TIMSS 2015 in Ireland:

MATHEMATICS AND SCIENCE IN PRIMARY AND POST-PRIMARY SCHOOLS

Aidan Clerkin • Rachel Perkins • Rachel Cunningham

Educational Research Centre
Foras Taighde ar Oideachas

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Preface

TIMSS (**T**rends in **I**nternational **M**athematics and **S**cience **S**tudy) is a project of the International Association for the Evaluation of Educational Achievement (IEA). It assesses the mathematics and science skills of students in many countries at both primary level (Fourth grade, which is Fourth Class in Ireland) and post-primary (Eighth grade, which is Second Year in Ireland). TIMSS 2015 is the sixth iteration of the study, which has taken place every four years since 1995. Ireland has previously taken part in 1995 (at both primary and post-primary levels) and in 2011 (at primary level only).

In 2015, Ireland participated in TIMSS at both grade levels. Students in 149 primary schools and 149 post-primary schools took part in April/May 2015, each completing a test of mathematics and science and an accompanying questionnaire. In total, more than 9000 students took part. These students' parents (at Fourth Class only), principals, and class teachers (for Fourth Class) or mathematics and science teachers (for Second Year) also completed questionnaires and supporting documentation.

This report is the first in a series of national reports that present the findings of TIMSS 2015, and is being published to coincide with the release of the IEA's international reports on mathematics (Mullis, Martin, Foy & Hooper, 2016) and science (Martin, Mullis, Foy & Hooper, 2016). It focuses on the main achievement-related findings for both grade levels, describing the mathematics and science performance of students in Ireland in comparison to their peers internationally, and also with reference to changes in Irish performance from previous cycles of TIMSS.

Chapter 1 introduces readers to the structure of TIMSS in general and Chapter 2 describes the implementation of TIMSS 2015 in Ireland more specifically. Chapter 3 presents the main mathematics and science results for both grade levels, with comparisons by gender and over time. Chapter 4 describes the distribution of performance (i.e., examining the performance of the 'highest-' and 'lowest-achieving' students on the assessment, and the range in-between). Chapter 5 discusses student achievement with reference to four internationally-defined Benchmarks of achievement, each of which describes the mathematical or scientific skills that students reaching that level can typically demonstrate. Chapter 6 presents relative strengths and weaknesses based on students' performance on the mathematics content and cognitive subscales. Chapter 7 presents similar information for science, based on the scientific content and cognitive subscales. Chapter 8 provides a comparison between the Irish curricula (for both subjects at both grade levels) and the TIMSS assessment frameworks, in order to identify areas of the curricula that may or may not have been covered by the time of the assessment. Finally, Chapter 9 provides a summary of the main findings, and introduces readers to a series of follow-on reports.

In 2017, a number of contextual reports will be published by the Educational Research Centre that will examine the educational context in Ireland more closely, and associations between contextual factors and student achievement. These reports will use the detailed information provided by students, parents, principals and teachers, together with national-level structural factors, to provide a more complete snapshot of mathematics and science education in Ireland.

Acknowledgements

We gratefully acknowledge the contributions of the members of the National Advisory Committees that provided ongoing guidance and feedback during the implementation of TIMSS 2015 in Ireland, at both primary and post-primary levels. The membership of both committees is given in full in Appendix A.

Thanks are due to staff at the Educational Research Centre, including Eemer Eivers and Peter Archer (CEO) for their guidance and support at all stages of the study. Carly Cheevers, Sylvia Denner, Darina Scully, Katie Gilligan, Adrian O'Flaherty and Emma Chubb worked on various parts of the study as Research Assistants, and David Millar, John Coyle, Caoimhe Máirtín, Deaglán Ó Caoimh, Mary Rohan, Paula Chute, Anne Comey and Hilary Walshe provided technical and administrative support. We also acknowledge the Inspectorate of the Department of Education and Skills for their assistance in administering a National Quality Control Monitoring programme in order to ensure that the administration of TIMSS in Ireland met with international standards.

Finally – and most importantly – we thank the many school principals, school coordinators, teachers, students and parents who participated in TIMSS 2015 at both Fourth Class and Second Year. Without their help this study, and the findings arising from it, would not be possible.

Chapter 1:
Introduction

TIMSS (**T**rends in **I**nternational **M**athematics and **S**cience **S**tudy) is one of the world's largest studies of educational achievement. It assesses the mathematics and science skills of students in Fourth grade (Fourth Class, in Ireland) and Eighth grade (Second Year). Ireland was among 56 countries that took part in the study in 2015.

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**, and we use these terms when referring specifically to the Irish results.

Overview of TIMSS 2015

TIMSS is organised by the International Association for the Evaluation of Educational Achievement (IEA), a non-profit organisation based in The Hague, Netherlands. At an international level, the study is managed by the TIMSS & PIRLS International Study Centre in Boston College, USA. The International Study Centre works collaboratively with the various National Research Centres which are responsible for managing each country's participation in TIMSS at a national level. In Ireland, the Educational Research Centre (ERC) fulfilled this role on behalf of the Department of Education and Skills (DES).

By assessing students' mathematics and science performance at both primary and post-primary levels, TIMSS provides detailed comparisons of the relative achievements, strengths, and weaknesses of education systems in the various participating countries. The study operates on a four-year cycle, with the first administration taking place in 1995. TIMSS 2015 is the sixth iteration.

Ireland has taken part in TIMSS twice previously: in 1995 (at both primary and post-primary levels) and in 2011 (at primary level only).[1] The results of the 2011 study were published in two volumes – the first describing the reading, mathematics and science achievement of Fourth Class pupils in Ireland (Eivers & Clerkin, 2012), and the second providing detail on the characteristics of Fourth Class pupils and the learning environments provided by their homes, schools, and classes (Eivers & Clerkin, 2013).

The data presented in this report are adapted from the international mathematics (Mullis, Martin, Foy & Hooper, 2016) and science (Martin, Mullis, Foy & Hooper, 2016) reports for TIMSS

1 In 2011, also Ireland took part in the Progress in International Reading Literacy Study (PIRLS), a sister study to TIMSS that is also organised by the International Study Centre on behalf of the IEA. The most recent administration of PIRLS occurred in 2016.

2015, which can be downloaded from http://timssandpirls.bc.edu. They provide results on average student achievement in each of the participating countries, together with some contextual information. This national report focuses more closely on the achievement of students in Ireland, with selected comparisons to the international findings. A series of national reports will follow in 2017 with more detailed examination of the educational contexts in which students in Ireland learn. Through Ireland's participation at both Fourth Class and Second Year in 2015, comparison between the primary and post-primary arms of the study can be made where appropriate.

Who took part in TIMSS 2015?

A list of all participating countries and benchmarking participants is given in Table 1.1. Benchmarking participants are sub-national regions or entities which must follow the same procedures and meet the same data quality standards as countries in order to participate.

Table 1.1: Participating countries and benchmarking participants in TIMSS 2015

Fourth grade and Eighth grade		Fourth grade only	Eighth grade only
Australia	Oman	Belgium (Flemish)	Botswana (G9)
Bahrain	Qatar	Bulgaria	Egypt
Canada	Russian Federation	Croatia	Israel
Chile	Saudi Arabia	Cyprus	Jordan
Chinese Taipei	Singapore	Czech Republic	Lebanon
England	Slovenia	Denmark	Malaysia
Georgia	Sweden	Finland	Malta
Hong Kong SAR	Turkey	France	South Africa (G9)
Hungary	United Arab Emirates	Germany	Thailand
Iran	United States	Indonesia	
Ireland		Netherlands	
Italy		Northern Ireland	
Japan	***Benchmarking participants***	Poland	
Kazakhstan	*Buenos Aires (Argentina)*	Portugal	
Korea, Rep. of	*Ontario (Canada)*	Serbia	
Kuwait	*Quebec (Canada)*	Slovak Republic	
Lithuania	*Norway (G4 and G8)*	Spain	
Morocco	*Abu Dhabi (UAE)*		
New Zealand	*Dubai (UAE)*		
Norway (G5 and G9)	*Florida (USA)*		

Note: Jordan and South Africa participated in an additional mathematics assessment, TIMSS Numeracy, at Fourth grade. Armenia also participated in TIMSS 2015. However, due to a delay in data collection, data for Armenia are not included in the international results tables and so they are not considered in the country information provided here.

As noted, 56 countries participated in the assessment in at least one grade level. At Fourth grade, about 312,000 students in 47 countries and seven benchmarking participants took part in TIMSS. At the Eighth grade, 270,000 students in 39 countries and seven benchmarking participants took part. Ireland was one of 30 countries and seven benchmarking participants that took part at both grade levels.

The breadth of geographic and cultural backgrounds evident in Table 1.1 is further demonstrated

by the fact that TIMSS tests were administered in 43 languages worldwide (Ebbs & Korsnakova, 2016). English and Arabic were the most common languages of administration. In 22 countries, including Ireland, the tests were administered in more than one language. Further details on the administration of TIMSS 2015 in Ireland – including sampling, participation rates, and quality control – are given in Chapter 2.

What does TIMSS assess?

The TIMSS assessments are based on detailed frameworks that specify the mathematics and science skills that students at the Fourth grade and Eighth grade in participating countries are expected to be able to demonstrate. These frameworks are organised with reference to **content domains**, which specify the subject matter of a mathematics or science item, and **cognitive domains**, which describe the type of thinking that students need to use to answer the question. Each item, or question, in the assessment is classified as belonging to one content domain and one cognitive domain.

Table 1.2 and Table 1.3 show the relative emphasis placed on the different content and cognitive domains by the assessment frameworks (Mullis & Martin, 2013).

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

	Content	%	Cognitive	%
Mathematics	Number	50	Knowing	40
	Geometric Shapes & Measures	35	Applying	40
	Data Display	15	Reasoning	20
Science	Life Science	45	Knowing	40
	Physical Science	35	Applying	40
	Earth Science	20	Reasoning	20

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

	Content	%	Cognitive	%
Mathematics	Number	30	Knowing	35
	Algebra	30	Applying	40
	Geometry	20	Reasoning	25
	Data & Chance	20		
Science	Biology	35	Knowing	35
	Chemistry	20	Applying	35
	Physics	25	Reasoning	30
	Earth Science	20		

As shown, the mathematics assessment at Fourth grade places relatively strong weighting on Number skills, with less emphasis on interpreting or using Data Displays. Algebra (which is subsumed under the Number content domain at Fourth grade) is explicitly identified as a content domain in the mathematics assessment at Eighth grade, reflecting the growing importance of algebraic skills at post-primary level. Questions relating to Data & Chance are also intended to be slightly more common at Eighth grade.

Life Science items make up nearly half of the science assessment at Fourth grade, although the

corresponding domain at Eighth grade (Biology) is closer to one-third of the assessment. Chemistry (considered part of the Physical Science domain at Fourth grade) is identified as a content domain at Eighth grade. Earth Science items make up about one-fifth of the assessment at both grade levels.

