterns were also observed in Australia and England, countries whose overall mathematics performance does not differ significantly from Ireland's. Singapore, the highest-achieving country, showed relative strengths in three of the four content domains (Algebra, Geometry and Data & Probability) and a relative weakness on Number. Each of the four highest-performing countries showed relative strengths in Algebra and Geometry.

The average performance of Second Year students in Ireland on each of the mathematics content domains has not changed significantly between 2015 and 2019.

Table 6.5: Scale scores (*SE*) on mathematics content domains, Ireland and comparison countries – Eighth grade

	Overall	Number	Algebra	Geometry	Data & Probability
Singapore	616	611 (*4.1*)	619 (*4.6*)	619 (*3.9*)	620 (*4.9*)
Chinese Taipei	612	613 (*2.7*)	618 (*2.6*)	623 (*2.7*)	593 (*2.5*)
Korea, Rep. of	607	605 (*2.6*)	609 (*3.5*)	617 (*2.9*)	598 (*2.6*)
Japan	594	578 (*3.5*)	602 (*3.2*)	610 (*3.4*)	594 (*2.5*)
Ireland	**524**	**541 (*3.0*)**	**505 (*2.8*)**	**506 (*2.8*)**	**541 (*3.4*)**
Australia	517	522 (*3.9*)	501 (*4.1*)	513 (*4.0*)	533 (*3.9*)
United States	515	520 (*4.5*)	520 (*5.4*)	499 (*4.8*)	509 (*5.4*)
England	515	519 (*5.4*)	504 (*5.8*)	509 (*5.3*)	523 (*6.2*)
Finland	509	515 (*2.6*)	489 (*2.9*)	511 (*3.2*)	514 (*3.6*)
New Zealand	482	483 (*3.6*)	464 (*3.5*)	477 (*3.4*)	496 (*3.7*)

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.

In Ireland, girls significantly outperformed boys on the Algebra content domain, while no significant differences between boys and girls were observed on the other content domains (Table 6.6). Among our comparison countries, there were no significant differences between boys and girls on the Data & Probability content domain and few significant differences between boys and girls across the other content domains. Girls significantly outperformed boys on the Algebra content domain in Chinese Taipei, the United States and Finland, while boys significantly outperformed girls on the Number content domain in Japan, Australia and New Zealand. Of our comparison countries, Finland was the only country with a significant difference between boys and girls on Geometry, with girls significantly outperforming boys.

Table 6.6: Mean scores of girls and boys on mathematics content domains, Ireland and comparison countries – Eighth grade

	Number		Algebra		Geometry		Data & Probability	
	Girls	Boys	Girls	Boys	Girls	Boys	Girls	Boys
Singapore	611	611	623	615	620	618	623	618
Chinese Taipei	612	614	623	613	623	623	593	594
Korea, Rep. of	602	608	611	608	613	621	594	601
Japan	573	583	605	600	609	611	592	597
Ireland	**538**	**544**	**510**	**501**	**504**	**508**	**541**	**540**
Australia	515	528	502	501	510	517	532	534
United States	518	522	528	512	500	499	510	509
England	513	526	507	500	510	507	523	523
Finland	512	517	495	483	517	504	517	511
New Zealand	477	489	464	464	474	479	492	499

Shading indicates that the subscale score is significantly higher than for the other gender on that subscale.
Standard errors for the data in this table can be found in Table C3 in Appendix C.

Second Year – cognitive domains

In Ireland, Second Year students demonstrated relative strengths in the Knowing (+7 points) and Applying (+3 points) cognitive domains and a relative weakness on the higher-order Reasoning (-16 points) cognitive domain, when compared to their overall mathematics performance (Table 6.7). Other countries that showed a relative strength in the Knowing cognitive domain include Chinese Taipei, the Republic of Korea and the United States, while Australia, England and New Zealand displayed relative strengths in the Applying cognitive domain. Singapore, Japan and New Zealand had relative strengths in the Reasoning cognitive domain, while Australia and the United States, countries with similar overall performance to Ireland, displayed relative weaknesses in this domain.

The average score of students in Ireland on the Reasoning mathematics cognitive domain is significantly lower (by 13 points) in 2019 compared to 2015, while the average scores on the Knowing and Applying domains have not changed significantly.

Table 6.7: Scale scores (*SE*) on mathematics cognitive domains, Ireland and comparison countries – Eighth grade

	Overall	Knowing	Applying	Reasoning
Singapore	616	614 (*4.3*)	614 (*3.8*)	620 (*4.5*)
Chinese Taipei	612	616 (*3.0*)	610 (*2.6*)	616 (*2.7*)
Korea, Rep. of	607	614 (*3.2*)	604 (*2.7*)	609 (*3.0*)
Japan	594	589 (*3.1*)	596 (*2.8*)	599 (*3.2*)
Ireland	**524**	**530 (*2.8*)**	**526 (*2.7*)**	**508 (*3.4*)**
Australia	517	511 (*4.0*)	521 (*3.8*)	515 (*3.9*)
United States	515	522 (*5.2*)	515 (*4.9*)	507 (*4.6*)
England	515	510 (*5.5*)	518 (*5.3*)	512 (*5.7*)
Finland	509	505 (*2.5*)	510 (*2.7*)	506 (*2.9*)
New Zealand	482	468 (*3.5*)	486 (*3.1*)	486 (*3.4*)

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.

There were no significant differences between boys and girls across the cognitive domains among Second Year students in Ireland, or among students in any of our comparison countries (Table 6.8).

Table 6.8: Mean scores of girls and boys on mathematics cognitive domains, Ireland and comparison countries – Eighth grade

	Knowing		Applying		Reasoning	
	Girls	Boys	Girls	Boys	Girls	Boys
Singapore	618	611	616	613	622	619
Chinese Taipei	619	613	611	609	616	616
Korea, Rep. of	612	616	602	606	606	612
Japan	589	589	594	598	598	600
Ireland	**533**	**528**	**527**	**526**	**507**	**509**
Australia	509	513	519	524	512	517
United States	525	519	517	513	508	507
England	507	514	519	517	512	512
Finland	506	504	513	508	509	504
New Zealand	462	473	483	489	483	489

Shading indicates that the subscale score is significantly higher than for the other gender on that subscale.
Standard errors for the data in this table can be found in Table C4 in Appendix C.

Chapter 7: Performance in content and cognitive domains: Science

This chapter presents the performance of students according to the particular science content areas and cognitive processes (i.e., thinking processes) outlined in the TIMSS 2019 science framework (Mullis & Martin, 2017). As is the case for mathematics, the science framework is broadly similar to the assessment framework used in 2015 but has been updated slightly to better reflect the science curricula of participating countries and to take account of both paper and digital assessment formats, with the transition to eTIMSS.

Each item in the science assessment is classified according to the main subject area (i.e., content domain) covered as well as the main cognitive process that is required to answer the question. Three content domains were included in the assessment at Fourth grade:

- **Life Science** (includes the characteristics and life processes of organisms; life cycles, reproduction and heredity; organisms, environment and their interactions; ecosystems; human health);
- **Physical Science** (includes the classification and properties of matter and changes in matter; forms of energy and energy transfer; forces and motion); and
- **Earth Science** (includes Earth's physical characteristics, resources and history; Earth's weather and climates; and Earth in the solar system). The Earth Science domain includes many topics that are covered in the geography curriculum in Ireland.

At Eighth grade, four content areas were assessed. These were:

- **Biology** (includes the characteristics and life processes of organisms; cells and their functions; life cycles, reproduction, and heredity; diversity, adaptation, and natural selection; ecosystems; and human health);
- **Physics** (includes topics such as physical states and changes in matter; energy transformation and transfer; light and sound; electricity and magnetism; motion and forces);
- **Chemistry** (includes the composition of matter; properties of matter; and chemical change); and
- **Earth Science** (Earth's structure and physical features; Earth's processes, cycles, and history; Earth's resources, their use, and conservation; Earth in the solar system and the universe). As at Fourth grade, some topics assessed as part of the Earth Science domain in TIMSS are considered to be part of the geography curriculum in Ireland.

As can be seen from Tables 1.2 and 1.3 in Chapter 1, the coverage of each content domain differs across the two grade levels, reflecting the nature and difficulty of the science taught at each grade. Three cognitive domains were assessed at both Fourth and Eighth grades:

- **Knowing** (covers the facts, relationships, processes, concepts and equipment that students need to know);
- **Applying** (refers to students' ability to apply their knowledge of facts, relationships, processes, concepts, equipment, and methods in familiar contexts); and
- **Reasoning** (involves students analysing data and other information, drawing conclusions, and extend their understanding to unfamiliar situations).

The performance of students across the different science content and cognitive areas is described in the remainder of this chapter. Areas of relative strength and weakness within Ireland and our comparison countries are identified.

> As with Chapter 6, statistical comparisons in this chapter are made *within countries*, not between them. The highlighted strengths and weaknesses are relative to a country's overall performance. This means that a country could have a relative weakness in one area (e.g., Earth Science in Singapore is relatively weak compared to overall Singaporean science achievement) yet still achieve a higher score in that area than other countries.

Fourth Class – content domains

Fourth Class pupils displayed a relative strength in Earth Science (+8 points) – the content area that includes aspects of what is taught as geography in Ireland – and a relative weakness in Physical Science (-5 points). Performance in Life Science was in line with Ireland's overall science score (Table 7.1). A similar pattern was also seen in Northern Ireland.

Across all TIMSS countries, only one (Austria) had no relative differences between science content domains. There was substantial variation among our comparison countries, although Physical Science is seen to be a relative strength in the four high-achieving East Asian countries.

The performance of Fourth Class pupils in Ireland on each of the content domains has not changed significantly between 2015 and 2019. However, Ireland's mean scores on the Life Science and Earth Science domains in 2019 are significantly higher than in 2011 (by 15 and 16 points, respectively).

Table 7.1: Scale scores (*SE*) on science content domains, Ireland and comparison countries – Fourth grade

	Overall	Life Science	Physical Science	Earth Science
Singapore	595	603 (*3.6*)	613 (*3.7*)	557 (*3.9*)
Korea, Rep. of	588	574 (*2.5*)	607 (*2.7*)	587 (*2.9*)
Japan	562	550 (*2.0*)	579 (*1.9*)	559 (*1.9*)
Chinese Taipei	558	540 (*2.0*)	573 (*1.9*)	568 (*1.8*)
Finland	555	558 (*2.9*)	544 (*3.2*)	563 (*3.5*)
United States	539	546 (*2.5*)	527 (*2.8*)	539 (*3.2*)
England	537	537 (*2.6*)	537 (*3.2*)	533 (*2.9*)
Australia	533	539 (*2.8*)	526 (*2.7*)	527 (*2.8*)
Ireland	**528**	**528 (*3.5*)**	**523 (*3.2*)**	**536 (*3.8*)**
Northern Ireland	518	520 (*2.8*)	511 (*2.2*)	525 (*2.6*)
New Zealand	503	510 (*2.3*)	492 (*2.1*)	503 (*3.1*)

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.

There were no significant gender differences in Ireland on either Life Science or Physical Science (Table 7.2). However, boys significantly outperformed girls on items assessing Earth Science. This pattern was also seen in the United States. In Singapore and the Republic of Korea, boys outperformed girls on Earth Science and Physical Science. In Life Science, girls achieved a higher score than boys in four countries (Japan, Finland, Australia, and New Zealand).

Table 7.2: Mean scores of girls and boys on science content domains, Ireland and comparison countries – Fourth grade

	Life Science		Physical Science		Earth Science	
	Girls	Boys	Girls	Boys	Girls	Boys
Singapore	601	605	607	619	548	565
Korea, Rep. of	572	576	600	613	579	594
Japan	554	547	580	577	558	560
Chinese Taipei	542	539	570	576	565	571
Finland	565	552	544	544	564	562
United States	547	546	523	531	533	543
England	540	535	534	540	532	534
Australia	543	535	524	528	524	530
Ireland	**530**	**526**	**520**	**526**	**529**	**543**
Northern Ireland	523	517	510	512	521	548
New Zealand	516	504	493	492	501	505

Shading indicates that the subscale score is significantly higher than for the other gender on that subscale.
Standard errors for the data in this table can be found in Table C5 in Appendix C.

Fourth Class – cognitive domains

On the cognitive domains for science, Fourth Class pupils displayed a relative strength in Knowing (+4 points) (Table 7.3). Pupils were able to Apply knowledge and Reason at a level on par with the overall national science score. This is a slight change from TIMSS 2015, when no relative strengths or weaknesses were observed in Ireland.

Internationally, five countries (Croatia, Germany, Malta, Portugal, and Montenegro) showed no relative strengths or weaknesses. Among our comparison countries, Knowing was a relative strength for four and a relative weakness for two. Reasoning was an area of relative strength in five countries and an area of relative weakness in two. In contrast, Applying was a relative weakness for six countries, including Northern Ireland, and a strength for three.

Ireland's performance on each of the science cognitive domains has not changed significantly since 2015, but is significantly higher on Knowing (+14 points) and Reasoning (+16 points) in 2019 compared to 2011.

Table 7.3: Scale scores (*SE*) on science cognitive domains, Ireland and comparison countries – Fourth grade

	Overall	Knowing	Applying	Reasoning
Singapore	595	588 (*3.7*)	595 (*3.7*)	604 (*3.5*)
Korea, Rep. of	588	584 (*2.5*)	596 (*2.6*)	581 (*2.4*)
Japan	562	535 (*2.6*)	576 (*2.2*)	580 (*2.4*)
Chinese Taipei	558	560 (*1.9*)	561 (*2.0*)	552 (*2.7*)
Finland	555	553 (*2.5*)	551 (*2.5*)	563 (*2.4*)
United States	539	542 (*2.7*)	535 (*3.1*)	538 (*2.7*)
England	537	544 (*3.3*)	526 (*3.0*)	544 (*3.7*)
Australia	533	538 (*3.0*)	524 (*3.2*)	538 (*3.0*)
Ireland	**528**	**532 (*3.4*)**	**525 (*3.0*)**	**525 (*3.8*)**
Northern Ireland	518	523 (*2.9*)	514 (*2.3*)	519 (*3.2*)
New Zealand	503	505 (*2.7*)	497 (*2.6*)	505 (*2.6*)

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.

No gender differences were found in Ireland on any of the science cognitive domains (Table 7.4). Boys and girls in Fourth Class performed at a similar level regardless of the cognitive process being tested.

Ireland was the only one of the countries selected in Table 7.4 where no gender differences were found; in most countries, one domain showed a difference. Boys outperformed girls in Knowing in four countries (Singapore, the Republic of Korea, Chinese Taipei, and the United States). Boys outperformed girls in Applying in Singapore, while girls outperformed boys on the same process in Japan. Finally, girls performed relatively better than boys on Reasoning in five countries (Finland, England, Australia, Northern Ireland, and New Zealand).

Table 7.4: Mean scores of girls and boys on science cognitive domains, Ireland and comparison countries – Fourth grade

	Knowing		Applying		Reasoning	
	Girls	Boys	Girls	Boys	Girls	Boys
Singapore	580	595	591	599	605	603
Korea, Rep. of	573	595	594	598	580	583
Japan	533	537	581	572	585	574
Chinese Taipei	556	565	559	562	556	548
Finland	553	553	554	548	568	557
United States	537	547	534	536	538	539
England	542	545	526	525	548	539
Australia	535	540	526	521	541	534
Ireland	**528**	**535**	**524**	**527**	**527**	**524**
Northern Ireland	521	525	514	514	525	514
New Zealand	504	505	500	495	512	498

Shading indicates that the subscale score is significantly higher than for the other gender on that subscale.
Standard errors for the data in this table can be found in Table C6 in Appendix C.

Second Year – content domains

Second Year students in Ireland displayed a relative strength in the Earth Science content domain (+13 points) and relative weaknesses on the Chemistry (-11 points) and Physics (-4 points) content domains (Table 7.5). Performance on the Biology content domain was similar to students' overall science performance. Chemistry was an area of relative weakness for many of our comparison countries, while most displayed a relative strength in the Earth Science content domain. Students in Singapore demonstrated a relative strength in Biology, Chemistry and Physics but a relative weakness in Earth Science.

The average score of students in Ireland on the Biology content domain has decreased significantly, by 13 points, since 2015, while performance on the other content domains has not changed significantly.

Table 7.5: Scale scores (*SE*) on science content domains, Ireland and comparison countries – Eighth grade

	Overall	Biology	Chemistry	Physics	Earth Science
Singapore	608	622 (*4.2*)	616 (*5.0*)	619 (*4.1*)	562 (*4.1*)
Chinese Taipei	574	576 (*2.2*)	594 (*2.4*)	555 (*2.7*)	579 (*2.5*)
Japan	570	574 (*2.3*)	560 (*2.7*)	570 (*2.5*)	572 (*3.2*)
Korea, Rep. of	561	560 (*2.2*)	551 (*2.5*)	569 (*2.7*)	562 (*3.2*)
Finland	543	534 (*3.3*)	545 (*3.8*)	539 (*3.9*)	558 (*3.5*)
Australia	528	531 (*3.3*)	515 (*3.8*)	529 (*3.6*)	533 (*3.3*)
Ireland	**523**	**521 (*3.2*)**	**512 (*3.9*)**	**519 (*3.8*)**	**536 (*3.8*)**
United States	522	530 (*4.8*)	509 (*5.2*)	515 (*5.0*)	530 (*5.1*)
England	517	516 (*5.2*)	512 (*6.0*)	516 (*5.1*)	517 (*5.5*)
New Zealand	499	498 (*3.7*)	482 (*3.8*)	502 (*3.8*)	510 (*3.7*)

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.

Table 7.6 presents the mean scores of girls and boys on each of the science content domains, for Ireland and comparison countries. No significant differences were observed between boys and girls in Ireland on the Biology, Physics or Earth Science content domains, but girls significantly outperformed boys in Chemistry. Among our comparison countries, where differences between boys and girls exist, they favour boys in Physics and Earth Science, and girls in Chemistry. In Biology, boys significantly outperformed girls in Japan and the Republic of Korea, while girls had significantly higher mean scores than boys in Finland and the United States.

Table 7.6: Mean scores of girls and boys on science content domains, Ireland and comparison countries – Eighth grade

	Biology		Chemistry		Physics		Earth Science	
	Girls	Boys	Girls	Boys	Girls	Boys	Girls	Boys
Singapore	621	623	617	614	614	624	551	572
Chinese Taipei	577	575	598	591	550	560	572	586
Japan	571	577	560	560	563	578	563	581
Korea, Rep. of	554	565	553	549	563	575	549	574
Finland	549	520	561	530	542	537	562	555
Australia	533	529	519	510	524	533	531	536
Ireland	**523**	**520**	**525**	**500**	**517**	**520**	**536**	**536**
United States	536	524	515	503	514	515	527	532
England	518	513	521	502	517	515	513	523
New Zealand	500	496	483	481	496	507	502	517

Shading indicates that the subscale score is significantly higher than for the other gender on that subscale.
Standard errors for the data in this table can be found in Table C7 in Appendix C.

Second Year – cognitive domains

The mean scores of students in Ireland, and of those in our comparison countries, on the science cognitive domains are presented in Table 7.7. The performance of students in Ireland on the Applying cognitive domain is in line with their overall science performance, while they demonstrated a relative weakness on the Knowing cognitive domain and a relative strength on the Reasoning domain. Many of our comparison countries (the Republic of Korea, Finland, Australia, the United States and New Zealand) also showed relative strengths in the Reasoning cognitive domain, while four countries (Japan, Australia, the United States and New Zealand) also demonstrated relative weaknesses on the Knowing domain.

Since 2015, Ireland's average performance has decreased significantly on the Knowing (-10 points) and Applying (-12 points) cognitive domains, while performance on the Reasoning cognitive domain has remained stable.

Table 7.7: Scale scores (SE) on science cognitive domains, Ireland and comparison countries – Eighth grade

	Overall	Knowing	Applying	Reasoning
Singapore	608	621 (*4.2*)	608 (*4.1*)	595 (*4.0*)
Chinese Taipei	574	600 (*2.4*)	567 (*2.1*)	559 (*2.1*)
Japan	570	563 (*2.4*)	576 (*2.3*)	570 (*2.5*)
Korea, Rep. of	561	558 (*2.6*)	560 (*2.4*)	564 (*2.3*)
Finland	543	545 (*3.2*)	537 (*3.3*)	548 (*3.4*)
Australia	528	515 (*3.5*)	532 (*3.4*)	536 (*3.1*)
Ireland	**523**	**513 (*3.0*)**	**521 (*3.4*)**	**534 (*3.4*)**
United States	522	515 (*4.6*)	523 (*4.8*)	528 (*4.7*)
England	517	520 (*5.0*)	515 (*5.1*)	513 (*5.0*)
New Zealand	499	480 (*3.6*)	503 (*3.8*)	510 (*3.5*)

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.

Boys and girls in Ireland did not differ significantly from each other in terms of their performance on the science cognitive domains (Table 7.8). Similar patterns were also observed in Singapore, Australia, the United States, England and New Zealand. In Finland, girls significantly outperformed boys on each of the cognitive domains. Boys significantly outperformed girls on the Knowing domain in Chinese Taipei, while in the Republic of Korea and Japan boys had significantly higher mean scores than girls on the Knowing and Applying domains.

Table 7.8: Mean scores of girls and boys on science cognitive domains, Ireland and comparison countries – Eighth grade

	Knowing		Applying		Reasoning	
	Girls	Boys	Girls	Boys	Girls	Boys
Singapore	617	624	604	613	591	598
Korea, Rep. of	592	608	567	567	560	558
Japan	555	572	571	581	569	571
Chinese Taipei	549	567	554	566	562	566
Finland	553	537	547	527	559	537
Australia	511	518	534	530	538	533
Ireland	**512**	**514**	**525**	**518**	**538**	**531**
United States	515	514	525	521	530	526
England	519	521	517	512	516	510
New Zealand	475	484	500	505	510	509

Shading indicates that the subscale score is significantly higher than for the other gender on that subscale.
Standard errors for the data in this table can be found in Table C8 in Appendix C.

Chapter 8: Curriculum coverage in TIMSS

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 be able to reflect the relevant curriculum in each participating country perfectly. For this reason, a Test-Curriculum Matching Analysis (TCMA) is included as part of the study. This analysis gives an indication of the extent to which the TIMSS assessments match the national curricula of participating countries. It also provides an opportunity to compare a country's performance on all items (i.e., their mean scores presented in Chapter 3) to what their performance would be if students had only been presented with items that were included on their curriculum. It is also possible to examine how other countries would have performed on a particular subset of items (i.e., what would Singapore's performance be if these students had only been presented with the items on the Irish curriculum). In addition, students' teachers were asked to indicate which topics they had covered in their mathematics or science lessons by the time of the TIMSS assessment.[23]

This chapter presents the results of the TCMA for each domain at Fourth and Eighth grade, followed by teachers' report of TIMSS topic coverage.

The Test-Curriculum Matching Analysis in Ireland

The TCMA in Ireland was conducted by subject experts at primary and post-primary level, who provided judgements (i.e., yes or no) as to whether the topic of each item in the TIMSS assessments was likely to have been covered in the lessons of most students in the relevant grade level. At primary level, the mathematics and science curricula for Third and Fourth Classes were used as a reference point. As the Junior Cycle curriculum covers First to Third Years at post-primary level, there is no specific Second Year curriculum that subject experts could draw on. Instead, subject experts provided their professional opinion as to whether or not the topics in the TIMSS Eighth grade assessment would have been covered by most students in Ireland by the end of Second Year.

Some of the items included in the Earth Science content area are not covered in the science curriculum in Ireland but are instead covered in geography. For this reason, curriculum experts were also asked to classify the Fourth and Eighth grade Earth Science items based on whether or not most students would be familiar with the content, whether taught through the science or geography curriculum.

Fourth grade items – mathematics and science

The outcomes of the TCMA for Fourth Class mathematics – showing subject experts' judgement of which items on the TIMSS assessment could be expected to be familiar to a Fourth Class pupil – are shown in Table 8.1. There was judged to be a high degree of overlap between the TIMSS assessment and the mathematics curriculum in Ireland, with all but a handful of items considered to be included

23 It may be worth noting that the approach to curriculum underpinning TIMSS is different to that used in PISA, another large-scale international assessment. In PISA, students aged 15 (across several grade levels in both junior and senior cycle) complete an assessment that is not directly linked to national curricula. Whereas TIMSS aims to assess how well students can demonstrate the skills and knowledge expected of them based on the curricula relevant to their stage of education (Fourth grade or Eighth grade) (https://timssandpirls.bc.edu/timss2019), PISA aims to assess students' ability to apply knowledge in specified 'real life' scenarios (https://www.oecd.org/pisa/aboutpisa.htm). A recent paper in the IEA's *Compass Briefs in Education* series, published in September 2020,offers a useful discussion of the similarities and differences between TIMSS, PISA, and other large-scale assessments: https://www.iea.nl/publications/series-journals/iea-compass-briefs-education-series/september-2020-international-large

in the curriculum. Overlap ranged from 96% (Measurement & Geometry[24]) to 100% (Number[25]) across the three content domains[26], with an overall coverage of 98%. The handful of items that were judged to be excluded came from the following topics: *Geometry* (Measurement & Geometry) and *Using Data to Solve Problems* (Data).

Table 8.1: TCMA overall and by content domain – Fourth grade mathematics items

	Number of items	Number of items included in curriculum	% included in curriculum
Number	84	84	100
Measurement & Geometry	51	49	96
Data	38	37	97
Overall	173	170	98

There was also quite a high overlap for science, albeit somewhat lower than for mathematics (Table 8.2). Just over four-fifths (81%) of science items were judged to be covered by the Irish curriculum. Physical Science[27] (94%) had the most overlap, followed by Life Science[28] (81%). Most of the items that were excluded came from the *Classification and Properties of Matter and Changes in Matter* (Physical Science) and *Human Health* and *Characteristics and Life Processes of Organisms* (Life Science) topic areas.

The inclusion rate for Earth Science was substantially lower, with 57% of Earth Science[29] items considered to be covered by the Irish curriculum. Items that addressed topics on the Irish geography curriculum were included if they were expected to be familiar to a Fourth Class pupil. In most cases, items were excluded on the basis that they would not be expected to be covered until Fifth or Sixth Class. Most of the Earth Science items judged to be excluded were in the topic areas *Earth in the Solar System* and *Earth's Physical Characteristics, Resources, and History.*

Table 8.2: TCMA overall and by content domain – Fourth grade science items

	Number of items	Number of items included in curriculum	% included in curriculum
Life Science	75	61	81
Physical Science	62	58	94
Earth Science	35	20	57
Overall	172	139	81

24 Measurement & Geometry covered two topic areas: Geometry; and Measurement.

25 Number covered three topic areas: Whole Numbers; Fractions and Decimals; and Expressions, Simple Equations, and Relationships.

26 Data covered two topics: Reading, Interpreting, and Representing; and Using Data to Solve Problems.

27 Physical Science covered three topics: Classification and Properties of Matter and Changes in Matter; Forces and Motion; and Forms of Energy and Energy Transfer.

28 Life Science covered five topic areas: Life Cycles, Reproduction, and Heredity; Human Health; Organisms, Environment, and their Interactions; Characteristics and Life Processes of Organisms; and Ecosystems.

29 Earth Science covered three topics: Earth's Physical Characteristics, Resources, and History; Earth in the Solar System; Earth's Weather and Climate.