In terms of the cognitive skills needed to complete the assessments successfully, Knowing skills (e.g., recall of facts) and Applying skills (e.g., using facts or simple procedures in familiar contexts) are given equal weighting at Fourth grade for both mathematics and science (40%). Reasoning skills (requiring the application of more complex procedures in unfamiliar scenarios to solve the problem) are relatively less common (20%). By comparison, Reasoning skills are assessed more frequently at Eighth grade (25% for mathematics and 30% for science).

In total, 337 items were included in the Fourth grade assessment (169 for mathematics and 168 for science), and 424 were included at Eighth grade (209 for mathematics and 215 for science).[2] These items were split into 14 blocks of mathematics items and 14 blocks of science items for each grade level, which were then combined (in a rotated overlapping design) into 14 different test booklets containing both mathematics and science items. All participating students were asked to complete one of these test booklets.

Both multiple-choice and constructed-response items were included in the assessment. Multiple-choice items are those where a student is asked to choose the correct answer from a list of (usually, but not always) four possible options. In contrast, constructed-response items require the student to generate their own answer, whether that be a number, a drawing, a single word, or a sentence or paragraph. Students' constructed-response answers were scored by a team of trained scorers in adherence to the strict scoring procedures set out for all participating countries by the International Study Centre.

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 2011 and TIMSS 2015. 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 (2015) assessment. In this way, long-term trends can be established between 1995 and 2015 even though all items in the 1995 assessment had been replaced by the time of the 2015 assessment.

2 A small number of additional items were originally included in the assessment but were dropped from scaling following administration due to poor psychometric properties.

Contextual information

In addition to the detail on students' mathematical and scientific knowledge provided by their participation in the test itself, one of the strengths of TIMSS is the breadth of contextual information gathered from a range of sources. For example, following the test, each participating student is asked to complete a short questionnaire which asks them about their attitudes towards mathematics and science, their educational aspirations, and so on. Students' teachers are asked about their training, their teaching methods, and the classroom environment, while school principals are asked to describe broader aspects of the school (e.g., enrolment, school atmosphere, school policies). At Fourth grade, but not Eighth grade, students' parents are also asked to complete a questionnaire related to the home environment – homework, activities that the child experienced before starting school, parents' beliefs about their child's school, and so on.

Information on the broader structure of the national education system is provided by a Curriculum Questionnaire and a TIMSS Encyclopaedia chapter for each country, which describe national-level policies and practice (Mullis, Martin, Goh & Cotter, 2016). Finally, a Test-Curriculum Matching Analysis (TCMA) is performed in order to determine how closely the content of the TIMSS assessment matched the national mathematics and science curricula for the respective grade levels – in other words, how much of the assessment a student in Fourth Class or Second Year in Ireland might have been expected to know, or to have been exposed to previously.

Table 1.4 summarises the types and sources of data that are gathered for the study.

Table 1.4: Summary of data gathered and data sources for TIMSS 2015

Type of data	Source	Instrument
Mathematics achievement	Student	Test
Science achievement	Student	Test
Personal characteristics (e.g., attitudes)	Student	Student Questionnaire
Home background *(Fourth Class only)*	Parents	Early Learning Survey
Classroom environment	Teachers	Teacher Questionnaire
School environment	Principals	School Questionnaire
Overlap between national curriculum & TIMSS	Subject experts	Test-Curriculum Matching Analysis
Structure of the national education system	DES / NCCA* / ERC	Curriculum Questionnaire and TIMSS Encyclopaedia country chapter

*National Council for Curriculum and Assessment.

This report focuses primarily on the achievement results arising from the mathematics and science tests. The contextual information will be considered in greater detail in a series of follow-on reports, to be published in 2017. However, some aspects of the TCMA are discussed further in Chapter 8.

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 is set to a centrepoint of 500 (see below) and a standard deviation (SD) of 100. This means that 68% of students' scores fall between 400 and 600 on the scale (i.e., 500 ± 1 SD), and 95% of scores fall between 300 and 700 (i.e., 500 ± 2 SD). The scales for both domains are set to the centrepoint of 500 in the same way, but they are constructed independently and should be considered independently. 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 is 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 main 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 error 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 in this report by multiplying the SE by 1.96 and then adding/subtracting the result to/from the mean score. For a quick approximate confidence interval, the SE can be multiplied by 2. For example, the confidence interval around a mean score of 520, where the SE is 3, is roughly 514-526. This means that, if we repeated the survey on many occasions under the same conditions, we would expect that the confidence interval would contain the true population score 95% of the time. As noted, smaller SEs indicate a smaller confidence interval, with 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 here is unlikely to have occurred by chance. In general, if the confidence intervals around two mean scores do not overlap (e.g., 514-526 vs 527-531), the difference between them is statistically significant.

Chapter 2:
TIMSS in Ireland

Ireland's participation in TIMSS 2015 was managed by the ERC on behalf of the DES. The implementation of TIMSS in Ireland, which took place in April and May 2015 and was preceded by a field trial in 2014, was assisted by a National Advisory Committee for each grade level (see Appendix A).

Who took part in TIMSS 2015 in Ireland?

Samples for TIMSS 2015 were drawn by Statistics Canada and the IEA's Data Processing Centre, in consultation with the ERC. The sampling process took place in two stages. First, lists of all primary and post-primary schools in Ireland were generated and from these, 149 primary and 150 post-primary schools were selected to participate in the TIMSS main study. Primary schools were randomly selected, but stratified to ensure a representative sample based on DEIS category (urban band 1, urban band 2, rural and non-DEIS), language of instruction and gender mix (all boys, all girls and mixed). At post-primary level, schools were randomly selected by sector (secondary, vocational and community/comprehensive), gender mix (all boys, all girls and mixed), socioeconomic status (low, medium and high) and school size (small, medium and large). The school samples for TIMSS were drawn in such a way as to exclude schools that were selected for the 2014 National Assessments (primary level) and PISA 2015 (post-primary level).

The second stage of sampling involved the selection of classes within schools. At primary level each participating school indicated the number of Fourth Class groups in their school. Where there were three or more Fourth Class groups in a school, two were randomly selected for inclusion. In smaller schools, all Fourth Class groups were automatically selected. At post-primary level, each participating school indicated the number of Second Year base class groups (i.e., the classes that students are grouped into for lessons such as P.E. or religion) in their school. In larger schools (five or more base classes), two class groups were selected at random, while in smaller schools (fewer than five base classes) one class group was selected at random. At both primary and post-primary level, a small number of students were excluded from the assessment due to functional or intellectual disabilities or limited English proficiency (Table 2.1)

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

	Fourth Class (Total=4593)		Second Year (Total=5170)	
	N	%	N	%
Functional disabilities	8	0.2	9	0.2
Intellectual disabilities	29	0.6	26	0.5
Limited English proficiency	15	0.3	12	0.2

At primary level, a total of 214 classes from all 149 sampled schools participated, giving a 100% response rate at both school and class level. Within these schools and classes, 4541 pupils were

selected to participate (after exclusions) and, of these, 4344[3] pupils took part in the assessment, giving an overall weighted response rate of 96%. Questionnaires were also completed by 214 teachers and 149 school principals, giving 100% response rates for both, and the home questionnaire was returned by 94% of parents whose children participated in the assessment (Table 2.2).

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

	N	%
TIMSS test	4344	96
Pupil questionnaire	4325	95
Home questionnaire (Early Learning Survey)*	4066	94
Teacher questionnaire*	4344	100
School questionnaire*	4344	100

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

At post-primary level, data from 149 of the 150 sampled schools were analysed,[4] giving a weighted school-level response rate of 99%. Within these schools, 5123 students (after exclusions) from 205 classes were selected. Of these, 4704[5] students in all 205 classes took part in the assessment, giving a weighted student response rate of 92%.[6] Questionnaires were also completed by 148 principals (99%) and 486 mathematics teachers and 404 science teachers. As base class groups were sampled at Second Year, there is not a one-to-one correspondence between teachers and classes (i.e., students may be grouped differently for science, mathematics and other subjects, and therefore students in a given base class may have different mathematics and science teachers), making it difficult to calculate precise response rates for teachers. However, of the 4704 students who participated in TIMSS, we can say that 93% had mathematics teachers who completed questionnaires and 94% had science teachers who completed questionnaires (Table 2.3). Of the 6% of students for whom science teacher data is not available, some did not study science in Second Year (4.7% of all students), and therefore the science teacher questionnaire was not applicable.

In general, therefore, Tables 2.2 and 2.3 show very high response rates in Ireland to the tests and questionnaires used in TIMSS 2015, indicating that the results can be considered representative of the broader national populations of Fourth Class and Second Year students.

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

	N	%
TIMSS test	4704	92
Student questionnaire	4672	91
Mathematics teacher questionnaire*	4396	93
Science teacher questionnaire*	4442	94
School questionnaire*	4650	99

* Response rates are presented in terms of the number of students whose teachers or principals completed questionnaires.

3 Of the 197 pupils who did not participate, parental permission was refused for 11 pupils and 186 were absent on the day of the assessment.

4 All 150 sampled schools participated in TIMSS at Second Year. However, due to an error in administration, data from one school were excluded from analyses.

5 Of the 419 students who did not participate, parental permission was refused for 41 students and 378 were absent on the day of the assessment.

6 Ireland's overall weighted participation rate at Second Year was 91% (accounting for school non-response).

In Ireland, Fourth Class pupils who participated in TIMSS had an average age of 10.4 years, slightly above the international average (10.2 years). The average testing age across all countries participating at primary level was between 9.6 and 10.9 years. At post-primary level, the average testing age in Ireland was 14.4 years, which is very similar to the international average of 14.3 years. For all countries participating at Eighth grade, the average testing age fell between 13.7 years and 14.7 years. More boys than girls participated at primary level in Ireland (52.7% boys and 47.3% girls), reflecting a slightly higher proportion of boys than girls in Fourth Class nationally, while TIMSS participants were evenly divided by gender (49.7% boys and 50.3% girls) at post-primary level.

How was testing conducted?

In Ireland, the TIMSS assessment took place in schools in April and May 2015. The assessment was administered by teachers in participating schools. At Fourth grade, 72 minutes was allocated to testing, compared to 90 minutes at Eighth grade. A short break was given in the middle of the tests at both grade levels. After the tests, and generally on the same day, students completed questionnaires, which took about 30 minutes. TIMSS uses a rotated booklet design which means that each student responded to just a subset of the entire pool of items. Items were distributed across 14 booklets and each booklet contained both mathematics and science items.

Of the participating schools, 18 primary schools and five post-primary schools taught through Irish and had the option of administering the assessment through Irish or English. Ten of the 18 primary schools (4.7% of the overall sample at Fourth Class) and all five Irish-medium post-primary schools (3.2% of the overall sample at Second Year) chose to do so.

Quality monitoring

In each participating country, at least 10% of selected schools (15 schools at both primary and post-primary level in Ireland) were visited on the testing day by international quality control monitors who were employed by the international consortium. Also, in Ireland, an additional 15 primary schools and 17 post-primary schools were visited by national quality control monitors who were members of the Department of Education and Skills Inspectorate. The role of the quality monitors was to observe testing sessions and to interview school coordinators to ensure that the international standards for testing were adhered to. The observation of these testing sessions indicated that the administration of TIMSS in Ireland met all required international standards.