Eighth grade items – mathematics and science

Table 8.3 presents the results of the TCMA for Eighth grade mathematics in Ireland. Overall, about 97% of mathematics items on the TIMSS tests were considered to be taught to most students by the end of Second Year. All of the Number[30] and Data and Probability[31] items in the TIMSS tests were identified as being covered by most students by the end of Second Year, while this was the case for 93% of Geometry[32] items and 95% of Algebra[33] items in the TIMSS tests. The small number of Algebra items not considered to have been taught by the end of Second Year were in the *Expressions, Operations and Equations* topic.

Table 8.3: TCMA overall and by content domain – Eighth grade mathematics items

	Number of items	Number of items included in curriculum	% included in curriculum
Number	64	64	100
Algebra	62	59	95
Geometry	43	40	93
Data & Probability	42	42	100
Overall	211	205	97

On other hand, for science, 69% of all items in the TIMSS tests were classified as being covered by most students by the end of Second Year. Chemistry[34] (82%) was the content domain with the highest percentage of items judged to be covered by most students by the Second Year. Of the Chemistry items that were not considered to be covered by the end of Second Year, most of these were in the area of *Properties of Matter.* About 80% of Earth Science items were judged to be taught by the end of Second Year and those that were not covered were spread across the four topic areas.[35] Just 60% of the items in the Physics content domain were considered to be have been taught to most students by the end of Second Year, while 64% of items in the Biology content domain were classified in this way. The Physics[36] items that were not considered to be taught to most students by the end of Second Year mostly covered the topics of *Electricity and Magnetism* and *Light and Sound.* For Biology, [37] the items not covered were spread across five of the six topic areas assessed.

30 Three topic areas were covered in Number: Fractions and Decimals; Integers; Ratio, Proportion and Percent.

31 Data and Probability were covered as separate topics in the Data & Probability content domain.

32 The Geometry content domain was not divided into subtopics, i.e., all items in this domain were classified as Geometry items.

33 The two topics in Algebra were: Expressions, Operations and Equations; and Relationships and Functions.

34 Three topics were assessed in Chemistry: Chemical Change; Composition of Matter; and Properties of Matter.

35 Four topics were assessed in Earth Science: Earth in the Solar System and the Universe; Earth's Processes, Cycles and History; Earth's Resources, Their Use and Conservation; and Earth's Structure and Physical Features.

36 Five topic areas were assessed in Physics: Electricity and Magnetism; Light and Sound; Energy Transformation and Transfer; Motions and Forces; Physical States and Changes in Matter.

37 The six topic areas for Biology were: Cells and Their Functions; Characteristics and Life Processes of Organisms; Diversity, Adaption and Natural Selection; Ecosystems, Human Health; and Life Cycles, Reproduction and Heredity. All items in Human Health were judged to be taught by the end of Second Year.

Table 8.4: TCMA overall and by content domain – Eighth grade science items

	Number of items	Number of items included in curriculum	% included in curriculum
Biology	77	49	64
Chemistry	44	36	82
Physics	52	31	60
Earth Science	43	34	79
Overall	216	150	69

Comparing performance according to the Test-Curriculum Matching Analysis

The next set of tables address a hypothetical scenario: "what score would have been achieved if Irish students had only been asked to answer items that are covered by the Irish curriculum?" The same scenario can be constructed for every other country that took part in TIMSS. Table 8.5 to Table 8.8 show the results of this exercise for Ireland and our comparison countries.

In each table, the first column shows the mean score achieved by each country on the full assessment. Each subsequent column presents the mean score achieved by *each other comparison country* based on the TCMA judgements of *one country* – for example, looking at the 'Singapore' column in Table 8.5, students in Chinese Taipei would have achieved a score of 601 if the TIMSS assessment had consisted only of items included in Singapore's TCMA (i.e., judged to have been taught to most students in Singapore by the end of Fourth grade), and Japanese students would have scored 591 on Singapore's TCMA. Conversely, each row presents the score achieved by *one country* based on the TCMA judgments of *every other country* – for example in Table 8.5, Singapore would have achieved a score of 626 based on the TCMA judgement of Chinese Taipei, and 624 on Japan's TCMA. The diagonal (bolded) cells show each country's hypothetical score according to their own TCMA.

The shaded row for Ireland shows the mean score that would have been achieved by Irish students, counting only the items on each country's TCMA. The shaded column shows the mean score of the other countries in relation to the items on Ireland's curriculum.

The bottom two rows show, firstly, the average of all TIMSS countries per each individual country's TCMA; and secondly, the number of items and score points that each country judged to be included in their own TCMA.[38]

Fourth grade – mathematics and science

Table 8.5 shows the results of this analysis for Fourth grade mathematics. As shown, the score of Fourth Class pupils varies very little regardless of which country's curriculum is used as the reference point (ranging from 544 to 550 across our comparison countries). If only the Fourth Class curriculum had been used as the basis of the TIMSS assessment, pupils in Ireland would have been expected to achieve a score of 549, very close to the actual achieved score (548). A similar pattern was seen internationally, with most countries' scores fluctuating within a narrow range depending on which curriculum is used as the reference point.

38 The number of score points is higher than the number of items because some items are worth 2 points (full credit) or 1 point (partial credit).

Among our comparison countries, Australia judged substantially fewer mathematics items to be covered by their curriculum than most other countries, although variation is evident throughout.

Table 8.5: Average scale scores on all items versus items in the curriculum, Ireland and comparison countries – Fourth grade mathematics

Country	Average scale score on all items	Singapore	Korea, Rep. of	Chinese Taipei	Japan	Northern Ireland	England	Ireland	United States	Finland	Australia	New Zealand
Singapore	625	**629**	625	626	624	626	625	627	625	625	624	622
Korea, Rep. of	600	599	**606**	598	604	600	599	600	599	601	601	599
Chinese Taipei	599	601	601	**601**	604	600	600	600	599	601	592	596
Japan	593	591	598	591	**601**	593	594	593	592	596	590	590
Northern Ireland	566	569	566	567	564	**566**	566	566	566	565	567	567
England	556	559	556	556	553	557	**556**	556	556	555	552	557
Ireland	**548**	550	548	549	547	549	549	**549**	549	548	544	547
United States	535	536	534	536	534	535	534	535	**535**	535	530	534
Finland	532	529	530	530	529	532	531	532	531	**532**	533	532
Australia	516	514	514	514	512	516	515	516	516	516	**521**	518
New Zealand	487	485	485	485	483	487	487	487	487	488	489	**489**
TIMSS average	523	524	524	523	523	523	523	523	523	523	524	523
Number of items (score points) included in curriculum *	171 (183)	137 (146)	132 (142)	144 (154)	127 (135)	164 (176)	161 (173)	166 (177)	164 (176)	163 (175)	59 (65)	119 (127)

International data from Mullis, Martin, Foy, Kelly and Fishbein (2020).
* The number of items and score points are based on the number of items included in scaling the Fourth grade mathematics achievement data. See Martin et al. (2020) for information about items deleted or recoded for scaling.

Table 8.6 shows the equivalent exercise for Fourth grade science. Using only the items judged by experts to be covered by the Irish science curriculum, Irish students would have been expected to achieve a score of 527, which is very close to the actual score (528). Relative to our comparison countries, the expected score of pupils in Ireland ranged from 516 (a low outlier in Japan) to 529 (Finland), with most estimates lying from 524-529.

Several countries, including the high-performing East Asian countries, judged relatively few science items to be covered by their Fourth grade curricula. In Singapore, the Republic of Korea, Japan, and Chinese Taipei, the hypothetical scores based only on their own curricula were substantially higher than their achieved score. However, for most countries, the TCMA shows only minimal differences between a country's hypothetical and actual scores.

Table 8.6: Average scale scores on all items versus items in the curriculum, Ireland and comparison countries – Fourth grade science

Country	Average scale score on all items	Singapore	Korea, Rep. of	Japan	Chinese Taipei	Finland	United States	England	Australia	Ireland	Northern Ireland	New Zealand
Singapore	595	**675**	601	619	608	591	598	595	608	596	596	600
Korea, Rep. of	588	577	**604**	595	599	578	588	588	581	586	581	586
Japan	562	578	578	**592**	578	556	562	562	567	561	558	564
Chinese Taipei	558	547	558	571	**582**	551	559	558	557	558	560	556
Finland	555	540	549	538	549	**555**	555	555	553	554	554	552
United States	539	527	534	529	534	538	**541**	539	540	537	541	539
England	537	535	534	532	536	538	537	**537**	538	537	539	535
Australia	533	532	527	522	534	535	533	533	**533**	533	535	533
Ireland	**528**	524	528	516	526	529	528	528	526	**527**	528	527
Northern Ireland	518	512	513	501	509	520	519	518	516	518	**521**	517
New Zealand	503	494	498	491	501	505	503	503	500	501	504	**502**
TIMSS average	491	492	490	490	490	490	491	491	492	491	491	490
Number of items (score points) included in curriculum *	169 (174)	42 (43)	64 (65)	46 (46)	64 (64)	97 (99)	144 (149)	169 (174)	91 (92)	136 (139)	135 (139)	105 (109)

International data from Mullis, Martin, Foy, Kelly and Fishbein (2020).
* The number of items and score points are based on the number of items included in scaling the Fourth grade science achievement data. See Martin et al. (2020) for information about items deleted or recoded for scaling.

Eighth grade – mathematics and science

Table 8.7 presents the mathematics performance of Ireland and each of our comparison countries, along with the TIMSS overall average, according to the TCMA. In total, there were 206 mathematics items included in the scaling of the Eighth grade mathematics achievement data. The number of these items judged to be covered by the Eighth grade mathematics curricula of our comparison countries ranged from 177 items in Japan and New Zealand to 206 (i.e., all TIMSS mathematics items) in the United States. Ireland's mean mathematics score was 524 when performance was examined using just the subset of items that were considered to be taught to the majority of students by the end of Second Year, which is the same as Ireland's performance on the complete set of TIMSS Eighth grade mathematics items (524). All of our comparison countries, with the exceptions of the United States, England and Finland, saw very small increases in their hypothetical scores (of between one and five points) when using the subset of items for their country.

There was also little variation in Ireland's mean mathematics score when using the subsets of items identified as being covered by the end of Eighth grade in each of our comparison countries. Ireland's mathematics performance ranged from 523 on the subset of items for Chinese Taipei to 526 on the subsets of items selected for the Republic of Korea, Japan and New Zealand. There was also little difference (in the region of one to two points) between the mean scores of our comparison countries on the complete set of TIMSS science items compared to their mean science scores when using the subset of items identified as being taught by the end of Second Year in Ireland.

Table 8.7: Average scale scores on all items versus items in the curriculum, Ireland and comparison countries – Eighth grade mathematics

Country	Average scale score on all items	Singapore	Chinese Taipei	Korea, Rep. of	Japan	Ireland	Australia	United States	England	Finland	New Zealand
Singapore	616	**617**	616	615	615	616	616	616	616	616	613
Chinese Taipei	612	613	**617**	613	611	613	612	612	612	612	611
Korea, Rep. of	607	608	606	**610**	607	605	605	607	606	607	603
Japan	594	593	593	595	**599**	595	594	594	593	593	592
Ireland	**524**	524	523	526	526	**524**	525	524	524	524	526
Australia	517	516	515	517	519	518	**518**	517	518	518	520
United States	515	515	514	515	515	515	515	**515**	515	516	514
England	515	514	512	515	518	516	516	515	**515**	515	517
Finland	509	509	509	510	511	509	509	509	509	**509**	510
New Zealand	482	480	480	481	484	482	482	482	481	482	**484**
TIMSS average	489	489	489	489	489	489	489	489	489	489	488
Number of items (score points) included in curriculum *	206 (217)	198 (209)	185 (195)	185 (194)	177 (186)	200 (211)	188 (198)	206 (217)	202 (213)	198 (209)	177 (187)

Adapted from Mullis, Martin, Foy, Kelly and Fishbein (2020).
* The number of items and score points are based on the number of items included in scaling the Eighth grade mathematics achievement data. See Martin et al. (2020) for information about items deleted or recoded for scaling.

Altogether, 211 items were included in the scaling of the Eighth grade science achievement data (Table 8.8). The number of these items included in the TCMA of our comparison countries ranged from 95 items in Japan (i.e., less than half of all TIMSS science items) to 198 items in Finland. Using the subset of science items that were considered to be taught to most students by the end of Second Year, Ireland's mean science score was 526, slightly above the mean score for Ireland when using all Eighth grade TIMSS science items (523). With the exception of Finland, all of our comparison countries saw increases in their mean scores when performance was examined using the subset of items for their country, from about one point in England and the Republic of Korea to about 14 points in Japan.

There was little variation (in the region of one to four points) between the mean scores of our comparison countries on the complete set of TIMSS science items and their mean scores when their performance was examined on the subset of items for Ireland. Further, when Ireland's performance was examined using the subsets of items identified as being covered by the end of Eighth grade in each of our comparison countries, the hypothetical mean science score of Second Year students ranged from 517 (for the items selected for Singapore and Japan) to 524 (for the subset of items selected for Finland).

Table 8.8: Average scale scores on all items versus items in the curriculum, Ireland and comparison countries – Eighth grade science

Country	Average scale score on all items	Singapore	Chinese Taipei	Japan	Korea, Rep. of	Finland	Australia	Ireland	United States	England	New Zealand
Singapore	608	**621**	612	614	613	607	611	607	605	609	608
Chinese Taipei	574	571	**578**	574	575	572	569	572	571	574	571
Japan	570	568	570	**584**	571	568	569	571	571	569	566
Korea, Rep. of	561	557	558	558	**562**	560	562	561	562	560	559
Finland	543	538	542	538	542	**543**	539	542	542	541	543
Australia	528	524	527	524	526	530	**533**	527	530	528	529
Ireland	**523**	517	522	517	523	524	523	**526**	523	523	523
United States	522	518	522	516	520	524	525	518	**524**	522	522
England	517	514	517	515	516	517	515	518	517	**518**	516
New Zealand	499	494	497	489	498	502	500	497	500	499	**501**
TIMSS average	490	490	490	490	491	490	490	489	490	490	490
Number of items (score points) included in curriculum *	211 (233)	138 (154)	174 (195)	95 (109)	159 (177)	198 (216)	157 (175)	148 (163)	186 (206)	194 (215)	171 (189)

Adapted from Mullis, Martin, Foy, Kelly and Fishbein (2020).
* The number of items and score points are based on the number of items included in scaling the Eighth grade science achievement data. See Martin et al. (2020) for information about items deleted or recoded for scaling.