For some test questions, students were required to provide written responses. Students' responses to these questions were scored by trained coders, using an international scoring guide. Coder reliability was assessed by having two coders independently score approximately 25% of the written response items in each country and comparing the assigned scores.

A similar procedure was carried out in order to assess cross-country scoring reliability, with coders in all countries required to score a common set of English-language responses (collected during the TIMSS 2011 assessment). These scores were subsequently compared across countries, ensuring that each country was scoring the answers provided by students in the same way. Finally, countries that had taken part in the previous cycle also tested trend scoring reliability by having coders in 2015 score real responses that had been collected in their country in 2011. Trend scoring was carried out in Ireland at Fourth Class only (following participation in the 2011 assessment).

Chapter 3:
Mathematics and science: Main results

The performance of students in Ireland on the mathematics and science tests is described in this chapter. Achievement is presented here in terms of the overall TIMSS scale scores, with comparison to all other participating countries and benchmarking entities. As noted in Chapter 1, both domains, at both grade levels, are measured on a scale which is set to a centrepoint of 500 (corresponding to the international average of TIMSS 1995) and a standard deviation of 100. Gender differences in achievement are also discussed, together with changes from previous cycles. In Chapter 4, student performance is discussed with reference to the distribution of performance (in contrast to the mean scores reported in this chapter). International Benchmarks that describe the particular skills demonstrated by students in each domain are presented in Chapter 5. More detailed discussion of students' mathematics and science performance – including performance on the cognitive and content domains – is provided in Chapter 6 and Chapter 7.

Mathematics and science performance at Fourth Class

Tables 3.1 and 3.2 show Fourth Class pupils' mathematics and science achievement in TIMSS 2015 compared to their international peers. The highest-performing countries for mathematics were Singapore, Hong Kong and the Republic of Korea. The mean mathematics achievement in all three countries was above 600 points, indicating that the average performance in these countries was at least one standard deviation above the scale centrepoint.[7] For science, the highest-performing countries were Singapore and the Republic of Korea, where pupils achieved a significantly higher mean score than pupils in all other countries.

Pupils in Ireland achieved a mean score of 547 in mathematics, which was significantly above the TIMSS centrepoint. Pupils in seven countries – Singapore, Hong Kong, the Republic of Korea, Chinese Taipei, Japan, Northern Ireland and the Russian Federation – achieved significantly higher mathematics scores than pupils in Ireland. By contrast, pupils in Ireland significantly outperformed those in 37 countries (including Finland, Poland, the United States and Australia). Mean mathematics achievement in Norway, England, Belgium (Flemish) and Kazakhstan was not significantly different from Ireland.

7 The scale centrepoint (500) represents the average of the countries that participated in TIMSS 1995, and has been used since then as an anchor for the scale against which to compare trends over time. The list of countries that participates in TIMSS varies from cycle to cycle. Therefore, the centrepoint is not shown in these tables to avoid it being misinterpreted as an international average for the *current* cycle. Comparisons of each country's mean score relative to the centrepoint can be found in the international reports.

Table 3.1: Mean country scores and standard errors for the TIMSS 2015 Fourth grade assessments, with significant differences compared to Ireland's mean score

Mathematics			Science		
Country	**Mean**	***(SE)***	**Country**	**Mean**	***(SE)***
Singapore	618	*(3.8)*	Singapore	590	*(3.7)*
Hong Kong SAR	615	*(2.9)*	Korea, Rep. of	589	*(2.0)*
Korea, Rep. of	608	*(2.2)*	Japan	569	*(1.8)*
Chinese Taipei	597	*(1.9)*	Russian Federation	567	*(3.2)*
Japan	593	*(2.0)*	Hong Kong SAR	557	*(2.9)*
Northern Ireland	570	*(2.9)*	Chinese Taipei	555	*(1.8)*
Russian Federation	564	*(3.4)*	Finland	554	*(2.3)*
Norway (G5)	549	*(2.5)*	Kazakhstan	550	*(4.4)*
Ireland	**547**	***(2.1)***	Poland	547	*(2.4)*
England	546	*(2.8)*	United States	546	*(2.2)*
Belgium (Flemish)	546	*(2.1)*	Slovenia	543	*(2.4)*
Kazakhstan	544	*(4.5)*	Hungary	542	*(3.3)*
Portugal	541	*(2.2)*	Sweden	540	*(3.6)*
United States	539	*(2.3)*	Norway (G5)	538	*(2.6)*
Denmark	539	*(2.7)*	England	536	*(2.4)*
Lithuania	535	*(2.5)*	Bulgaria	536	*(5.9)*
Finland	535	*(2.0)*	Czech Republic	534	*(2.4)*
Poland	535	*(2.1)*	Croatia	533	*(2.1)*
Netherlands	530	*(1.7)*	**Ireland**	**529**	***(2.4)***
Hungary	529	*(3.2)*	Germany	528	*(2.4)*
Czech Republic	528	*(2.2)*	Lithuania	528	*(2.5)*
Bulgaria	524	*(5.3)*	Denmark	527	*(2.1)*
Cyprus	523	*(2.7)*	Canada	525	*(2.6)*
Germany	522	*(2.0)*	Serbia	525	*(3.7)*
Slovenia	520	*(1.9)*	Australia	524	*(2.9)*
Sweden	519	*(2.8)*	Slovak Republic	520	*(2.6)*
Serbia	518	*(3.5)*	Northern Ireland	520	*(2.2)*
Australia	517	*(3.1)*	Spain	518	*(2.6)*
Canada	511	*(2.3)*	Netherlands	517	*(2.7)*
Italy	507	*(2.6)*	Italy	516	*(2.6)*
Spain	505	*(2.5)*	Belgium (Flemish)	512	*(2.3)*
Croatia	502	*(1.8)*	Portugal	508	*(2.2)*
Slovak Republic	498	*(2.5)*	New Zealand	506	*(2.7)*
New Zealand	491	*(2.3)*	France	487	*(2.7)*
France	488	*(2.9)*	Turkey	483	*(3.3)*
Turkey	483	*(3.1)*	Cyprus	481	*(2.6)*
Georgia	463	*(3.6)*	Chile	478	*(2.7)*
Chile	459	*(2.4)*	Bahrain	459	*(2.6)*
United Arab Emirates	452	*(2.4)*	Georgia	451	*(3.7)*
Bahrain	451	*(1.6)*	United Arab Emirates	451	*(2.8)*
Qatar	439	*(3.4)*	Qatar	436	*(4.1)*
Iran, Islamic Rep. of	431	*(3.2)*	Oman	431	*(3.1)*
Oman	425	*(2.5)*	Iran, Islamic Rep. of	421	*(4.0)*
Indonesia	397	*(3.7)*	Indonesia	397	*(4.8)*
Jordan	388	*(3.1)*	Saudi Arabia	390	*(4.9)*
Saudi Arabia	383	*(4.1)*	Morocco	352	*(4.7)*
Morocco	377	*(3.4)*	Kuwait	337	*(6.2)*
South Africa (G5)	376	*(3.5)*			
Kuwait	353	*(4.6)*			

Average achievement significantly higher than Ireland

Average achievement significantly lower than Ireland

Note: Norway and South Africa assessed students at Grade 5 rather than Grade 4. Jordan and South Africa participated only in TIMSS Numeracy (for mathematics) and did not collect data on science achievement.

Table 3.2: Mean scores of benchmarking participants on the TIMSS 2015 Fourth grade assessments, with significant differences relative to Ireland's mean score

Mathematics			Science		
Region	Mean	*(SE)*	Region	Mean	*(SE)*
Florida, US	546	*(4.7)*	Florida, US	549	*(4.8)*
Quebec, Canada	536	*(4.0)*	Ontario, Canada	530	*(2.5)*
Ontario, Canada	512	*(2.3)*	Quebec, Canada	525	*(4.1)*
Dubai, UAE	511	*(1.4)*	Dubai, UAE	518	*(1.8)*
Norway (G4)	493	*(2.3)*	Norway (G4)	493	*(2.2)*
Buenos Aires, Argentina	432	*(2.9)*	Buenos Aires, Argentina	418	*(4.7)*
Abu Dhabi, UAE	419	*(4.7)*	Abu Dhabi, UAE	415	*(5.6)*
Average achievement significantly higher than Ireland			Average achievement significantly lower than Ireland		

Note: Norway assessed students at Grade 5 and also participated as a benchmarking participant at Grade 4.

In science, pupils in Ireland achieved a mean score of 529, which was significantly above the TIMSS centrepoint. Fifteen countries (including Singapore, Finland, Poland and Norway) significantly outperformed Ireland, while the Irish score was significantly higher than that of 22 countries (including Northern Ireland, Belgium [Flemish], New Zealand and France). Nine countries (including Germany, Denmark and Australia) achieved mean scores that were not significantly different to Ireland.

The mathematics performance of pupils in Ireland was significantly higher in 2015 (547) than in 2011 (527) or 1995 (523). Similarly, Irish performance on the science assessment was significantly higher in the current cycle (529) than in 2011 (516) or 1995 (515).

Table 3.3 presents gender differences in mathematics and science achievement within Ireland in TIMSS 2015. Differences in the performance of girls and boys relative to Irish pupils in previous cycles of TIMSS are also provided. As shown, the differences between boys and girls in Fourth Class in 2015 were small (4 points on the mathematics assessment and 5 points for science), and not statistically significant.

Both genders achieved higher mean scores in 2015 than did their counterparts in previous cycles. For mathematics, both boys and girls achieved a mean score about one-fifth of a standard deviation higher than in 2011 (20 and 19 points, respectively). The improvement was smaller for science (15 and 10 points).

Table 3.3: Mean scores on the TIMSS 2015 Fourth grade assessments and differences relative to the corresponding 1995 and 2011 TIMSS mean scores, among boys and girls in Ireland

			Mathematics				Science			
	%	*(SE)*	Mean	*(SE)*	2015-2011	2015-1995	Mean	*(SE)*	2015-2011	2015-1995
Boys	53	*(1.5)*	549	*(2.9)*	+20	+28	531	*(2.9)*	+15	+15
Girls	47	*(1.5)*	545	*(2.6)*	+19	+20	526	*(2.9)*	+10	+13
Diff. (boys-girls)			+4	*(3.4)*	-	-	+5	*(3.4)*	-	-

In mathematics, gender differences in mean scores were not significant in many countries. Girls significantly outperformed boys in eight countries (including Saudi Arabia, South Africa, Indonesia and Finland), while boys outperformed girls in 18 countries (including the Republic of Korea, Hong Kong, the United States, Australia and England). Across all countries that took part in TIMSS 2015, average mathematics performance was similar for both boys and girls (505).

In science, girls had, on average, a four-point advantage over boys (508 for girls and 504 for boys). Girls in 11 countries (including Finland, Sweden, Saudi Arabia and Bahrain) achieved a significantly higher mean score than their male counterparts, while boys significantly outperformed girls in 11 countries (including the Republic of Korea, Hong Kong, Chinese Taipei, Italy and the United States).

Mathematics and science performance at Second Year

Table 3.4 and Table 3.5 present the mean mathematics and science scores of Second Year students in Ireland, along with the mean scores of their peers in other participating countries and regions. Students in Singapore achieved the highest mean scores in both mathematics (621) and science (597), significantly outperforming students in every other participating country. As was the case in Fourth grade mathematics, the four highest-performing countries were Singapore, the Republic of Korea, Chinese Taipei and Hong Kong.

The mean mathematics score of students in Ireland was 523, which was significantly above the TIMSS centrepoint of 500 (the average score of all countries that participated in 1995). Six countries (Singapore, the Republic of Korea, Chinese Taipei, Hong Kong, Japan and the Russian Federation) had significantly higher mean mathematics scores than Ireland. The mean scores of five countries (Kazakhstan, Canada, England, the United States and Hungary) did not differ significantly from Ireland, while Ireland's mean score was higher than the remaining 27 countries (including Slovenia, Australia and New Zealand). Although not statistically significant, Ireland's mathematics performance improved by about 5 points since 1995, the last time that Ireland participated in TIMSS at Second Year.

Second Year students in Ireland had a mean science score of 530, which was also significantly above the TIMSS centrepoint of 500. Ireland's mean score was significantly lower than that of seven countries (Singapore, Japan, Chinese Taipei, the Republic of Korea, Slovenia, Hong Kong and the Russian Federation) but did not differ significantly from the mean scores in England, Kazakhstan, the United States, Hungary, Canada and Sweden. Twenty-five countries (including New Zealand and Australia) performed significantly less well than Ireland on TIMSS science. The mean science performance of students in Ireland improved significantly, by 12 points, since 1995 (518).

Of the seven countries that significantly outperformed Ireland on science, six also outperformed Ireland on mathematics, while five of the six countries that performed similarly to Ireland on science also did so on mathematics. Slovenia performed significantly less well than Ireland on mathematics. However, their mean science score was significantly higher than Ireland's (a pattern which was also evident at Fourth grade).

Table 3.4: Mean country scores and standard errors for the TIMSS 2015 Eighth grade assessment, with significant differences compared to the Irish mean score

Mathematics			Science		
Country	**Mean**	***(SE)***	**Country**	**Mean**	***(SE)***
Singapore	621	*(3.2)*	Singapore	597	*(3.2)*
Korea, Rep. of	606	*(2.6)*	Japan	571	*(1.8)*
Chinese Taipei	599	*(2.4)*	Chinese Taipei	569	*(2.1)*
Hong Kong SAR	594	*(4.6)*	Korea, Rep. of	556	*(2.2)*
Japan	586	*(2.3)*	Slovenia	551	*(2.4)*
Russian Fed.	538	*(4.7)*	Hong Kong SAR	546	*(3.9)*
Kazakhstan	528	*(5.3)*	Russian Fed.	544	*(4.2)*
Canada	527	*(2.2)*	England	537	*(3.8)*
Ireland	**523**	***(2.7)***	Kazakhstan	533	*(4.4)*
United States	518	*(3.1)*	**Ireland**	**530**	***(2.8)***
England	518	*(4.2)*	United States	530	*(2.8)*
Slovenia	516	*(2.1)*	Hungary	527	*(3.4)*
Hungary	514	*(3.8)*	Canada	526	*(2.2)*
Norway (G9)	512	*(2.3)*	Sweden	522	*(3.4)*
Lithuania	511	*(2.8)*	Lithuania	519	*(2.8)*
Israel	511	*(4.1)*	New Zealand	513	*(3.1)*
Australia	505	*(3.1)*	Australia	512	*(2.7)*
Sweden	501	*(2.8)*	Norway (G9)	509	*(2.8)*
Italy	494	*(2.5)*	Israel	507	*(3.9)*
Malta	494	*(1.0)*	Italy	499	*(2.4)*
New Zealand	493	*(3.4)*	Turkey	493	*(4.0)*
Malaysia	465	*(3.6)*	Malta	481	*(1.6)*
United Arab Emirates	465	*(2.0)*	United Arab Emirates	477	*(2.3)*
Turkey	458	*(4.7)*	Malaysia	471	*(4.1)*
Bahrain	454	*(1.4)*	Bahrain	466	*(2.2)*
Georgia	453	*(3.4)*	Qatar	457	*(3.0)*
Lebanon	442	*(3.6)*	Iran, Islamic Rep. of	456	*(4.0)*
Qatar	437	*(3.0)*	Thailand	456	*(4.2)*
Iran, Islamic Rep. of	436	*(4.6)*	Oman	455	*(2.7)*
Thailand	431	*(4.8)*	Chile	454	*(3.1)*
Chile	427	*(3.2)*	Georgia	443	*(3.1)*
Oman	403	*(2.4)*	Jordan	426	*(3.4)*
Kuwait	392	*(4.6)*	Kuwait	411	*(5.2)*
Egypt	392	*(4.1)*	Lebanon	398	*(5.3)*
Botswana (G9)	391	*(2.0)*	Saudi Arabia	396	*(4.5)*
Jordan	386	*(3.2)*	Morocco	393	*(2.5)*
Morocco	384	*(2.3)*	Botswana (G9)	392	*(2.7)*
South Africa (G9)	372	*(4.5)*	Egypt	371	*(4.3)*
Saudi Arabia	368	*(4.6)*	South Africa (G9)	358	*(5.6)*

Average achievement significantly higher than Ireland

Average achievement significantly lower than Ireland

Note: Three countries (Norway, Botswana and South Africa) assessed students at Grade 9 rather than Grade 8.

Table 3.5: Mean scores of benchmarking participants on the TIMSS 2015 Eighth grade assessments, with significant differences relative to Ireland's mean score

Mathematics			Science		
Region	Mean	*(SE)*	Region	Mean	*(SE)*
Quebec, Canada	543	*(3.9)*	Quebec, Canada	530	*(4.4)*
Ontario, Canada	522	*(2.9)*	Dubai, UAE	525	*(2.0)*
Dubai, UAE	512	*(2.1)*	Ontario, Canada	524	*(2.5)*
Florida, US	493	*(6.4)*	Florida, US	508	*(6.0)*
Norway (G8)	487	*(2.0)*	Norway (G8)	489	*(2.4)*
Abu Dhabi, UAE	442	*(4.7)*	Abu Dhabi, UAE	454	*(5.6)*
Buenos Aires, Argentina	396	*(4.2)*	Buenos Aires, Argentina	386	*(4.2)*
Average achievement significantly higher than Ireland			Average achievement significantly lower than Ireland		

Note: Norway assessed students at Grade 9 and also participated as a benchmarking participant at Grade 8.

In Ireland, gender differences were not significant on either domain. On average, boys scored five points higher than girls on mathematics, while girls scored two points higher than boys on science (Table 3.6). The mean mathematics score for boys in Ireland increased by one point since 1995, while girls saw an improvement of nine points. For science, boys' mean performance increased by two points and girls' mean performance increased by 21 points.

Table 3.6: Mean scores on the TIMSS 2015 Eighth grade assessments and differences relative to the corresponding 1995 TIMSS mean scores, among boys and girls in Ireland

			Mathematics			Science		
	%	*(SE)*	Mean	*(SE)*	*2015-1995*	Mean	*(SE)*	*2015-1995*
Boys	50	*(1.1)*	526	*(4.0)*	+1	529	*(3.9)*	+2
Girls	50	*(1.1)*	521	*(2.6)*	+9	531	*(2.8)*	+21
Diff (boys-girls)			+5	*(3.9)*	-	-2	*(3.7)*	-

Gender differences were not significant in mathematics in many countries at Eighth grade. Girls significantly outperformed boys in seven countries (including Singapore), while boys outperformed girls in six countries (including the Russian Federation, Sweden and Canada). At the international average, girls (483) achieved a slightly higher mean score than boys (480).

In science, girls outperformed boys by ten points internationally (491 for girls and 481 for boys). Girls in 14 countries (including Saudi Arabia and Turkey) achieved a significantly higher mean score than boys. On the other hand, boys significantly outperformed girls in five countries (including Hong Kong, Italy and the United States).

Chapter 4:
Distribution of achievement

This chapter examines the performance of higher- and lower-achieving students by exploring the distribution of achievement (i.e., the difference between scores at the 5th and 95th percentiles) within countries. Results for Ireland are presented alongside the equivalent results for a subset of countries that were selected on the basis of high performance or cultural and/or linguistic similarities to Ireland. The selected comparison countries are Singapore, the Republic of Korea, Hong Kong, the Russian Federation, Slovenia, England, the United States, Australia, and New Zealand for both Fourth Class and Second Year, and Northern Ireland and Finland (both of which participated at Fourth grade only). Countries are presented in descending order based on their overall mean score, at each grade level and for each domain.

The results are presented graphically, with the mean score for each country represented by a black band (see Figure 4.1). The black band represents a 95% confidence interval (±2 standard errors from the mean) in order to account for measurement and sampling error. 'Below-average' (those scoring between the 5th and 25th percentiles) and 'above-average' students (those scoring between the 75th and 95th percentiles) are represented by dark blue bands, and all other students (those close to the average) are represented by light blue bands.

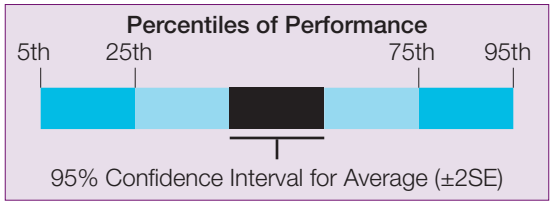

Figure 4.1: Percentiles of performance (adapted from international reports)

The figures for each domain and grade level are also divided according to whether a country's mean achievement is significantly higher than, similar to, or lower than Ireland's mean achievement scores (see Table 4.1).

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

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

Performance is discussed for each domain and grade level in relation to four categories of students:

- The 'lowest-achieving' students (those at the 5th percentile);
- The 'below-average range' of students (those scoring between the 5th and 25th percentiles);
- The 'above-average range' of students (those scoring between the 75th and 95th percentiles); and
- The 'highest-achieving' students (those at the 95th percentile).

Distribution of achievement – Fourth Class, mathematics

Although Ireland and England's overall mean scores for Fourth grade mathematics were very similar, the performance of the 'lowest-achieving' pupils in Ireland was somewhat higher than that of the corresponding pupils in England (Figure 4.2). The spread of the 'below-average range' of pupils is similar for both countries. On the other hand, there is a larger spread among the 'above-average range' of pupils in England compared to Ireland, meaning that the performance of the 'highest-achieving' pupils (those at the 95th percentile) in England is considerably higher than in Ireland.

The spread of the 'below-average range' of students in Northern Ireland is larger than in Ireland, meaning that although the performance of the 'lowest-achieving' pupils is similar to Ireland, the score of those at the 25th percentile is somewhat higher. Also, the 'highest-achieving' pupils in Northern Ireland are performing at a considerably higher level than their counterparts in Ireland.

The performance of pupils at the 75th percentile in Singapore is higher than the performance of the 'highest-achieving' pupils (those at the 95th percentile) in Ireland.