Teacher reports of TIMSS topic coverage

The overlap between the TIMSS assessment frameworks and the Irish curricula in the first section of this chapter (Table 8.1 to Table 8.4) present the findings in terms of the main content domains (e.g., Number, Data, Life Science, Physical Science). Each of these content domains is composed of a number of more specific topics, which teachers were asked to consider and report whether each topic had been taught to their students *mostly before this year, mostly this year,* or *not yet taught or just introduced.* These teacher reports can therefore give another perspective on the extent to which students in Ireland might be expected to have been familiar with the topics covered by the TIMSS assessment.

Table 8.9 to Table 8.12 summarise teachers' reports of topic coverage in Ireland and at the TIMSS average, for each of the main content domains. A complete presentation of teachers' reports of the extent to which specific mathematics topics (e.g., *finding and estimating perimeter, area and volume*) and science topics (*e.g., human health: transmission and prevention of diseases, everyday behaviours that promote good health*) had been taught at each grade level is provided in Appendix D.

Fourth grade – mathematics and science

In Ireland, teachers reported a higher level of coverage of the Fourth grade mathematics topics (88%) than was reported on average across TIMSS countries (80%) (Table 8.9). This was especially noticeable for Data topics, where coverage in Ireland was reported at 92% compared to 78% internationally – albeit with the caveat that the Data domain comprised fewer topics (three) than either Number (seven) or Measurement & Geometry (seven). Number was the most-covered domain, both in Ireland and internationally.

Table 8.9: Percentages of pupils taught the TIMSS mathematics topics – Fourth grade

	All mathematics (17 topics) % (*SE*)	Number (7 topics) % (*SE*)	Measurement & Geometry (7 topics) % (*SE*)	Data (3 topics) % (*SE*)
Ireland	88 (*0.8*)	94 (*0.9*)	81 (*1.4*)	92 (*1.9*)
TIMSS	80 (*0.1*)	86 (*0.1*)	76 (*0.2*)	78 (*0.3*)

Percentages of pupils mostly taught before or in the assessment year, averaged across topics.
See Appendix D for more detail on individual topics.
International data from Mullis, Martin, Foy, Kelly and Fishbein (2020).

Coverage of the science topics was lower than for mathematics, both in Ireland (71%) and internationally (62%) (Table 8.10).[39] Physical Science topics were reported to receive somewhat less coverage by Fourth grade than topics in Life Science or Earth Science, both in Ireland and at the TIMSS average.

Table 8.10: Percentages of pupils taught the TIMSS science topics – Fourth grade

	All science (26 topics) % (*SE*)	Life Science (7 topics) % (*SE*)	Physical Science (12 topics) % (*SE*)	Earth Science (7 topics) % (*SE*)
Ireland	71 (*1.3*)	76 (*1.6*)	68 (*1.6*)	72 (*1.5*)
TIMSS	62 (*0.2*)	73 (*0.2*)	58 (*0.2*)	60 (*0.3*)

Percentages of pupils mostly taught before or in the assessment year, averaged across topics.
See Appendix D for more detail on individual topics.
International data from Mullis, Martin, Foy, Kelly and Fishbein (2020).

39 There were five science topics which the teachers of at least 50% of Fourth Class pupils reported as having been not yet taught or just introduced by the end of Fourth Class (Appendix D, Table D2): characteristics of plants and animals that are inherited (Life Science); mixtures, including methods for separating a mixture into its components and chemical changes in everyday life (both Physical Science); and changes in Earth's surface over time and fossils and what they can tell us about past conditions on Earth (both Earth Science). In contrast, there were no mathematics topics to which at least 50% of pupils had not yet been introduced (Table D1).

Second Year – mathematics and science

Table 8.11 presents the percentages of Second Year students taught the TIMSS mathematics topics in Ireland as well as the average across all TIMSS countries, according to teachers' reports. Overall, slightly fewer students in Ireland (68%) were taught the TIMSS mathematics topics compared to the TIMSS average (72%). However, there was considerable variation in the coverage of topics across the four mathematical content domains. Greater percentages of students in Ireland compared to the TIMSS average were taught the topics on the Data and Probability and Algebra domains. Almost all students in Ireland and on average across TIMSS countries had covered the topics on the Number domain. On the other hand, less than half of students in Ireland had been taught the Geometry topics, compared to a TIMSS average of 76% of students.[40]

Table 8.11: Percentages of students taught the TIMSS mathematics topics – Eighth grade

	All mathematics (22 topics) % (*SE*)	Number (3 topics) % (*SE*)	Algebra (7 topics) % (*SE*)	Geometry (6 topics) % (*SE*)	Data & Probability (6 topics) % (*SE*)
Ireland	68 (*1.1*)	99 (*0.3*)	73 (*1.3*)	49 (*2.3*)	66 (*2.2*)
TIMSS	72 (*0.2*)	98 (*0.1*)	68 (*0.2*)	76 (*0.2*)	60 (*0.3*)

Percentages of students mostly taught before or in the assessment year, averaged across topics.
See Appendix D for more detail on individual topics.
International data from Mullis, Martin, Foy, Kelly and Fishbein (2020).

Overall coverage of Eighth grade science items was lower in Ireland than on average across TIMSS countries (63% compared to 72%) (Table 8.12). However, as for mathematics, there was variation in coverage across the four content domains. The highest level of coverage in Ireland was in Chemistry with 77% of students having teachers who reported that these topics were taught by the end of Second Year, which is slightly higher than the TIMSS average (74%). Across the other three content domains, coverage of topics was lower in Ireland than on average across TIMSS countries. In particular, coverage of Physics topics was considerably lower in Ireland, with 48% of students' teachers reporting that these topics were taught by the end of Second Year compared to a TIMSS average of 68%.[41]

Table 8.12: Percentages of students taught the TIMSS science topics – Eighth grade

	All science (26 topics) % (*SE*)	Biology (7 topics) % (*SE*)	Chemistry (8 topics) % (*SE*)	Physics (7 topics) % (*SE*)	Earth Science (4 topics) % (*SE*)
Ireland	63 (*0.8*)	66 (*1.2*)	77 (*1.1*)	48 (*1.4*)	54 (*2.5*)
TIMSS	72 (*0.2*)	74 (*0.2*)	74 (*0.2*)	68 (*0.2*)	71 (*0.3*)

Percentages of students mostly taught before or in the assessment year, averaged across topics.
See Appendix D for more detail on individual topics.
International data from Mullis, Martin, Foy, Kelly and Fishbein (2020).

40 There were four mathematics topics that teachers of at least 50% of Second Year students reported as having been not yet taught or just introduced by the end of Second Year. Three of these topics were in Geometry (translation, reflection and rotation; congruent figures and similar triangles; and solving problems with 3D shapes). The fourth topic (theoretical and empirical probability of compound events) was in the Data and Probability domain (see Appendix D, Table D3).

41 There were 10 science topics which teachers of at least 50% of Second Year students reported as having been not yet taught or just introduced by the end of Second Year. Two of these were in Biology (role of variation and adaptation in survival/extinction; and interdependence of populations of organisms in ecosystems); two were in Chemistry (matter and energy in chemical reactions; and the role of electrons in chemical bonds); four were in Physics (properties/behaviours of light; properties/behaviours of sound; electric circuits; and properties and uses of permanent magnets and electromagnets); and two were in Earth Science (Earth's structure and physical features; Earth's processes, cycles and history).

Chapter 9: Summary

This chapter provides a summary of the mathematics and science performance of students in Ireland in TIMSS 2019, which are described in full in the preceding chapters. An overview of an analysis of curriculum coverage in TIMSS is also presented, and details of further national reporting on TIMSS 2019 are provided.

Mathematics and science performance at Fourth Class

Fourth Class pupils achieved a mean score of 548 in mathematics and 528 in science. Seven countries for mathematics, and 12 countries for science, achieved significantly higher scores than Ireland. Conversely, 46 countries for mathematics, and 33 countries for science, achieved significantly lower scores than Ireland. Five countries (Singapore, the Republic of Korea, the Russian Federation, Japan, and Chinese Taipei) significantly outperformed Ireland in both domains. Hong Kong and Northern Ireland achieved significantly higher scores than Ireland for mathematics but similar (Hong Kong) or significantly lower (Northern Ireland) scores for science.

Of the 22 EU countries that participated at Fourth grade, no EU country had a higher mean mathematics score than Ireland, while four (Finland, Latvia, Lithuania and Sweden) significantly outperformed Ireland in science. Two EU countries (Latvia and Lithuania) had similar mathematics performance to Ireland and 19 achieved significantly lower mean mathematics scores than Ireland. For science, eight EU countries had similar mean scores as Ireland while nine performed at significantly lower levels.

Trends (1995-2011-2015-2019)

There were no significant changes in Fourth Class pupils' mean performance in either mathematics or science since 2015. In both domains, the mean score achieved in 2019 was within one scale point of the 2015 Fourth Class averages. Comparing further back, the mean scores achieved in 2019 were significantly higher than those observed in 2011 and in 1995, for both domains.

Differences between boys and girls

Differences between boys and girls at Fourth Class were small and not statistically significant. In mathematics, boys achieved an average score of 552, while girls' average score was 545. Since 2015, there has been a small increase in boys' score (from 549 in 2015) and no change among girls (545 in 2015). Compared to 2011 (529 for boys and 526 for girls), substantial increases have been observed. In science, differences between boys (530) and girls (526) were also small and not statistically significant. Both scores were almost identical to those reported in 2015 (531 and 526, respectively) and higher than those reported in 2011 (516 for both boys and girls).

Mathematics and science performance at Second Year

Second Year students in Ireland achieved a mean score of 524 in mathematics and 523 in science. Six countries significantly outperformed Ireland in mathematics, and seven countries had significantly higher mean science scores than Ireland. Singapore, Chinese Taipei, the Republic of Korea, Japan and the Russian Federation significantly outperformed Ireland in both mathematics and science. In addition, Hong Kong achieved a significantly higher mean mathematics score (but not science) than Ireland, while Finland and Lithuania significantly outperformed Ireland in science (but not mathematics). Ireland's mathematics performance did not differ significantly from the performance of six countries and 26 countries performed significantly lower than Ireland in mathematics. For science, eight countries had average scores that did not differ significantly from Ireland's score, while Ireland significantly outperformed 23 countries in science.

Of the ten EU countries that participated at Eighth grade, none significantly outperformed Ireland in mathematics while two (Finland and Lithuania) achieved significantly higher mean scores in science. Two EU countries (Lithuania and Hungary) had similar mathematics performance to Ireland and seven achieved significantly lower mean mathematics scores than Ireland. For science, three EU countries (Hungary, Sweden and Portugal) had similar mean scores as Ireland while four (Italy, France, Cyprus and Romania) achieved significantly lower scores.

Trends (1995-2015-2019)

Ireland's mean mathematics performance has not changed significantly since 2015 or 1995. Although not statistically significant, Ireland's mean score in science dropped by seven points since 2015. This means that, while Ireland's mean science score increased significantly by 12 points between 1995 and 2015, Ireland's science performance in 2019 does not differ significantly from either 2015 or 1995.

Differences between boys and girls

On average, boys and girls in Ireland achieved very similar mathematics scores (523 and 524, respectively). The performance of boys in Ireland in mathematics has remained relatively stable since 1995, when their average score was 525 points. On the other hand, the mathematics performance of girls increased considerably between 1995 and 2019 (from 512 to 524 points). The average science performance of boys and girls in Ireland was also similar (521 and 526, respectively). Between 1995 and 2015, the average science score for boys remained stable, changing slightly from 527 to 529. On the other hand, girls experienced a large increase from 510 to 531 in their average science score. Between 2015 and 2019, average science performance in Ireland dropped by eight points for boys and almost five points for girls.

Distribution of performance

The performance of students within a country can also be described in terms of the distribution of achievement (i.e., from the lowest- to the highest-achieving students) which can highlight important patterns among students.

Fourth Class

A general overview of the distribution of achievement at Fourth Class compared to Fourth grade in our comparison countries suggests that pupils in Ireland perform relatively well at the lower end of the distribution (e.g., at the 5th percentile) but less well at the upper end (e.g., at the 95th percentile).

This can be seen by comparing the distribution of mathematics achievement in Ireland to those in Northern Ireland (with a higher mean score) and England (with a similar score to Ireland). The score achieved at the 5th percentile among Fourth Class pupils was slightly higher than the 5th percentile in both countries, but mathematics achievement in Ireland was lower at the 75th and, particularly, the 95th percentiles. At the same time, the score at the 95th percentile in the United States (where the mean score was significantly lower than in Ireland) was similar to the 95th percentile in Ireland, but the United States' score at the 5th percentile was substantially lower than in Ireland. These patterns suggest that the highest-performing pupils in Ireland are underperforming in mathematics, relative to the achievement of the lower-achieving students in Ireland and the national average achievement.

This pattern was not as clear in science. Among our comparison countries, Australia achieved a similar mean score to Ireland but had a wider distribution of achievement at both tails – that is, the lowest-performing pupils in Australia achieved lower scores than in Ireland, and the highest-achieving pupils in Australia achieved higher scores than in Ireland. The highest-performing pupils in Ireland achieved higher scores than their counterparts in Northern Ireland (with a lower mean score), even

though performance at the lower end of the distribution was similar in both jurisdictions. However, in England (with a higher mean score), pupils at the 5th percentile achieved substantially higher scores than pupils in Ireland, but the score among the highest-achieving students was only slightly higher than in Ireland. These mixed patterns, and the more moderate performance of Fourth Class pupils in science compared to mathematics relative to all TIMSS countries, suggests that there is room for strengthening science learning in Fourth Class at all levels of achievement.