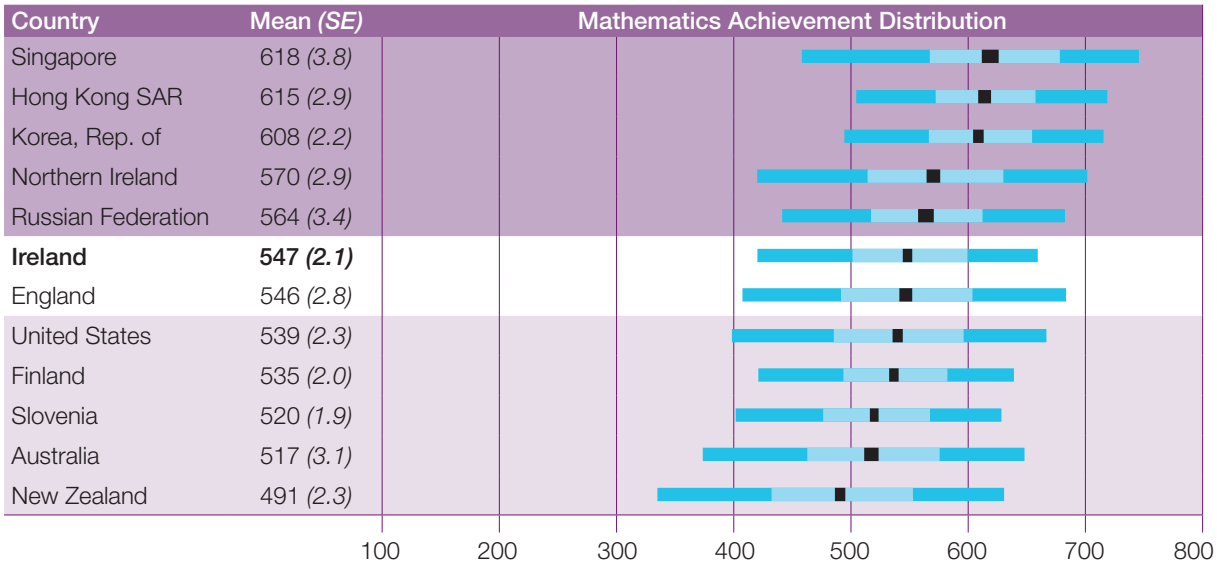

Figure 4.2: Distribution of mathematics achievement – Fourth grade

Figure 4.3 shows the distribution of mathematics achievement among pupils in Ireland across the three assessment cycles in which Ireland participated at Fourth Class. Improvements in performance have been made among both the 'below-average range' and the 'above-average range' of pupils, although the improvements are most marked among the 'lowest-achieving' pupils.

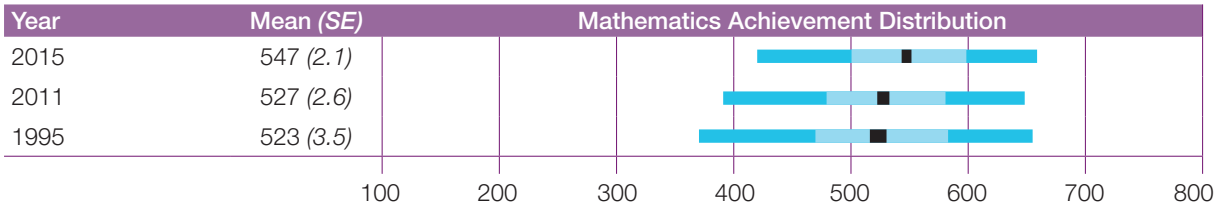

Figure 4.3: Trends in the distribution of mathematics achievement in Ireland – Fourth Class

Distribution of achievement – Fourth Class, science

A somewhat different pattern can be seen for science. Both the 'below-average range' and 'above-average range' of pupils in Ireland are performing slightly better than their counterparts in Northern Ireland, but slightly less well than the corresponding pupils in England (Figure 4.4). In Ireland, the 'lowest-achieving' pupils are performing at a higher level than their counterparts in Australia, a country with similar mean science performance to Ireland. On the other hand, the 'highest-achieving' pupils in Ireland perform slightly less well than the corresponding pupils in Australia.

There is a larger spread of achievement among the 'below-average range' of pupils in Singapore, the highest achieving country, compared to Ireland, although the 'lowest-achieving' pupils in Singapore have higher performance than those pupils in Ireland. As with mathematics, the performance of the pupils at the 95th percentile in Ireland is lower than the performance of pupils at the 75th percentile in Singapore, indicating that there is a considerable difference in the performance of the 'highest-achieving' pupils in Ireland and the highest-achieving country.

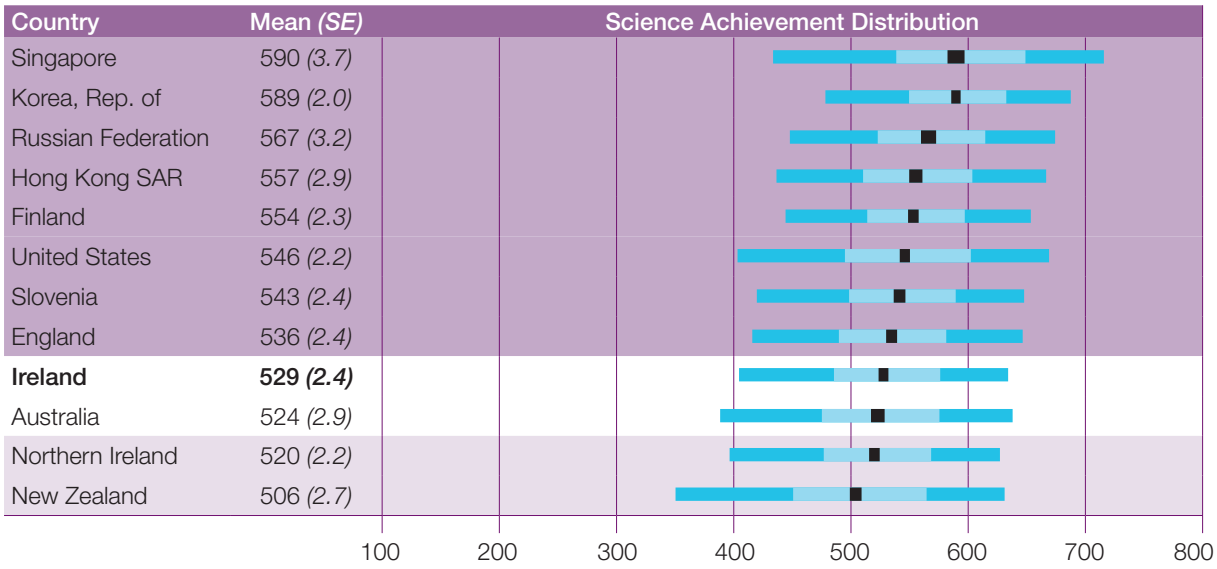

Figure 4.4: Distribution of science achievement – Fourth grade

There have been substantial improvements in science performance among the 'lowest-achieving' pupils across the three assessment cycles in which Ireland participated (Figure 4.5), and mean performance has significantly improved (Chapter 3). However, there has been a slight disimprovement among the 'highest-achieving' pupils since 1995.

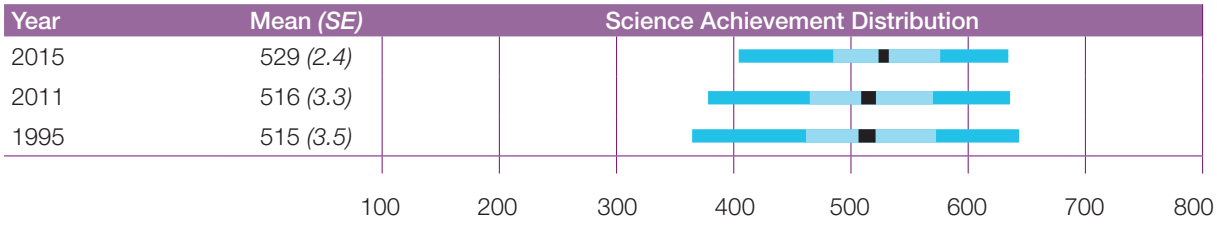

Figure 4.5: Trends in the distribution of science achievement in Ireland – Fourth Class

Distribution of achievement – Second Year, mathematics

While students in the United States and England had similar overall mathematics performance to students in Ireland at Eighth grade, the performance of the 'below-average range' of students in Ireland is somewhat higher than in these two countries (Figure 4.6). On the other hand, the spread of the 'above-average range' of students is larger in the United States and England compared to Ireland, meaning that while the performance of students at the 75th percentile is similar in all three countries, the 'highest-achieving' students (those at the 95th percentile) in Ireland are underperforming compared to their counterparts in England and the United States. The performance of the 'highest-achieving' students in Ireland is similar to the performance of these students in Australia and New Zealand, two countries that had lower mean mathematics performance than Ireland.

The 'lowest-achieving' students in mathematics in Singapore, the Republic of Korea and Hong Kong (three of the highest-achieving countries) are performing at considerably higher levels than the 'lowest-achieving' students in Ireland. At the other end of the achievement distribution, the performance of the students at the 95th percentile in Ireland is somewhat below the performance of those at the 75th percentiles in these countries. This indicates that Ireland's 'highest-achieving' students are performing at a level that is considered 'above-average' but not among the 'highest-achieving' students in the three top-performing countries.

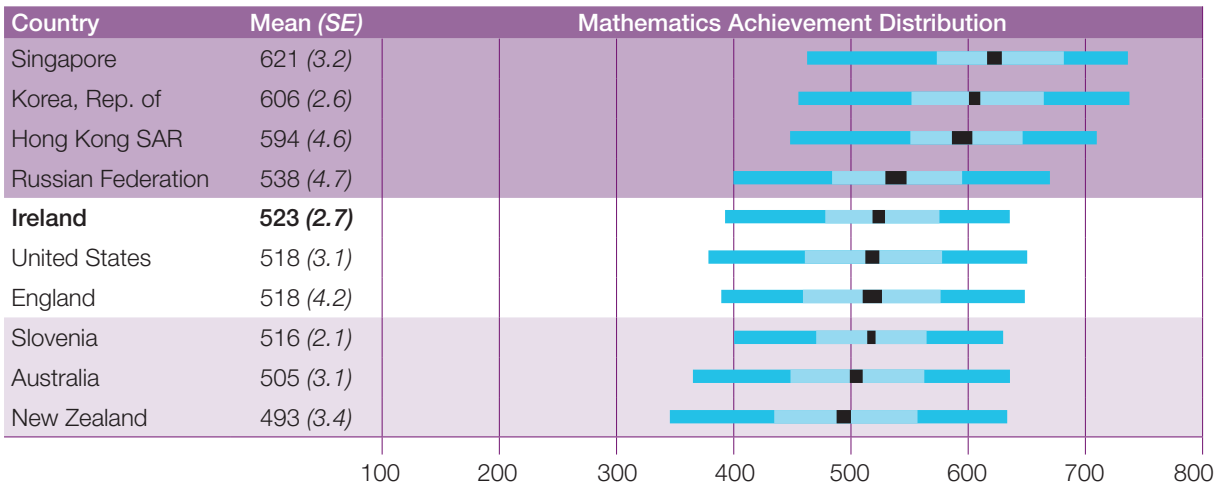

Figure 4.6: Distribution of mathematics achievement – Eighth grade

Figure 4.7 shows the distribution of mathematics achievement among students in Second Year in Ireland in 1995 and 2015. While the performance of the 'lowest-achieving' students has improved between the two cycles, there has been a small disimprovement among the 'highest-achieving' students.

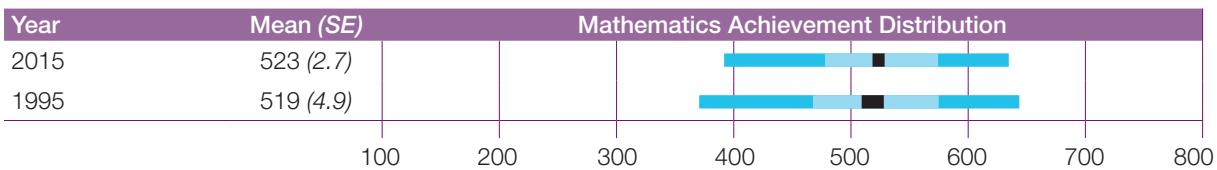

Figure 4.7: Trends in the distribution of mathematics achievement in Ireland – Second Year

Distribution of achievement – Second Year, science

The 'lowest-achieving' students in science at Second Year in Ireland are performing at similar levels to those in the United States, but slightly less well than the corresponding students in England, two countries with similar overall science performance to Ireland (Figure 4.8). However, the spread of performance among the 'below-average range' of students in Ireland is larger than in these two countries, meaning that students in Ireland make relative gains in achievement at the 25th percentile. At the other end of the achievement distribution, the performance of the 'highest-achieving' students in Ireland is somewhat lower than their counterparts in England and the United States.

The 'lowest-achieving' students in Singapore are performing at considerably higher levels than the 'lowest-achieving' students in Ireland, although the difference is not as great as for mathematics. However, as with mathematics, students at the 95th percentile in science in Ireland have slightly lower performance than those at the 75th percentile in Singapore.

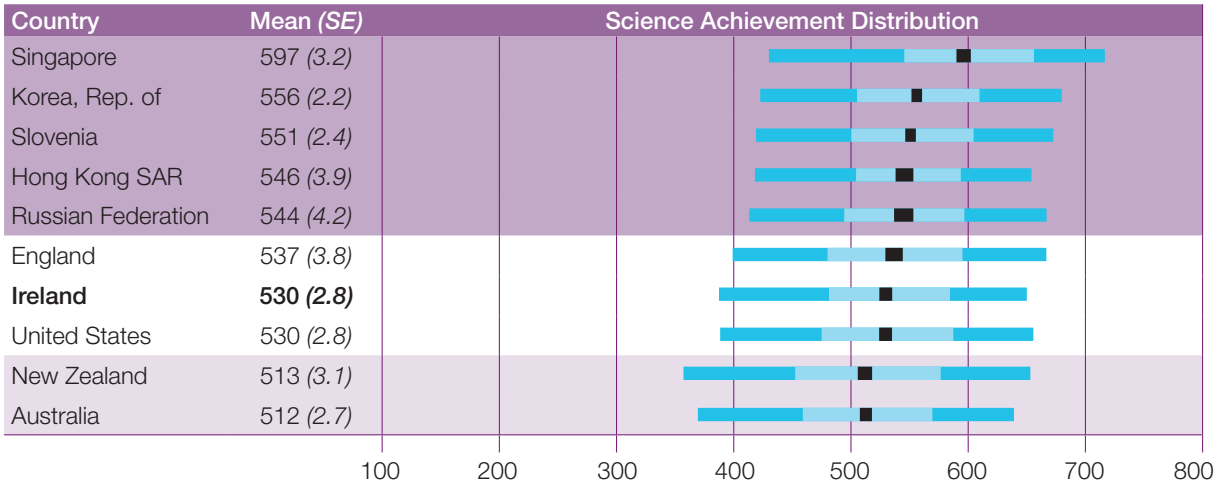

Figure 4.8: Distribution of science achievement – Eighth grade

As with mathematics, there has been an improvement since 1995 in performance among the 'below-average range' of students in science in Second Year, while performance has declined slightly among the 'highest-achieving' students (Figure 4.9).

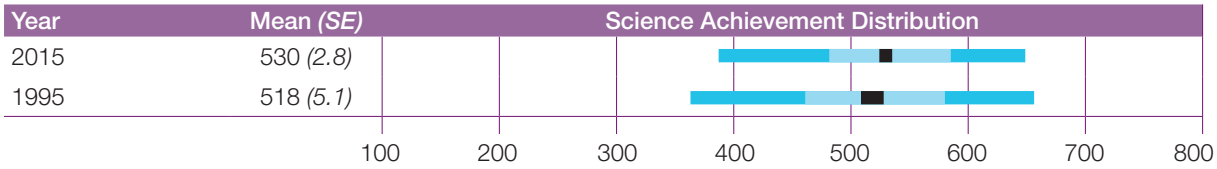

Figure 4.9: Trends in the distribution of science achievement in Ireland – Second Year

Chapter 5:
Performance at International Benchmarks

Building on the results presented in the previous chapters, student achievement is described here with reference to four International Benchmarks that represent increasing levels of mathematical or scientific skill. Each Benchmark is associated with a defined set of attributes which typify the skills that students at that level can demonstrate consistently. As before, the results for Ireland are presented alongside those of the selected comparison countries, as well as the overall TIMSS median attainment of each Benchmark.

Introduction to International Benchmarks

As well as the overall measures of mathematical and scientific proficiency presented in Chapter 3 – the scale scores – student achievement can be described with reference to the specific skills that students at a particular level of performance are typically able to demonstrate. These skillsets are known as International Benchmarks, and provide an intuitive method of interpreting country-level performance on the assessment.

Each participating student is classified as being at one of four Benchmarks, depending on their performance on the test. Benchmarks are defined in terms of cutpoints on the continuous achievement scale, as shown in Figure 5.1. For example, a student who scored 460 points on the mathematics test reached the Low Benchmark of mathematical achievement, and another student who scored 549 points reached the Intermediate Benchmark. A student whose performance was more than one standard deviation below the scale centrepoint (i.e., below 400) is described as not reaching the Low Benchmark.

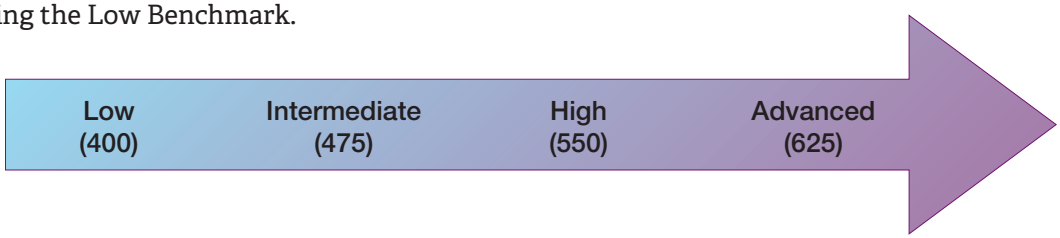

Figure 5.1: Benchmarks reached by students scoring *at or above* each scale score cutpoint

The cutpoints used to demarcate these Benchmarks were determined by international subject experts for mathematics and for science, drawing on detailed analyses of students' performance overall and on particular items that can be used to 'anchor' each benchmark. Anchoring items are those that can consistently be completed successfully by students reaching a particular Benchmark, but not by those at a lower Benchmark. The characteristics of these anchoring items thus define the types of skills that students at a Benchmark can usually demonstrate.

As a corollary, Benchmark performance is cumulative – in other words, a student reaching the High Benchmark can also demonstrate the skills expected of students at the Low and Intermediate Benchmarks, as well as the additional skills that are specific to the High Benchmark. The full detail relating to the construction of the cutpoints is described in Martin, Mullis and Hooper (2016). The particular skills that are typical of each Benchmark, as well as the percentage of students in Ireland who reached the various cutpoints, are described next. First, the Benchmarks for mathematics and science at Fourth grade are described, followed by their equivalents at Eighth grade.

Benchmark performance – Fourth Class, mathematics

The typical skills displayed by pupils who reach each of the four mathematical Benchmarks are summarised in Table 5.1. As shown, pupils at higher Benchmarks show greater understanding and the ability to solve more complex problems than pupils at lower Benchmarks. For example, pupils at the Low Benchmark can provide evidence of basic mathematical knowledge, while those at the Intermediate Benchmark demonstrate greater ability to apply their basic mathematical knowledge in simple situations. Pupils at the High Benchmark can solve increasingly complex problems, with more advanced skills – particularly the ability to complete multi-step problems – evident among pupils at the Advanced Benchmark.

Table 5.1: International Benchmarks – Fourth grade mathematics

Benchmark	Scoring at least	Pupils typically can:
Advanced *Pupils can apply their understanding & knowledge in a variety of relatively complex situations, and explain their reasoning.*	625	✓ Solve multi-step word problems involving whole numbers. ✓ Show increasing understanding of fractions and decimals. ✓ Apply knowledge of a range of two- and three- dimensional shapes in a variety of situations. ✓ Interpret and represent data to solve multi-step problems.
High *Pupils can apply their knowledge & understanding to solve problems.*	550	✓ Solve word problems involving operations with whole numbers, simple fractions, and two-place decimals. ✓ Demonstrate understanding of geometric properties of shapes and of angles that are less than or greater than a right angle. ✓ 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	✓ Demonstrate an understanding of whole numbers and some understanding of fractions and decimals. ✓ Relate two- and three-dimensional shapes, and identify and draw shapes with simple properties. ✓ Read and interpret bar graphs and tables.
Low *Pupils have some basic mathematical knowledge.*	400	✓ Add and subtract whole numbers, have some understanding of multiplication by one-digit numbers, and solve simple word problems. ✓ Show some knowledge of simple fractions, geometric shapes, and measurement. ✓ Read and complete simple bar graphs and tables.

Adapted from Mullis, Martin, Foy and Hooper (2016).

Table 5.2 shows the percentage of pupils in Ireland and in the selected comparison countries who reached each of the four Benchmarks. The percentages are presented in cumulative format. That is, the table should be interpreted as showing that almost all Fourth Class pupils in Ireland (97%) reached *at least* the Low Benchmark, some of whom also reached *at least* the Intermediate Benchmark (84% of all pupils), some of whom also reached *at least* the High Benchmark, some of whom also reached the highest level of performance, the Advanced Benchmark.

As shown, slightly more than half (51%) of Fourth Class pupils reached at least the High Benchmark, compared to a median[8] of 36% across all countries. About one-in-seven pupils in Ireland (14%) also reached the Advanced Benchmark for mathematics. This is more than twice the proportion who reached this Benchmark internationally (6%).

Among the highest-performing countries, practically all pupils (99-100%) were categorised as reaching at least the Low International Benchmark in Singapore, Hong Kong, and the Republic of Korea. Half or close to half of all pupils in Singapore (50%), Hong Kong (45%) and the Republic of Korea (41%) reached the Advanced Benchmark in mathematics, indicating that they are proficient at the most advanced skills that are included in the assessment. Similarly, almost all pupils in Hong Kong and the Republic of Korea (97-98%) reached at least the Intermediate Benchmark, in comparison to the international median of 75% of pupils.