A comparison of trends indicates that, between TIMSS 2011 and 2015, substantial improvements were observed among lower-achieving pupils (those at the 5th percentile of all scores in Ireland), which meant that the overall distribution of achievement narrowed considerably (i.e., there was less of a gap between lower- and high-achieving pupils). In contrast, the distribution of achievement in 2019 is very similar to 2015, with no major changes. In fact, a very slight widening of the distribution (lower at the 5th percentile and higher at the 95th percentile) can be seen.

Second Year

At Second Year, the lowest-achieving students in Ireland (i.e., those at the 5th percentile) perform relatively well in both mathematics and science compared to their international counterparts, while those with the highest performance in each domain (i.e., at the 95th percentile) achieve relatively less well.

In mathematics, the lowest-achieving students in Ireland score over 50 points lower than their peers in Singapore (the country with the highest achievement), while the difference is over 100 points for the highest-achieving students. Students at the 5th percentile in Ireland have a mathematics score that is considerably higher than the corresponding scores of students in countries with similar overall performance (including Australia, England and the United States). On the other hand, the mathematics score of those at the 95th percentile in Ireland is lower than the corresponding scores of students in these countries. However, the performance of students at the 75th percentile in Ireland is similar to that of their peers in a number of countries with similar overall performance (including England and Australia), indicating that the relative underperformance of students in Ireland at the upper end of the mathematics distribution is among the very highest-achieving students.

A similar pattern can be observed for the distribution of science achievement at Second Year. The score of those at the 5th percentile in Ireland is similar to or higher than the corresponding scores in many of the countries with similar overall science performance (students in Portugal and Hungary have considerably higher scores at the 5th percentile). The score of students in Ireland at the 95th percentile is lower than that of their peers in all but one of the eight countries with similar overall mean science scores (the corresponding score in Portugal was about 13 points lower than Ireland's score).

Looking back to previous cycles, we see that between TIMSS 1995 and 2015 there was a marked improvement in both mathematics and science among lower-achieving students (those at the 5th percentile of all scores in Ireland). While there was a more modest improvement (of about 3 points) in mathematics between 2015 and 2019, the science scores of students at the 5th and 25th percentiles declined by about 12 points. The performance of high-achieving students in mathematics and science (at the 95th percentile) has remained stable between 2015 and 2019, while it is somewhat lower in 2019 than in 1995.

Performance at International Benchmarks

TIMSS also describes student achievement with reference to specific skills that students at particular levels are able to demonstrate. At each grade level, and for both mathematics and science, four Benchmarks, or levels of achievement, are described: Low, Intermediate, High and Advanced. Students achieving at the Low Benchmark can demonstrate some basic knowledge in a subject area. The skills and knowledge that students can demonstrate increase with each Benchmark, with those at the Advanced Benchmark able to apply knowledge and reason in a variety of situations.

Fourth Class

For mathematics, the percentage of Fourth Class pupils reaching each Benchmark was higher than the corresponding TIMSS median percentages. Almost all pupils in Ireland (97%) reached at least the Low Benchmark (TIMSS median: 92%), and most (84%) achieved at least an Intermediate level of proficiency (TIMSS median: 71%). More than half of Fourth Class pupils (52%) were classified as reaching the High Benchmark for mathematics (TIMSS median: 34%). Finally, about one-seventh of Fourth Class pupils (15%) reached the Advanced Benchmark for mathematics, compared to 7% at the TIMSS median.

There were no significant differences between the percentages of boys and girls reaching any of the mathematics Benchmarks in Ireland. Compared to previous TIMSS assessments, there were no significant differences between Benchmark performance in TIMSS 2015 and TIMSS 2019. However, the percentage of pupils reaching each mathematics Benchmark was significantly higher in 2019 than in TIMSS 2011 or TIMSS 1995.

Performance at the science Benchmarks was not as strong at Fourth Class as for mathematics. In science, most Fourth Class pupils could reach the Low (94%) and Intermediate (77%) Benchmarks (TIMSS median: 92% and 71%, respectively). However, this means that 6% of pupils could not consistently demonstrate the most basic skills assessed by the test. Fewer than half of pupils in Fourth Class (41%) reached the High Benchmark (TIMSS median: 32%), while almost one-tenth (9%) achieved the Advanced Benchmark (TIMSS median: 6%).

There were no significant differences between boys and girls at any of the science Benchmarks at Fourth Class. There were also no significant differences between the percentages of pupils reaching each Benchmark in 2019 compared to 2015. However, compared to TIMSS 2011, a significantly greater percentage of pupils reached the Intermediate and High Benchmarks. Compared to TIMSS 1995, a significantly greater percentage of pupils reached the Low, Intermediate, and High Benchmarks. There has been no significant change in the percentage of pupils reaching the Advanced Benchmark for science at Fourth Class since Ireland first took part in TIMSS (8% in 1995, 7% in 2011, 7% in 2015, and 9% in 2019).

Second Year

At Second Year, the percentages of students reaching each Benchmark in mathematics are higher than the corresponding international median percentages, although only marginally so at the Advanced Benchmark. In Ireland, 94% of students reached at least the Low Benchmark in mathematics, compared to a TIMSS median of 87%. This means that about 6% of Second Year students in Ireland could not consistently demonstrate the most basic skills assessed in the mathematics test. Further, 76% of students in Ireland reached the Intermediate Benchmark (TIMSS median: 56%) and 38% reached at least the High Benchmark (TIMSS median: 25%). Seven percent of Second Year students achieved at the Advanced Benchmark, compared to a TIMSS median of 5%. In Singapore, the highest-achieving country, the percentages reaching the Intermediate (92%), High (79%) and Advanced (51%) Benchmarks

are considerably higher than in Ireland. There were no significant differences between the percentages of boys and girls reaching each mathematics Benchmark in Ireland. The overall percentages of Irish students reaching these Benchmarks has not changed significantly since 1995.

For science, 92% of students in Ireland reached at least the Low Benchmark (TIMSS median: 85%), meaning that 8% of students did not consistently demonstrate the most basic skills measured by the science assessment. The percentages of students in Ireland reaching at least the Intermediate and High Benchmarks (73% and 40%, respectively) were considerably higher than the corresponding TIMSS median percentages (61% and 29%, respectively) but substantially lower than the percentages reaching these levels in Singapore (91% and 77%, respectively). Ten percent of students in Ireland achieved the Advanced Benchmark, slightly above the international median of 7% but substantially lower than the corresponding percentage in Singapore (48%). In Ireland, significantly more girls than boys reached at least the Low Benchmark, while there were no significant differences in the percentages of girls and boys reaching the Intermediate, High or Advanced Benchmarks. The percentages of students reaching the Low, High, and Advanced Benchmarks in Ireland are not significantly different to the corresponding percentages in 2015 or 1995. However, there was a statistically significant decrease in the percentage of students reaching the Intermediate benchmark for science in 2019 (73%) compared to 2015 (77%).

Performance on the content and cognitive domains

As well as measuring overall performance in mathematics and science, TIMSS describes performance in these subjects across a number of content and cognitive subscales. For mathematics, three content areas were assessed at Fourth grade (Number, Measurement & Geometry, and Data) while four content areas were assessed at Eighth grade (Number, Algebra, Geometry, and Data & Probability). Three content areas were assessed for science at Fourth grade (Life Science, Physical Science, and Earth Science) and four areas at Eighth grade (Biology, Chemistry, Physics, and Earth Science). At each grade level and for each subject, there are three cognitive subscales: Knowing, Applying and Reasoning. Within each country, performance on each of these content and cognitive subscales is compared to overall performance on the subject so that areas of relative strength and weakness can be identified.

Table 9.1 presents the areas of relative strength in mathematics and science at both Fourth grade and Eighth grade. In mathematics, Number was an area of relative strength for students in Ireland at both grade levels. Algebra is incorporated into the Number domain at primary level, but is assessed as a separate domain at Second Year and was found to be an area of relative weakness. Students in Ireland also displayed a relative weakness in the areas of Measurement & Geometry (at Fourth Class) and Geometry (at Second Year). While Data was an area of relative weakness for Fourth Class students, Second Year students displayed a relative strength in Data & Probability. Girls and boys did not differ significantly from each other on any of the mathematics content domain at Fourth Class. At Second Year, girls significantly outperformed boys on the Algebra content domain, while no significant differences between boys and girls were observed on the other content domains.

In science, Earth Science was found to be a relative strength at both grade levels in Ireland. At Second Year, Physics and Chemistry were areas of relative weakness, as was Physical Science at Fourth Class (which include aspects of both Physics and Chemistry). Students' performance on Life Science (at Fourth Class) and Biology (at Second Year) was in line with their overall science performance. Few differences were observed between boys and girls across the science content domains. At Fourth Class, boys significantly outperformed girls on items assessing Earth Science, while girls significantly outperformed boys in Chemistry at Second Year.

Table 9.1: Summary of relative strengths and weaknesses in mathematics and science content domains

	Mathematics			Science		
	Relative weakness	**Similar to overall performance**	**Relative strength**	**Relative weakness**	**Similar to overall performance**	**Relative strength**
Fourth Class	*Measurement & Geometry* *Data*	-	*Number*	*Physical Science*	*Life Science*	*Earth Science*
Second Year	*Algebra* *Geometry*	-	*Number* *Data & Probability*	*Chemistry* *Physics*	*Biology*	*Earth Science*

The relative strengths and weaknesses of students in Ireland across the cognitive domains (Knowing, Applying, and Reasoning) measured in mathematics and science are presented in Table 9.2. In mathematics, both Fourth Class and Second Year students in Ireland showed a relative strength in the Applying cognitive domain and a relative weakness in Reasoning. On the other hand, performance on mathematics items measuring the Knowing cognitive domain was in line with overall mathematics performance at Fourth Class, but was an area of relative strength at Second Year. No significant differences were observed between boys and girls in any of the mathematics cognitive domains in Ireland, at either grade level.

For science, Fourth Class students displayed a relative strength in Knowing, while this was an area of relative weakness among Second Year students. Performance on the items measuring the Applying cognitive domain was in line with overall science performance at both grade levels. Reasoning was an area of relative strength among Second Year students, while at Fourth Class, performance on this domain was in line with overall science performance. No significant differences were observed between boys and girls across any of the science cognitive domains at either Fourth Class or Second Year.

Table 9.2: Summary of relative strengths and weaknesses in mathematics and science cognitive domains

	Mathematics			Science		
	Relative weakness	**Similar to overall performance**	**Relative strength**	**Relative weakness**	**Similar to overall performance**	**Relative strength**
Fourth Class	*Reasoning*	*Knowing*	*Applying*	-	*Applying* *Reasoning*	*Knowing*
Second Year	*Reasoning*	-	*Knowing* *Applying*	*Knowing*	*Applying*	*Reasoning*

Curriculum analysis

Almost all (98%) of the TIMSS Fourth grade mathematics assessment was considered by subject experts in Ireland to be covered by pupils in Ireland by the end of Fourth Class. While the coverage of science items was also relatively high (81%) in Ireland, it was much lower than for mathematics. A similar pattern was observed at Eighth grade, where 97% of mathematics items and 69% of science items were considered to be covered by most students by the end of Second Year. Geometry was the mathematics content area with the lowest coverage at both Fourth grade (Measurement & Geometry: 96%) and Second Year (Geometry: 93%) For science, coverage was lowest for items in the Earth Science domain at Fourth grade (57%) and the Physics domain at Eighth grade (60%).

The Test-Curriculum Matching Analysis allows us to examine how student performance may vary if students were only presented with the subsets of items which were judged to be included in the curricula in their country. At each grade level and domain, Ireland's average performance on these subsets of items did not vary substantially from performance on the complete set of items on the TIMSS tests. This was also the case for many of our comparison countries, when performance was re-examined using just the relevant subset of items for each country. Some notable exceptions were observed for Fourth grade science, where students in Singapore, the Republic of Korea, Japan and Chinese Taipei performed considerably better on the items judged to be part of their respective curricula. Coverage of the TIMSS Fourth grade science items in the curricula of these countries was also very low.

Ireland's mean scores also did not change greatly when performance was examined on each of the subsets of items included in the TCMAs of our comparison countries, with the exception of Fourth grade science performance on the items included in Japan's TCMA. The relative stability of students' performance on the assessment regardless of which country's curriculum is used as the reference point hints at the myriad of factors that contribute to mathematics and science achievement beyond the intended curriculum and classroom coverage of topics. Our follow-up national reporting on TIMSS 2019, described briefly below, will examine some of these other factors, including student, home, teacher/class, and school factors (see also, for example, Clerkin, Perkins & Chubb, 2020).

Finally, teachers were asked to indicate whether they taught specific topic areas in their lessons with the TIMSS students. Fourth Class teachers reported higher overall coverage of the TIMSS mathematics and science topics (88% for mathematics and 71% for science) when compared to the corresponding international averages (80% for mathematics and 63% for science). Reported coverage was also higher in Ireland across each of the mathematics and science content domains at Fourth Class. At Second Year, teachers reported slightly lower coverage of mathematics items overall when compared to the international average (68% compared to 72%), but coverage varied considerably by content domain. For example, in Ireland, reported coverage of Algebra (73%) and Data & Probability (66%) topics was higher than on average across TIMSS countries (68% and 60%, respectively), but coverage of Geometry items was considerably lower (49% in Ireland, 76% internationally).