A slightly higher percentage of pupils in England than in Ireland reached the Advanced Benchmark (17%, compared to 14%, respectively). However, fewer pupils in England attained the High (49% vs 51%), Intermediate (80% vs 84%) or Low (96% vs 97%) Benchmarks. Thus, a relatively high percentage of very high-achieving pupils were found in England (based on the cutpoint used to define the Advanced Benchmark) but pupils in Ireland were slightly more likely than their English peers to demonstrate the skills needed to reach each of the lower levels.

Among the other comparison countries, several (including Finland, Slovenia, Australia and New Zealand) had relatively few pupils at the Advanced Benchmark (6-9%). High percentages of pupils in Australia (9%) and New Zealand (16%) did not reach the Low Benchmark, meaning that they could not consistently demonstrate the most basic mathematical skills that were assessed.

Table 5.2: Percentages of pupils reaching each International Benchmark, selected countries – Fourth grade mathematics

	Mean score	Percent of pupils (cumulative) *(SE)*			
		Low	Intermediate	High	Advanced
Singapore	618	99 *(0.3)*	93 *(0.9)*	80 *(1.7)*	50 *(2.1)*
Hong Kong SAR	615	100 *(0.1)*	98 *(0.4)*	84 *(1.3)*	45 *(2.0)*
Korea, Rep. of	608	100 *(0.1)*	97 *(0.4)*	81 *(1.0)*	41 *(1.3)*
Northern Ireland	570	97 *(0.6)*	86 *(1.1)*	61 *(1.5)*	27 *(1.3)*
Russian Fed.	564	98 *(0.4)*	89 *(1.1)*	59 *(1.8)*	20 *(1.8)*
Ireland	**547**	**97 *(0.4)***	**84 *(1.0)***	**51 *(1.6)***	**14 *(1.0)***
England	546	96 *(0.7)*	80 *(1.2)*	49 *(1.5)*	17 *(1.2)*
United States	539	95 *(0.5)*	79 *(1.0)*	47 *(1.1)*	14 *(0.8)*
Finland	535	97 *(0.4)*	82 *(1.0)*	43 *(1.3)*	8 *(0.7)*
Slovenia	520	95 *(0.5)*	75 *(1.2)*	34 *(1.4)*	6 *(0.5)*
Australia	517	91 *(0.9)*	70 *(1.3)*	36 *(1.6)*	9 *(0.9)*
New Zealand	491	84 *(0.9)*	59 *(1.2)*	26 *(0.9)*	6 *(0.5)*
TIMSS (median)	-	93 *(-)*	75 *(-)*	36 *(-)*	6 *(-)*

There has been a significant increase in the percentages of Fourth Class pupils in Ireland reaching each of the four Benchmarks in 2015, relative to the two previous cycles in which Ireland

8 The median is the 'halfway point' when all countries are rank-ordered. In this example, it means that half of the participating TIMSS countries (including Ireland) had more than 36% of students reaching the High Benchmark, and half had fewer than 36% of students reaching this level.

participated (Table 5.3). In TIMSS 2011, only the Low Benchmark showed a significant increase over TIMSS 1995 (94% vs 91%), while performance at the higher Benchmarks remained relatively unchanged. By contrast, in TIMSS 2015, significantly greater percentages of pupils attained scores that matched or exceeded each of the cutpoints across the entire distribution of performance.

Therefore, performance appears to have improved among both lower- and higher-achieving pupils in Ireland over the last 20 years. A similar pattern was observed in many other countries – 14 of the 17 countries that took part in both 1995 and 2015 reported significant improvements over that timespan. Of more significance, perhaps, is that much of this improvement in the mathematics performance of Fourth Class pupils appears to have occurred since 2011. For example, significantly more pupils reached at least the Low Benchmark in 2015 (97%, compared to 94% in 2011 and 91% in 1995). At the same time, more pupils attained the High (51% in 2015 vs 41% in 2011) and Advanced (14% in 2015 vs 9% in 2011) Benchmarks in the current assessment.

Table 5.3: Overall mean score, and percentage of Fourth Class pupils reaching the mathematics International Benchmarks in TIMSS 2015 and previous cycles

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

Percentages in **bold** are significantly lower than the equivalent in 2015.

As shown in Table 5.4, a slightly higher percentage of boys reached the Advanced (15%) and High (53%) Benchmarks for mathematics than did girls (13% and 49%, respectively). However, these differences were not statistically significant. Equal percentages of boys and girls reached the two lower Benchmarks (84% and 97%, respectively).

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

	Mean score	Low (400)	Intermediate (475)	High (550)	Advanced (625)
Boys	549	97 *(0.5)*	84 *(1.3)*	53 *(1.7)*	15 *(1.2)*
Girls	545	97 *(0.5)*	84 *(1.3)*	49 *(2.1)*	13 *(1.3)*

Benchmark performance – Fourth Class, science

As with mathematics, the descriptors for the International Benchmarks for science at Fourth grade (Table 5.5) define increasing levels of scientific knowledge and understanding from the Low to Advanced Benchmarks. Pupils at the Low Benchmark can show basic knowledge of the life sciences and physical science, as well as interpreting simple tables and diagrams. By contrast, pupils at the Advanced Benchmark can demonstrate facility with a range of more complex concepts, including processes related to scientific inquiry and experimentation, as well as a greater depth of knowledge in the life, physical, and Earth science domains.

Table 5.5: International Benchmarks – Fourth grade science

Benchmark	Scoring at least	Pupils typically can:
Advanced *Pupils communicate understanding of life, physical, and Earth science, 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 and apply knowledge of factors related to human health. ✓ Communicate understanding of properties and states of matter and physical and chemical changes. ✓ Apply some knowledge of forms of energy and energy transfer. ✓ Show some knowledge of forces and an understanding of their effect on motion. ✓ Communicate understanding of Earth's structure, physical characteristics, processes, and history, and show knowledge of earth's revolution and rotation. ✓ Demonstrate basic knowledge and skills related to scientific inquiry: recognising how a simple experiment should be set up, interpreting the results of an investigation, reasoning and drawing conclusions from descriptions and diagrams, and evaluating and supporting an argument.
High *Pupils communicate and apply knowledge of life, physical, and Earth science in everyday and abstract contexts.*	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. ✓ Communicate and apply knowledge of states and properties of matter, and of energy transfer in practical contexts, as well as showing some understanding of forces and motion. ✓ Apply knowledge of Earth's structure, physical characteristics, process, and history, and show basic understanding of the Earth-Moon-Sun system. ✓ Compare, contrast, and make simple inferences using models, diagrams, and descriptions of investigations, and provide brief descriptive responses using science concepts, both in everyday and abstract contexts.
Intermediate *Pupils show basic knowledge and understanding of life, physical, and Earth science.*	475	✓ Demonstrate some knowledge of life processes of plants and humans. ✓ Communicate and apply knowledge of the interaction of living things with their environments, as well as impacts humans can have on their environment. ✓ Communicate knowledge of basic facts related to human health. ✓ Apply knowledge about some properties of matter and about some facts related to electricity and energy transfer. ✓ Apply elementary knowledge of forces and motion. ✓ Show some understanding of Earth's physical characteristics. ✓ Demonstrate some basic knowledge of Earth in the solar system. ✓ Interpret information in diagrams, apply factual knowledge to everyday situations, and provide simple explanations for biological and physical phenomena.
Low *Pupils show basic knowledge of life and physical science.*	400	✓ Demonstrate some basic knowledge of behavioural and physical characteristics of plants and animals, as well as of the interaction of living things with their environments. ✓ Apply knowledge of some facts related to human health. ✓ Show basic knowledge of states of matter and physical properties of matter. ✓ Interpret simple diagrams, complete simple tables, and provide short, fact-based written responses.

Adapted from Martin, Mullis, Foy and Hooper (2016).

The percentage of pupils reaching each Benchmark in Ireland, the selected comparison countries, and the TIMSS median at each Benchmark is shown in Table 5.6. At all Benchmarks, the performance of pupils in Ireland was similar to, or slightly ahead of, the median performance of their peers across all other TIMSS countries.

Four percent of Fourth Class pupils did not reach the lowest Benchmark (indicating that they could not consistently demonstrate the most basic science skills), compared to 5% of pupils internationally. About four-fifths of pupils in Ireland (79%) achieved *at least* the Intermediate Benchmark, while two-fifths (40%) also reached the High Benchmark. A relatively small percentage of pupils in Ireland (7%) and internationally (7%) reached the Advanced Benchmark for science.

Only two of our comparison countries had fewer pupils reaching the Advanced Benchmark in science than Ireland – Northern Ireland (5%) and New Zealand (6%). In New Zealand, one-third of pupils did not reach the Intermediate Benchmark, and 12% did not reach the Low Benchmark. Conversely, in three countries (the Republic of Korea, the Russian Federation, and Finland) there was nearly universal attainment of the Low Benchmark (99-100%). Roughly one-third of pupils in Singapore (37%) and the Republic of Korea (29%), and one-fifth of pupils in the Russian Federation (20%), reached the Advanced Benchmark.

Table 5.6: Percentages of pupils reaching each International Benchmark, selected countries – Fourth grade science

	Mean score	Percent of pupils (cumulative) *(SE)*			
		Low	Intermediate	High	Advanced
Singapore	590	97 *(0.5)*	90 *(1.1)*	71 *(1.8)*	37 *(2.0)*
Korea, Rep. of	589	100 *(0.1)*	96 *(0.5)*	75 *(1.1)*	29 *(1.6)*
Russian Fed.	567	99 *(0.3)*	91 *(1.0)*	62 *(2.0)*	20 *(1.5)*
Hong Kong SAR	557	98 *(0.4)*	88 *(1.1)*	55 *(1.8)*	16 *(1.2)*
Finland	554	99 *(0.4)*	89 *(0.9)*	54 *(1.4)*	13 *(0.9)*
United States	546	95 *(0.5)*	81 *(0.9)*	51 *(1.1)*	16 *(0.8)*
Slovenia	543	97 *(0.5)*	84 *(1.0)*	49 *(1.4)*	11 *(0.9)*
England	536	97 *(0.5)*	81 *(1.2)*	43 *(1.5)*	10 *(0.8)*
Ireland	**529**	**96 *(0.6)***	**79 *(1.2)***	**40 *(1.6)***	**7 *(0.9)***
Australia	524	94 *(0.8)*	75 *(1.4)*	39 *(1.6)*	8 *(0.7)*
Northern Ireland	520	95 *(0.6)*	76 *(1.3)*	34 *(1.3)*	5 *(0.6)*
New Zealand	506	88 *(0.9)*	67 *(1.4)*	32 *(1.1)*	6 *(0.6)*
TIMSS (median)	-	95 *(-)*	76 *(-)*	39 *(-)*	7 *(-)*

A comparison between the performance of pupils in Ireland in the TIMSS 1995 and TIMSS 2011 science assessments shows some improvement in the current cycle, albeit to a somewhat lesser extent than in mathematics (discussed earlier). As shown in Table 5.7, significantly greater percentages of Fourth Class pupils reached at least the Low (96%) and Intermediate (79%) Benchmarks for science in 2015 than in both of the previous cycles. More pupils also reached the High Benchmark in 2015 (40%) than in 2011 (35%).