Overall, reported coverage of TIMSS science topics at Fourth grade was also higher in Ireland than on average across TIMSS countries (71% compared to 62%) and this was especially the case for topics in Earth Science (72% compared to 60%). On the other hand, overall reported coverage of science topics at Eighth grade was somewhat lower in Ireland compared to the international average (63% compared to 72%). As was the case for mathematics, coverage of topics varied by content domain, with reported coverage of Chemistry being slightly higher in Ireland than at the international average (77% compared to 74%), while coverage of the other domains was lower and was especially low for Physics (48% compared to 68%). Reported coverage of Earth Science topics by teachers in Ireland was also considerably lower than the TIMSS average (54% compared to 71%). However, it should

be noted that some of the Earth Science content domain in TIMSS is covered by the geography curriculum in Ireland.

Further publications for TIMSS 2019

The current report presents the initial TIMSS 2019 achievement findings for Ireland. TIMSS also collects a variety of contextual information from students, their parents (at Fourth Class only), their teachers, and their principals. These data include:

- Structural characteristics of the Irish education system.
- Characteristics of Fourth Class and Second Year teachers in Ireland, including their classroom practices and professional development needs.
- Use of ICT in the classroom by teachers and students, as well as students' use of ICT at home.
- Students' attitudes towards learning mathematics and science as well as attitudes towards school more generally.
- Students' experiences in school, including bullying behaviour.
- Interaction between the students' homes and their schools.

These data are presented for all countries in *TIMSS 2019 International Results in Mathematics and Science* (Mullis, Martin, Foy, Kelly & Fishbein, 2020). Further national reporting will examine the relationships between student achievement and these contextual factors in Ireland. Separate contextual reports will be published for Fourth Class and Second Year and will be available at www.erc.ie/timss.

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Appendix A: National Advisory Committees

Ireland's participation in TIMSS 2019 was assisted by a National Advisory Committee at each grade level. The members of the committees, as of November 2020, are named below

Fourth Class

- Aedín Ní Thuathail (Irish Primary Principals' Network).
- Aidan Clerkin (Educational Research Centre).
- Áine Lynch (National Parents Council – Primary).
- Arlene Forster (National Council for Curriculum and Assessment).
- Deirbhile Nic Craith (Irish National Teachers' Organisation).
- Eddie Fox (Educate Together).
- Fionnuala Shortt (Educational Research Centre).
- John Mescal (Department of Education).
- Máirín Ní Chéileachair (Gaelscoileanna).
- Mary Delaney (Educational Research Centre).
- Noreen Fiorentini (Department of Education, Chair).
- Nuala Taaffe (Professional Development Service for Teachers).
- Seán Delaney (Marino Institute of Education).

Second Year

- Conor Galvin (University College Dublin).
- Elizabeth Oldham (Trinity College Dublin, the University of Dublin).
- Gerry Hyde (State Examinations Commission).
- Kevin McClean (Department of Education)
- Liz O'Neill (Department of Education).
- Maurice O'Reilly (Dublin City University).
- Odilla Finlayson (Dublin City University).
- Orlaith O'Connor (Department of Education, Chair).
- Paul Behan (National Council for Curriculum and Assessment).
- Philip Matthews (Trinity College Dublin, the University of Dublin).
- Rachel Linney (National Council for Curriculum and Assessment).
- Rachel Perkins (Educational Research Centre).
- Tom McCloughlin (Dublin City University).

Appendix B: Percentiles of achievement

Table B1: Percentiles of mathematics achievement for Ireland and comparison countries – Fourth grade

	5th	10th	25th	50th	75th	90th	95th
Singapore	481 (*8.0*)	519 (*7.0*)	578 (*4.9*)	633 (*4.5*)	682 (*3.8*)	720 (*3.5*)	741 (*3.8*)
Korea, Rep. of	477 (*5.7*)	509 (*4.1*)	556 (*3.0*)	603 (*2.3*)	648 (*2.7*)	687 (*3.3*)	710 (*4.0*)
Chinese Taipei	483 (*5.6*)	513 (*4.9*)	557 (*2.7*)	603 (*1.7*)	645 (*3.2*)	681 (*2.4*)	701 (*2.6*)
Japan	474 (*3.7*)	502 (*3.3*)	548 (*2.5*)	595 (*2.0*)	641 (*2.3*)	680 (*2.9*)	703 (*3.1*)
Northern Ireland	410 (*8.0*)	449 (*5.2*)	510 (*3.6*)	572 (*3.6*)	627 (*3.4*)	672 (*5.3*)	699 (*5.9*)
England	411 (*5.5*)	445 (*5.1*)	499 (*3.5*)	558 (*4.4*)	615 (*4.1*)	665 (*4.8*)	693 (*6.5*)
Ireland	**414 (*5.6*)**	**446 (*5.2*)**	**501 (*3.5*)**	**553 (*2.3*)**	**601 (*2.1*)**	**643 (*4.2*)**	**665 (*3.4*)**
United States	383 (*5.9*)	421 (*4.4*)	480 (*3.2*)	542 (*2.8*)	594 (*3.0*)	639 (*2.8*)	663 (*4.0*)
Finland	402 (*5.0*)	431 (*4.9*)	483 (*3.4*)	535 (*3.3*)	585 (*1.9*)	628 (*3.6*)	653 (*3.2*)
Australia	364 (*6.0*)	401 (*5.9*)	460 (*3.6*)	519 (*3.0*)	575 (*3.4*)	625 (*3.7*)	654 (*5.8*)
New Zealand	338 (*4.7*)	368 (*4.4*)	425 (*3.4*)	489 (*3.2*)	549 (*3.3*)	602 (*3.6*)	634 (*4.2*)

Table B2: Percentiles of science achievement for Ireland and comparison countries – Fourth grade

	5th	10th	25th	50th	75th	90th	95th
Singapore	454 (*6.3*)	493 (*5.8*)	548 (*4.5*)	602 (*3.7*)	649 (*3.3*)	687 (*3.2*)	708 (*3.7*)
Korea, Rep. of	474 (*7.0*)	504 (*4.2*)	545 (*3.2*)	590 (*2.3*)	633 (*2.3*)	671 (*3.1*)	693 (*4.1*)
Japan	442 (*4.5*)	473 (*3.8*)	519 (*2.7*)	566 (*1.9*)	609 (*2.1*)	645 (*2.7*)	668 (*3.4*)
Chinese Taipei	444 (*4.7*)	471 (*4.4*)	516 (*2.7*)	562 (*2.0*)	604 (*1.9*)	639 (*2.7*)	659 (*4.1*)
Finland	429 (*6.9*)	464 (*4.5*)	513 (*3.1*)	559 (*1.9*)	602 (*2.8*)	640 (*3.0*)	662 (*3.3*)
United States	387 (*5.6*)	426 (*4.8*)	486 (*3.6*)	546 (*3.0*)	598 (*2.2*)	641 (*2.5*)	664 (*2.6*)
England	413 (*6.8*)	444 (*4.5*)	491 (*3.3*)	540 (*2.7*)	587 (*3.3*)	626 (*4.6*)	648 (*4.8*)
Australia	389 (*6.0*)	427 (*4.4*)	484 (*2.8*)	538 (*3.2*)	587 (*2.4*)	629 (*3.6*)	653 (*4.3*)
Ireland	**393 (*7.1*)**	**427 (*5.4*)**	**481 (*4.8*)**	**534 (*3.5*)**	**580 (*3.2*)**	**620 (*2.8*)**	**643 (*4.5*)**
Northern Ireland	392 (*7.0*)	424 (*4.1*)	473 (*3.3*)	524 (*3.0*)	568 (*2.8*)	606 (*3.7*)	627 (*4.7*)
New Zealand	360 (*4.0*)	392 (*4.5*)	448 (*3.2*)	507 (*2.6*)	561 (*2.5*)	605 (*3.4*)	629 (*3.7*)

Table B3: Percentiles of mathematics achievement for Ireland and comparison countries – Eighth grade

	5th	10th	25th	50th	75th	90th	95th
Singapore	445 (*7.8*)	487 (*10.4*)	565 (*7.5*)	628 (*4.6*)	679 (*3.1*)	718 (*2.8*)	740 (*3.3*)
Chinese Taipei	435 (*5.4*)	475 (*3.9*)	550 (*4.0*)	623 (*3.3*)	682 (*3.6*)	731 (*3.5*)	759 (*4.8*)
Korea, Rep. of	435 (*6.2*)	475 (*5.5*)	547 (*3.1*)	613 (*2.7*)	674 (*4.1*)	727 (*6.6*)	755 (*6.0*)
Japan	451 (*4.3*)	485 (*3.9*)	538 (*2.6*)	595 (*2.3*)	653 (*3.5*)	700 (*5.4*)	727 (*6.9*)
Ireland	**395 (*7.3*)**	**426 (*5.8*)**	**476 (*3.9*)**	**528 (*2.7*)**	**574 (*2.5*)**	**614 (*3.8*)**	**636 (*3.0*)**
Australia	369 (*5.3*)	401 (*4.0*)	456 (*3.8*)	518 (*4.2*)	578 (*5.2*)	632 (*7.0*)	666 (*9.0*)
United States	348 (*9.4*)	385 (*7.2*)	448 (*5.8*)	518 (*5.1*)	588 (*5.3*)	642 (*4.8*)	671 (*4.9*)
England	363 (*9.2*)	398 (*8.3*)	457 (*6.9*)	516 (*5.9*)	575 (*6.8*)	628 (*7.6*)	660 (*10.2*)
Finland	384 (*6.0*)	412 (*5.4*)	460 (*3.6*)	512 (*2.7*)	560 (*2.9*)	602 (*3.1*)	624 (*2.9*)
New Zealand	333 (*7.1*)	367 (*6.3*)	422 (*5.1*)	482 (*3.5*)	542 (*3.6*)	598 (*4.0*)	629 (*4.3*)

Table B4: Percentiles of science achievement for Ireland and comparison countries – Eighth grade

	5th	10th	25th	50th	75th	90th	95th
Singapore	439 (*12.2*)	485 (*9.4*)	557 (*7.4*)	621 (*4.5*)	669 (*2.8*)	708 (*3.2*)	731 (*2.6*)
Chinese Taipei	426 (*5.6*)	464 (*3.2*)	522 (*2.2*)	581 (*2.6*)	634 (*2.4*)	674 (*2.4*)	698 (*3.9*)
Japan	444 (*3.7*)	473 (*3.6*)	523 (*2.1*)	573 (*2.4*)	620 (*3.2*)	659 (*4.0*)	681 (*4.7*)
Korea, Rep. of	415 (*6.5*)	453 (*4.1*)	509 (*3.4*)	563 (*1.9*)	617 (*2.9*)	666 (*3.9*)	694 (*5.6*)
Finland	388 (*8.8*)	428 (*6.6*)	490 (*4.2*)	549 (*3.1*)	602 (*2.7*)	647 (*4.0*)	673 (*3.8*)
Australia	373 (*6.5*)	409 (*4.6*)	473 (*4.3*)	534 (*3.4*)	589 (*3.8*)	635 (*4.8*)	663 (*6.2*)
Ireland	**376 (*8.7*)**	**413 (*5.9*)**	**470 (*4.2*)**	**529 (*3.4*)**	**582 (*3.4*)**	**624 (*3.1*)**	**649 (*5.2*)**
United States	345 (*11.0*)	388 (*8.8*)	458 (*6.4*)	531 (*5.4*)	594 (*4.1*)	642 (*4.2*)	670 (*3.9*)
England	356 (*9.3*)	393 (*8.6*)	458 (*6.9*)	523 (*5.0*)	580 (*4.7*)	630 (*6.6*)	659 (*7.9*)
New Zealand	336 (*8.1*)	375 (*6.5*)	440 (*5.1*)	505 (*3.5*)	563 (*3.7*)	613 (*3.4*)	643 (*4.2*)

Appendix C: Standard errors for mean scores on content and cognitive subscales

Mathematics – Fourth Class – content domains

Table C1: Mean scores of girls and boys and associated standard errors in mathematics content domains – Fourth Class

	Number		Measurement & Geometry		Data	
	Girls	Boys	Girls	Boys	Girls	Boys
Singapore	631 (*4.3*)	639 (*4.3*)	615 (*4.0*)	625 (*4.5*)	611 (*4.1*)	616 (*4.3*)
Korea, Rep. of	589 (*2.6*)	597 (*3.1*)	605 (*3.0*)	610 (*3.1*)	605 (*3.2*)	600 (*3.5*)
Chinese Taipei	597 (*2.4*)	602 (*2.2*)	606 (*1.9*)	609 (*2.4*)	588 (*3.6*)	592 (*2.7*)
Japan	585 (*2.2*)	587 (*2.2*)	602 (*3.4*)	601 (*2.6*)	608 (*2.5*)	603 (*2.2*)
Northern Ireland	571 (*3.6*)	574 (*3.8*)	551 (*3.8*)	560 (*3.7*)	564 (*3.1*)	564 (*4.0*)
England	556 (*4.4*)	562 (*3.4*)	540 (*4.5*)	550 (*3.2*)	561 (*4.2*)	568 (*3.5*)
Ireland	**551 (*3.2*)**	**558 (*3.2*)**	**538 (*3.7*)**	**543 (*3.2*)**	**540 (*3.8*)**	**545 (*3.4*)**
United States	537 (*2.9*)	547 (*3.1*)	513 (*3.0*)	526 (*3.0*)	527 (*3.2*)	539 (*3.8*)
Finland	525 (*2.9*)	530 (*2.8*)	537 (*3.4*)	540 (*3.3*)	534 (*3.6*)	534 (*3.1*)
Australia	501 (*3.0*)	511 (*3.8*)	509 (*3.2*)	523 (*3.9*)	531 (*4.0*)	537 (*3.6*)
New Zealand	476 (*4.3*)	481 (*3.6*)	476 (*3.7*)	486 (*3.4*)	503 (*4.8*)	504 (*3.8*)

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

Mathematics – Fourth Class – cognitive domains

Table C2: Mean scores of girls and boys and associated standard errors in mathematics cognitive domains – Fourth Class

	Knowing		Applying		Reasoning	
	Girls	Boys	Girls	Boys	Girls	Boys
Singapore	634 (*4.2*)	646 (*4.4*)	623 (*4.0*)	628 (*4.2*)	609 (*4.2*)	619 (*4.4*)
Korea, Rep. of	608 (*4.8*)	616 (*4.3*)	594 (*2.7*)	595 (*2.9*)	591 (*3.1*)	601 (*3.5*)
Chinese Taipei	619 (*2.1*)	624 (*2.6*)	599 (*1.9*)	601 (*2.0*)	570 (*2.4*)	581 (*2.9*)
Japan	597 (*2.4*)	598 (*2.6*)	594 (*2.8*)	591 (*2.0*)	588 (*3.0*)	590 (*2.5*)
Northern Ireland	570 (*4.0*)	579 (*4.2*)	565 (*3.4*)	564 (*3.7*)	556 (*3.2*)	561 (*3.9*)
England	555 (*4.4*)	570 (*3.6*)	552 (*4.1*)	555 (*3.4*)	550 (*5.0*)	558 (*3.3*)
Ireland	**546 (*4.1*)**	**554 (*3.4*)**	**548 (*3.4*)**	**554 (*3.0*)**	**538 (*3.4*)**	**546 (*3.3*)**
United States	528 (*3.0*)	544 (*3.0*)	534 (*3.0*)	541 (*2.9*)	516 (*3.3*)	531 (*2.8*)
Finland	528 (*3.1*)	534 (*3.0*)	532 (*3.1*)	530 (*2.8*)	533 (*3.1*)	538 (*3.2*)
Australia	499 (*3.4*)	519 (*4.0*)	513 (*2.9*)	519 (*3.5*)	517 (*3.2*)	528 (*3.8*)
New Zealand	469 (*4.3*)	482 (*3.6*)	487 (*3.7*)	488 (*3.1*)	499 (*3.5*)	503 (*3.5*)

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

Mathematics – Second Year – content domains

Table C3: Mean scores of girls and boys and associated standard errors in mathematics content domains – Second Year

	Number		Algebra		Geometry		Data & Probability	
	Girls	Boys	Girls	Boys	Girls	Boys	Girls	Boys
Singapore	611 (*4.5*)	611 (*4.8*)	623 (*5.1*)	615 (*5.3*)	620 (*4.7*)	618 (*4.4*)	623 (*5.4*)	618 (*5.3*)
Chinese Taipei	612 (*3.3*)	614 (*3.5*)	623 (*3.0*)	613 (*3.4*)	623 (*3.2*)	623 (*3.7*)	593 (*3.7*)	594 (*3.4*)
Korea, Rep. of	602 (*3.3*)	608 (*3.2*)	611 (*4.2*)	608 (*4.0*)	613 (*3.9*)	621 (*3.3*)	594 (*3.5*)	601 (*3.0*)
Japan	573 (*3.7*)	583 (*4.0*)	605 (*2.9*)	600 (*4.1*)	609 (*3.4*)	611 (*4.0*)	592 (*2.7*)	597 (*3.0*)
Ireland	**538 (*3.4*)**	**544 (*4.0*)**	**510 (*3.1*)**	**501 (*3.7*)**	**504 (*3.5*)**	**508 (*3.6*)**	**541 (*3.6*)**	**540 (*4.6*)**
Australia	515 (*3.7*)	528 (*5.7*)	502 (*4.1*)	501 (*5.9*)	510 (*3.9*)	517 (*5.8*)	532 (*3.8*)	534 (*5.7*)
United States	518 (*3.7*)	522 (*5.7*)	528 (*4.5*)	512 (*6.8*)	500 (*4.1*)	499 (*6.1*)	510 (*4.4*)	509 (*7.0*)
England	513 (*5.6*)	526 (*7.4*)	507 (*6.5*)	500 (*7.8*)	510 (*5.8*)	507 (*7.2*)	523 (*6.6*)	523 (*8.3*)
Finland	512 (*2.8*)	517 (*3.1*)	495 (*3.2*)	483 (*3.6*)	517 (*3.7*)	504 (*3.8*)	517 (*3.6*)	511 (*4.4*)
New Zealand	477 (*3.8*)	489 (*5.1*)	464 (*4.1*)	464 (*5.2*)	474 (*4.1*)	479 (*5.1*)	492 (*3.9*)	499 (*5.5*)

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

Mathematics – Second Year – cognitive domains

Table C4: Mean scores of girls and boys and associated standard errors in mathematics cognitive domains – Second Year

	Knowing		Applying		Reasoning	
	Girls	Boys	Girls	Boys	Girls	Boys
Singapore	618 (*5.0*)	611 (*4.8*)	616 (*4.4*)	613 (*4.2*)	622 (*5.0*)	619 (*5.1*)
Chinese Taipei	619 (*3.4*)	613 (*3.7*)	611 (*3.0*)	609 (*3.2*)	616 (*3.0*)	616 (*3.2*)
Korea, Rep. of	612 (*4.2*)	616 (*3.5*)	602 (*3.5*)	606 (*2.9*)	606 (*3.3*)	612 (*3.7*)
Japan	589 (*3.6*)	589 (*3.5*)	594 (*3.0*)	598 (*3.2*)	598 (*3.3*)	600 (*3.6*)
Ireland	**533 (*3.4*)**	**528 (*3.6*)**	**527 (*2.9*)**	**526 (*3.6*)**	**507 (*3.5*)**	**509 (*4.3*)**
Australia	509 (*3.7*)	513 (*5.8*)	519 (*3.6*)	524 (*5.6*)	512 (*4.0*)	517 (*5.7*)
United States	525 (*4.4*)	519 (*6.6*)	517 (*4.1*)	513 (*6.3*)	508 (*3.9*)	507 (*5.8*)
England	507 (*6.1*)	514 (*7.3*)	519 (*5.7*)	517 (*7.2*)	512 (*6.1*)	512 (*7.8*)
Finland	506 (*2.8*)	504 (*3.0*)	513 (*2.9*)	508 (*3.3*)	509 (*3.2*)	504 (*3.5*)
New Zealand	462 (*3.7*)	473 (*5.2*)	483 (*3.5*)	489 (*4.6*)	483 (*3.4*)	489 (*5.0*)

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

Science – Fourth Class – content domains

Table C5: Mean scores of girls and boys and associated standard errors in science content domains – Fourth Class

	Life Science		Physical Science		Earth Science	
	Girls	Boys	Girls	Boys	Girls	Boys
Singapore	601 (*3.9*)	605 (*4.2*)	607 (*3.9*)	619 (*4.0*)	548 (*3.9*)	565 (*4.5*)
Korea, Rep. of	572 (*3.2*)	576 (*2.5*)	600 (*3.3*)	613 (*2.8*)	579 (*3.5*)	594 (*3.7*)
Japan	554 (*2.4*)	547 (*2.4*)	580 (*2.2*)	577 (*2.2*)	558 (*2.9*)	560 (*3.2*)
Chinese Taipei	542 (*3.6*)	539 (*2.3*)	570 (*1.9*)	576 (*2.8*)	565 (*2.7*)	571 (*2.0*)
Finland	565 (*3.7*)	552 (*3.3*)	544 (*3.8*)	544 (*4.3*)	564 (*3.7*)	562 (*5.1*)
United States	547 (*2.6*)	546 (*3.4*)	523 (*3.7*)	531 (*3.1*)	533 (*3.7*)	543 (*3.4*)
England	540 (*3.7*)	535 (*3.7*)	534 (*4.2*)	540 (*3.6*)	532 (*3.3*)	534 (*3.8*)
Australia	543 (*2.9*)	535 (*3.4*)	524 (*3.4*)	528 (*3.3*)	524 (*3.0*)	530 (*3.5*)
Ireland	**530 (*4.3*)**	**526 (*3.6*)**	**520 (*4.1*)**	**526 (*3.3*)**	**529 (*4.8*)**	**543 (*3.9*)**
Northern Ireland	523 (*3.9*)	517 (*4.2*)	510 (*2.7*)	512 (*2.9*)	521 (*3.2*)	528 (*3.9*)
New Zealand	516 (*3.9*)	504 (*2.8*)	493 (*2.9*)	492 (*2.9*)	501 (*5.4*)	505 (*3.6*)

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

Science – Fourth Class – cognitive domains

Table C6: Mean scores of girls and boys and associated standard errors in science cognitive domains – Fourth Class

	Knowing		Applying		Reasoning	
	Girls	Boys	Girls	Boys	Girls	Boys
Singapore	580 (*3.9*)	595 (*4.2*)	591 (*4.1*)	599 (*3.9*)	605 (*4.0*)	603 (*3.8*)
Korea, Rep. of	573 (*2.3*)	595 (*3.2*)	594 (*2.9*)	598 (*2.8*)	580 (*2.9*)	583 (*3.7*)
Japan	533 (*2.5*)	537 (*3.3*)	581 (*2.3*)	572 (*2.9*)	585 (*3.1*)	574 (*4.3*)
Chinese Taipei	556 (*2.3*)	565 (*2.6*)	559 (*2.5*)	562 (*2.4*)	556 (*4.1*)	548 (*3.0*)
Finland	553 (*3.1*)	553 (*2.7*)	554 (*3.3*)	548 (*2.7*)	568 (*3.1*)	557 (*3.2*)
United States	537 (*3.4*)	547 (*3.1*)	534 (*3.1*)	536 (*3.7*)	538 (*3.1*)	539 (*3.2*)
England	542 (*3.9*)	545 (*4.0*)	526 (*4.1*)	525 (*3.4*)	548 (*3.9*)	539 (*4.5*)
Australia	535 (*3.0*)	540 (*3.7*)	526 (*4.0*)	521 (*3.5*)	541 (*3.2*)	534 (*3.3*)
Ireland	**528 (*4.8*)**	**535 (*3.5*)**	**524 (*4.0*)**	**527 (*3.1*)**	**527 (*4.7*)**	**524 (*4.1*)**
Northern Ireland	521 (*3.7*)	525 (*3.7*)	514 (*3.6*)	514 (*3.3*)	525 (*3.9*)	514 (*4.0*)
New Zealand	504 (*3.8*)	505 (*3.6*)	500 (*3.6*)	495 (*3.5*)	512 (*3.5*)	498 (*3.3*)

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

Science – Second Year – content domains

Table C7: Mean scores of girls and boys and associated standard errors in science content domains – Second Year

	Number		Algebra		Geometry		Data & Probability	
	Girls	Boys	Girls	Boys	Girls	Boys	Girls	Boys
Singapore	621 (*4.7*)	623 (*5.2*)	617 (*5.8*)	614 (*5.7*)	614 (*5.0*)	624 (*4.8*)	551 (*5.4*)	572 (*4.3*)
Chinese Taipei	577 (*3.1*)	575 (*2.7*)	598 (*3.3*)	591 (*3.1*)	550 (*3.3*)	560 (*3.3*)	572 (*3.4*)	586 (*2.8*)
Japan	571 (*2.2*)	577 (*3.2*)	560 (*2.5*)	560 (*3.6*)	563 (*2.8*)	578 (*3.4*)	563 (*3.5*)	581 (*4.9*)
Korea, Rep. of	554 (*3.0*)	565 (*2.8*)	553 (*4.0*)	549 (*3.7*)	563 (*3.7*)	575 (*3.2*)	549 (*4.3*)	574 (*3.7*)
Finland	549 (*3.4*)	520 (*4.1*)	561 (*4.0*)	530 (*4.7*)	542 (*4.0*)	537 (*5.1*)	562 (*4.4*)	555 (*4.0*)
Australia	533 (*3.2*)	529 (*4.8*)	519 (*3.5*)	510 (*5.3*)	524 (*3.6*)	533 (*5.0*)	531 (*3.3*)	536 (*4.6*)
Ireland	**523 (*3.2*)**	**520 (*4.4*)**	**525 (*4.6*)**	**500 (*5.0*)**	**517 (*4.1*)**	**520 (*4.7*)**	**536 (*4.5*)**	**536 (*4.2*)**
United States	536 (*4.0*)	524 (*6.2*)	515 (*4.6*)	503 (*7.0*)	514 (*4.2*)	515 (*6.6*)	527 (*4.5*)	532 (*6.8*)
England	518 (*5.9*)	513 (*6.7*)	521 (*7.5*)	502 (*7.9*)	517 (*5.9*)	515 (*7.2*)	513 (*6.8*)	523 (*7.0*)
New Zealand	500 (*3.7*)	496 (*5.0*)	483 (*3.8*)	481 (*6.1*)	496 (*3.9*)	507 (*5.4*)	502 (*3.5*)	517 (*5.4*)

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

Science – Second Year – cognitive domains

Table C8: Mean scores of girls and boys and associated standard errors in science cognitive domains – Second Year

	Knowing		Applying		Reasoning	
	Girls	Boys	Girls	Boys	Girls	Boys
Singapore	617 (*4.9*)	624 (*4.9*)	604 (*4.6*)	613 (*5.0*)	591 (*4.8*)	598 (*4.5*)
Chinese Taipei	592 (*2.9*)	608 (*2.9*)	567 (*2.5*)	567 (*2.9*)	560 (*2.7*)	558 (*2.6*)
Japan	555 (*3.3*)	572 (*2.7*)	571 (*2.5*)	581 (*2.7*)	569 (*2.5*)	571 (*3.0*)
Korea, Rep. of	549 (*3.8*)	567 (*3.0*)	554 (*3.2*)	566 (*2.8*)	562 (*3.4*)	566 (*2.5*)
Finland	553 (*3.2*)	537 (*4.2*)	547 (*3.4*)	527 (*4.0*)	559 (*3.9*)	537 (*4.1*)
Australia	511 (*3.3*)	518 (*5.3*)	534 (*3.2*)	530 (*4.9*)	538 (*3.1*)	533 (*4.7*)
Ireland	**512 (*3.6*)**	**514 (*4.1*)**	**525 (*4.1*)**	**518 (*4.2*)**	**538 (*3.6*)**	**531 (*4.6*)**
United States	515 (*4.1*)	514 (*5.9*)	525 (*4.2*)	521 (*6.3*)	530 (*3.8*)	526 (*6.2*)
England	519 (*6.1*)	521 (*6.9*)	517 (*6.0*)	512 (*6.8*)	516 (*5.7*)	510 (*6.8*)
New Zealand	475 (*3.7*)	484 (*5.3*)	500 (*4.2*)	505 (*5.2*)	510 (*3.6*)	509 (*5.0*)

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

Appendix D: Teacher reports of topic coverage

Mathematics – Fourth Class

Table D1: Percentages of students taught the TIMSS mathematics topics (teachers' reports) – Fourth Class

		Mostly taught before this year % students (*SE*)	Mostly taught this year % students (*SE*)	Not yet taught or just introduced % students (*SE*)
Number	Concepts of whole numbers, including place value and ordering	71 (*3.0*)	27 (*3.2*)	1 (*1.2*)
	Adding, subtracting, multiplying and dividing with whole numbers	57 (*3.3*)	43 (*3.3*)	0.3 (*0.3*)
	Concepts of multiples and factors; odd and even numbers	53 (*4.0*)	42 (*3.8*)	5 (*1.6*)
	Number sentences (finding the missing number, representing problem situations with number sentences)	54 (*3.8*)	40 (*3.5*)	6 (*1.7*)
	Number patterns (extending number patterns and finding missing terms)	60 (*3.6*)	36 (*3.7*)	4 (*1.2*)
	Concepts of fractions, including representing, comparing and ordering, adding and subtracting simple fractions	13 (*2.2*)	73 (*2.9*)	14 (*2.5*)
	Concepts of decimals, including place value and ordering, adding and subtracting with decimals	13 (*2.7*)	79 (*3.6*)	8 (*2.7*)
Measurement & Geometry	Solving problems involving length, including measuring and estimating	42 (*3.7*)	47 (*3.7*)	11 (*1.8*)
	Solving problems involving mass, volume and time	22 (*3.1*)	43 (*4.1*)	35 (*3.7*)
	Finding and estimating perimeter, area and volume	12 (*2.6*)	55 (*4.3*)	33 (*3.9*)
	Parallel and perpendicular lines	22 (*3.3*)	76 (*3.1*)	2 (*1.0*)
	Comparing and drawing angles	10 (*2.4*)	62 (*4.2*)	28 (*3.7*)
	Elementary properties of common geometric shapes	39 (*3.9*)	49 (*3.9*)	12 (*2.4*)
	3-D shapes, including relationships with their 2-D representations	36 (*4.1*)	52 (*3.8*)	13 (*2.2*)
Data	Reading and interpreting data from tables, pictographs, bar graphs, line graphs and pie charts	41 (*3.6*)	53 (*3.6*)	6 (*1.8*)
	Organising and representing data to help answer questions	33 (*3.8*)	58 (*3.8*)	9 (*2.2*)
	Drawing conclusions from data displays	32 (*4.1*)	58 (*3.8*)	10 (*2.2*)

Due to rounding, percentages do not always add to 100.

Science – Fourth Class

Table D2: Percentages of pupils taught the TIMSS science topics (teachers' reports) – Fourth Class

		Mostly taught before this year % students (*SE*)	Mostly taught this year % students (*SE*)	Not yet taught or just introduced % students (*SE*)
Life Science	Physical and behavioural characteristics of living things and major groups of living things (e.g., mammals, birds, insects, flowering plants)	59 (*3.8*)	36 (*3.7*)	4 (*1.5*)
	Major body structures and their functions in humans, other animals and plants	28 (*3.5*)	57 (*3.7*)	16 (*2.6*)
	Life cycles of common plants and animals (e.g., flowering plants, butterflies, frogs)	72 (*3.5*)	16 (*2.7*)	11 (*2.6*)
	Characteristics of plants and animals that are inherited	30 (*3.4*)	19 (*2.7*)	51 (*3.8*)
	Interactions between organisms and their environment (e.g., physical features and behaviours that help living things survive in their environments)	24 (*3.2*)	47 (*4.2*)	29 (*3.4*)
	Relationships in ecosystems (e.g., simple food chains, predator-prey relationships, competition)	29 (*3.4*)	43 (*3.6*)	28 (*2.7*)
	Human health (transmission and prevention of diseases, everyday behaviours that promote good health)	30 (*3.6*)	45 (*3.8*)	25 (*3.6*)
Physical Science	States of matter (solid, liquid, gas) and their properties (volume, shape)	23 (*3.2*)	55 (*4.2*)	22 (*3.3*)
	Classifying materials based on physical properties (weight/mass, volume, state of matter, conductivity of heat or electricity)	22 (*3.1*)	44 (*4.2*)	34 (*3.9*)
	Mixtures, including methods for separating a mixture into its components (e.g., sifting, filtering, evaporation, using a magnet)	17 (*2.9*)	31 (*3.0*)	52 (*3.4*)
	Properties of magnets (e.g., like poles repel and opposite poles attract, magnets can attract some objects)	42 (*3.6*)	38 (*3.8*)	20 (*3.1*)
	Physical changes in everyday life (e.g., changes of state, dissolving)	32 (*3.6*)	42 (*4.0*)	25 (*3.7*)
	Chemical changes in everyday life (e.g., decaying, burning, rusting, cooking)	17 (*2.7*)	30 (*3.5*)	53 (*3.6*)
	Common sources of energy (e.g., the Sun, wind, oil) and uses of energy (heating and cooling homes, providing light)	30 (*3.1*)	60 (*3.8*)	10 (*2.5*)
	Light and sound in everyday life (e.g., shadows and reflections, vibrating objects make sound)	39 (*4.0*)	43 (*4.4*)	18 (*3.3*)
	Heat transfer (e.g., energy flows from a hot object to a colder object)	20 (*2.9*)	35 (*3.4*)	44 (*3.7*)
	Electricity and simple circuits (e.g., a circuit must be complete to work correctly)	22 (*2.9*)	34 (*3.5*)	44 (*4.2*)
	Forces that cause objects to move (e.g., gravity, pushing/pulling) or change their motion (e.g., friction)	32 (*3.9*)	46 (*3.7*)	22 (*3.1*)
	Simple machines (e.g., levers pulleys, wheels, ramps) that help make motion easier	21 (*2.8*)	38 (*3.2*)	41 (*3.4*)

(Cont.)

Table D2 (continued): Percentages of pupils taught the TIMSS science topics (teachers' reports) – Fourth Class

		Mostly taught before this year % students (*SE*)	Mostly taught this year % students (*SE*)	Not yet taught or just introduced % students (*SE*)
Earth Science	Physical makeup of Earth's surface (e.g., land and water in unequal proportions, sources of fresh and salt water)	24 (*3.6*)	49 (*4.1*)	27 (*3.0*)
	Earth's resources used in everyday life (e.g., water, wind, soil, forests, oil, natural gas, minerals)	19 (*3.1*)	62 (*3.5*)	19 (*2.7*)
	Changes in Earth's surface over time (e.g., mountain building, weathering, erosion)	8 (*2.0*)	41 (*3.6*)	50 (*3.9*)
	Fossils and what they can tell us about past conditions on Earth	14 (*2.5*)	28 (*3.3*)	58 (*3.6*)
	Weather and climate (e.g., daily, seasonal, and locational variations versus long-term trends)	31 (*3.7*)	60 (*3.9*)	9 (*1.9*)
	Objects in the solar system (the Sun, the Earth, the Moon, and other planets) and their movements	40 (*3.8*)	43 (*3.5*)	17 (*3.1*)
	Earth's motion and related patterns observed on Earth (e.g., day and night, seasons)	40 (*3.4*)	44 (*3.4*)	16 (*2.8*)

Due to rounding, percentages do not always add to 100.

Mathematics – Second Year

Table D3: Percentages of students taught the TIMSS mathematics topics (teachers' reports) – Second Year

		Mostly taught before this year % students (*SE*)	Mostly taught this year % students (*SE*)	Not yet taught or just introduced % students (*SE*)
Number	Computing with negative numbers	94 (*1.3*)	6 (*1.3*)	0 (*0.0*)
	Concepts of fractions and decimals	94 (*1.3*)	6 (*1.3*)	0 (*0.0*)
	Solving problems involving proportions and percent	74 (*2.7*)	23 (*2.7*)	3 (*0.9*)
Algebra	Simplifying and evaluating algebraic expressions	42 (*3.4*)	57 (*3.4*)	1 (*0.4*)
	Simple linear equations	37 (*3.1*)	61 (*3.1*)	2 (*0.6*)
	Simple linear inequalities	6 (*1.4*)	72 (*3.1*)	22 (*2.7*)
	Simultaneous (two variables) equations	2 (*1.1*)	70 (*3.2*)	28 (*3.0*)
	Representation of liner and quadratic functions in tables, graphs, words or equations	2 (*0.8*)	56 (*2.8*)	42 (*2.9*)
	Properties of functions	3 (*1.4*)	51 (*3.2*)	45 (*3.4*)
	Numeric, algebraic and geometric patterns of sequences	13 (*2.2*)	41 (*3.3*)	46 (*3.4*)
Geometry	Geometric properties of angles, pairs of lines and geometric shapes	42 (*3.2*)	32 (*3.1*)	27 (*3.0*)
	Solving problems involving perimeters, circumferences and areas	22 (*2.9*)	52 (*3.4*)	26 (*3.0*)
	Solving problems involving the Pythagorean Theorem	2 (*0.8*)	53 (*3.4*)	45 (*3.5*)
	Translation, reflection and rotation	12 (*2.5*)	18 (*2.6*)	70 (*3.2*)
	Congruent figures and similar triangles	3 (*1.1*)	27 (*3.1*)	70 (*3.3*)
	Solving problems with 3D shapes	2 (*0.9*)	33 (*3.4*)	65 (*3.5*)
Data and Probability	Reading and interpreting data from one or more sources to solve problems	28 (*2.9*)	38 (*3.3*)	34 (*3.2*)
	Identifying appropriate procedures for collecting data	46 (*3.4*)	37 (*3.4*)	17 (*2.6*)
	Organising and representing data to help answer questions	42 (*3.5*)	41 (*3.3*)	17 (*2.5*)
	Calculating and interpreting statistics summarising data distributions	18 (*2.8*)	47 (*3.6*)	35 (*3.5*)
	Theoretical and empirical probability of simple events	25 (*2.9*)	33 (*3.3*)	42 (*2.9*)
	Theoretical and empirical probability of compound events	9 (*1.9*)	30 (*3.1*)	61 (*3.4*)

Due to rounding, percentages do not always add to 100.

Science – Second Year

Table D4: Percentages of students taught the TIMSS science topics (teachers' reports) – Second Year

		Mostly taught before this year % students (*SE*)	Mostly taught this year % students (*SE*)	Not yet taught or just introduced % students (*SE*)
Biology	Differences among major taxonomic groups of organisms	53 (*3.2*)	12 (*2.3*)	35 (*3.3*)
	Major organs and organ systems in humans and other organisms	43 (*3.6*)	51 (*3.4*)	6 (*1.9*)
	Cells, their structure and functions including respiration and photosynthesis	58 (*2.9*)	33 (*3.0*)	9 (*2.1*)
	Life cycles, sexual reproduction and heredity	9 (*2.3*)	49 (*4.0*)	42 (*4.0*)
	Role of variation and adaptation in survival/ extinction	8 (*1.9*)	34 (*3.6*)	59 (*3.5*)
	Interdependence of populations of organisms in ecosystems	7 (*1.6*)	35 (*3.2*)	58 (*3.5*)
	Human health	29 (*3.1*)	41 (*3.3*)	30 (*3.2*)
Chemistry	Particulate structure, classification and composition of matter	40 (*4.0*)	54 (*3.8*)	6 (*1.9*)
	The periodic table as an organising principle for the known elements	26 (*3.0*)	66 (*3.5*)	8 (*2.1*)
	Physical and chemical properties of matter	67 (*3.5*)	29 (*3.3*)	4 (*1.4*)
	Mixtures and solutions	80 (*2.6*)	17 (*2.3*)	2 (*1.2*)
	Properties of common acids and bases	21 (*3.3*)	61 (*3.8*)	18 (*2.3*)
	Characteristics of chemical reactions	8 (*2.2*)	51 (*4.0*)	40 (*3.7*)
	Matter and energy in chemical reactions	6 (*1.4*)	40 (*3.6*)	54 (*3.9*)
	The role of electrons in chemical bonds	4 (*1.2*)	46 (*4.0*)	50 (*4.0*)
Physics	Physical states and changes in matter	78 (*2.7*)	15 (*2.5*)	7 (*1.4*)
	Energy transformation and transfer	32 (*3.4*)	48 (*3.9*)	21 (*3.0*)
	Properties/behaviours of light	7 (*1.7*)	13 (*2.4*)	81 (*2.6*)
	Properties/behaviours of sound	4 (*0.9*)	17 (*2.7*)	79 (*2.7*)
	Electric circuits	3 (*1.1*)	16 (*2.6*)	81 (*2.8*)
	Properties and uses of permanent magnets and electromagnets	7 (*1.4*)	17 (*2.7*)	76 (*2.8*)
	Motion and forces	19 (*3.2*)	61 (*3.7*)	20 (*3.3*)
Earth Science	Earth's structure and physical features	25 (*3.0*)	22 (*2.9*)	53 (*3.6*)
	Earth's processes, cycles and history	12 (*2.2*)	31 (*3.8*)	57 (*3.6*)
	Earth's resources, their use and conservation	16 (*2.6*)	39 (*3.7*)	44 (*3.7*)
	Earth in the solar system and the universe	27 (*3.2*)	44 (*3.6*)	28 (*3.8*)

Due to rounding, percentages do not always add to 100..

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