However, performance at the Advanced Benchmark has not changed, either over the last 20 years or since 2011. It remains the case that relatively few pupils in Ireland (7%) are able to demonstrate the more advanced scientific skills that characterise this Benchmark.

Overall, therefore, we can say that more Fourth Class pupils in Ireland have attained a basic level of scientific understanding than in previous years, but that there has been little change in the percentage of higher performers.

Table 5.7: Overall mean score, and percentage of Fourth Class pupils reaching the science International Benchmarks in TIMSS 2015 and previous cycles

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

Percentages in **bold** are significantly lower than the equivalent in 2015.

As with mathematics, no significant differences were found by gender. Slightly more boys reached the Advanced (8%) and High (42%) Benchmarks than girls (5% and 38%, respectively) (Table 5.8).

Table 5.8: Percentages of boys and girls achieving at each Benchmark – Fourth Class science

	Mean score	Low (400)	Intermediate (475)	High (550)	Advanced (625)
Boys	531	95 *(0.8)*	79 *(1.4)*	42 *(2.0)*	8 *(1.3)*
Girls	526	96 *(0.6)*	80 *(1.6)*	38 *(2.1)*	5 *(1.0)*

Benchmark performance – Second Year, mathematics

As at Fourth Class, the mathematics performance of Second Year students is described in terms of four Benchmarks: Low, Intermediate, High and Advanced. Table 5.9 describes the typical skills displayed by students who reach each of these four mathematical Benchmarks. Students at higher Benchmarks are able to solve more complex problems and demonstrate a greater understanding of mathematical concepts than students at lower Benchmarks. For example, students at the Low Benchmark have some knowledge of whole numbers and basic graphs and those at the Intermediate Benchmark can apply basic mathematical knowledge in a variety of situations, while students at the High Benchmark can apply understanding and knowledge in a variety of relatively complex situations and those at the Advanced Benchmark can apply and reason in a variety of problem situations, solve linear equations, and make generalisations (Mullis, Martin, Foy and Hooper, 2016).

Table 5.9: International Benchmarks – Eighth grade mathematics

Benchmark	Scoring at least	Indicative skills
Advanced *Students can apply and reason in a variety of problem situations.*	625	✓ Solve a variety of fraction, proportion, and percent problems and can justify their conclusions. ✓ Use their knowledge of geometric figures to solve a wide range of problems about area. ✓ Demonstrate an understanding of the meaning of averages and can solve problems involving expected values.
High *Students can apply their understanding and knowledge in a variety of relatively complex situations.*	550	✓ Use information to solve problems involving different types of numbers and operations. ✓ Relate fractions, decimals, and percentages to each other. ✓ Show basic procedural knowledge related to algebraic expressions. ✓ Solve a variety of problems with angles including those involving triangles, parallel lines, rectangles, 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 negative numbers, decimals, percentages, and proportions. ✓ Show some knowledge of linear expressions and two- and three-dimensional shapes. ✓ Read and interpret data in graphs and tables. ✓ Show some basic knowledge of chance.
Low *Students have some knowledge of whole numbers and basic graphs.*	400	There is insufficient information on which to base a description of the mathematical skills of these students.

Adapted from Mullis, Martin, Foy and Hooper (2016).

The percentage of students reaching each of the four Benchmarks in Ireland and in the selected comparison countries is presented in Table 5.10. As shown, most students in Ireland (94%) reached *at least* the Low Benchmark, while just over three-quarters reached *at least* the Intermediate Benchmark, 38% reached *at least* the High Benchmark, and 7% reached the Advanced Benchmark (the highest level of performance). For comparison, the TIMSS median percentage reaching each Benchmark was lower than in Ireland: 84% (Low), 62% (Intermediate), 26% (High), and 5% (Advanced).

While the percentage of students reaching at least the Low Benchmark in Ireland was somewhat lower than in the highest-achieving countries (99% in Singapore and the Republic of Korea), it was about the same as in England (93%) and Slovenia (95%). The gap in performance between Ireland and the highest-achieving country widened at the higher Benchmarks, with 38% of students in Ireland and 81% in Singapore reaching the High Benchmark and 7% of students in Ireland and 54% in Singapore reaching the Advanced Benchmark.

Amongst the selected comparison countries, both Australia and New Zealand achieved mean mathematics scores that were considerably lower than Ireland's. In line with this higher overall performance, a greater proportion of students reached the Low, Intermediate and High Benchmarks in Ireland than in Australia or New Zealand. However, at the most advanced level, the proportion of students reaching the Advanced Benchmark in Ireland was found to be similar to Australia and New Zealand.

Table 5.10: Percentages of students reaching each International Benchmark, selected countries – Eighth grade mathematics

	Mean score	Percent of students (cumulative) *(SE)*			
		Low	Intermediate	High	Advanced
Singapore	621	99 *(0.2)*	94 *(0.9)*	81 *(1.5)*	54 *(1.8)*
Korea, Rep. of	606	99 *(0.2)*	93 *(0.5)*	75 *(1.0)*	43 *(1.4)*
Hong Kong SAR	594	98 *(0.6)*	92 *(1.3)*	75 *(1.9)*	37 *(2.3)*
Russian Fed.	538	95 *(0.8)*	78 *(1.9)*	46 *(2.5)*	14 *(1.4)*
Ireland	**523**	**94 *(0.8)***	**76 *(1.3)***	**38 *(1.7)***	**7 *(0.8)***
United States	518	91 *(0.7)*	70 *(1.4)*	37 *(1.5)*	10 *(0.9)*
England	518	93 *(1.2)*	69 *(2.4)*	36 *(2.4)*	10 *(1.1)*
Slovenia	516	95 *(0.6)*	73 *(1.2)*	32 *(1.3)*	6 *(0.6)*
Australia	505	89 *(1.0)*	64 *(1.6)*	30 *(1.4)*	7 *(0.8)*
New Zealand	493	85 *(1.2)*	58 *(1.5)*	27 *(1.2)*	6 *(0.8)*
TIMSS (median)	-	84 *(-)*	62 *(-)*	26 *(-)*	5 *(-)*

In Ireland, there have only been small, and not statistically significant, changes in the percentages of students at each Benchmark since 1995. The percentages at the Low and Intermediate benchmarks both increased by three percentage points, while the percentages at the High and Advanced benchmarks remained relatively unchanged (Table 5.11), indicating that there have been slight improvements among lower-achieving students. Of the 16 countries that took part in both 1995 and 2015, five (including the Republic of Korea, the United States and England) saw significant improvements among students at the Low Benchmark and 10 (including Singapore, the Republic of Korea, the United States and England) saw significant increases at the Advanced Benchmark since 1995.

Table 5.11: Overall mean score, and percentage of Second Year students reaching the mathematics International Benchmarks in TIMSS 2015 and 1995

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

Percentages in bold are significantly lower than the equivalent in 2015.

Slightly more boys reached the Advanced (8%) and High (40%) mathematical Benchmarks, with 5% and 37% of girls attaining a similar level of performance (Table 5.12). However, these differences were not statistically significant. Identical percentages of boys and girls reached the Intermediate and Low Benchmarks.

Table 5.12: Percentages of boys and girls achieving at each Benchmark – Second Year mathematics

	Mean score	Low (400)	Intermediate (475)	High (550)	Advanced (625)
Boys	526	94 *(1.0)*	76 *(1.8)*	40 *(2.4)*	8 *(1.2)*
Girls	521	94 *(0.8)*	76 *(1.5)*	37 *(1.8)*	5 *(0.8)*

Benchmark performance – Second Year, science

Science performance at Second Year is also described in terms of four International Benchmarks (from the Low to Advanced Benchmarks) which describe increasing levels of scientific knowledge and understanding (Table 5.13). Students at the Low Benchmark can recognise some basic facts from the life and physical sciences, as well as interpret simple diagrams and tables and apply their knowledge to practical situations. Those at the Intermediate Benchmark can recognise and apply their understanding of basic scientific knowledge in various contexts, as well as interpret information from tables, graphs and diagrams and communicate their understanding through brief descriptive responses. Students at the High Benchmark have an understanding of concepts related to science cycles, systems and principles and can demonstrate some scientific inquiry skills. They are also capable of combining and interpreting information from various types of diagrams, contour maps, graphs and tables and can select and analyse relevant information, draw conclusions and provide short explanations. Students performing at the Advanced International Benchmark can communicate an understanding of complex and abstract concepts in biology, chemistry, physics, and Earth science and can also combine information from several sources to solve problems, draw conclusions, and provide written explanations to communicate scientific knowledge (Martin, Mullis, Foy and Hooper, 2016).

Table 5.13: International Benchmarks – Eighth grade science

Benchmark	Scoring at least	Students typically can:
Advanced *Students can communicate understanding of complex concepts related to biology, chemistry, physics and Earth science in practical, abstract and experimental contexts.*	625	✓ Apply knowledge of cells and their functions as well as characteristics and life processes of organisms. ✓ Demonstrate an understanding of diversity, adaptation, and natural selection among organisms and of ecosystems and the interaction of organisms with their environment. ✓ Apply knowledge of life cycles and heredity in plants and animals. ✓ Demonstrate knowledge of the composition and physical properties of matter and apply knowledge of chemical and physical change in practical and experimental contexts. ✓ Communicate an understanding of physical states and changes in matter in practical and experimental contexts, apply knowledge of energy transfer and demonstrate knowledge of electricity and magnetism. ✓ Communicate understanding of forces and pressure and demonstrate knowledge of light and sound in practical and abstract situations. ✓ Communicate understanding of Earth's structure, physical features and resources as well as of Earth in the solar system. ✓ Show understanding of the basic aspects of scientific investigation and can identify which variables to control in an experimental situation, compare information from several sources, combine information to predict and draw conclusions and interpret information in diagrams, maps, graphs, and tables to solve problems. ✓ Provide written explanations to communicate scientific knowledge.

Table 5.13: International Benchmarks – Eighth grade science *(continued)*

Benchmark	Scoring at least	Students typically can:
High *Students can apply and communicate understanding of concepts from biology, chemistry, physics and Earth science in everyday and abstract situations.*	550	✓ Apply knowledge of cells and their functions and of the characteristics and life processes of organisms. ✓ Communicate understanding of ecosystems and the interaction of organisms with their environment and apply some knowledge of human health related to nutrition and infectious disease. ✓ Show knowledge and understanding of the composition and properties of mater and chemical change. ✓ Apply basic knowledge of energy transformation and transfer and of light and sound in practical situations and demonstrate understanding of simple electrical circuits and properties of magnets. ✓ Apply their knowledge of forces and motion to everyday and abstract situations. ✓ Apply their knowledge of Earth's physical features, processes, cycles, and history and show some understanding of Earth's resources, their use and conservation as well as some knowledge of the interaction between Earth and the Moon. ✓ Demonstrate some scientific inquiry skills, including selecting and justifying an appropriate experimental method. ✓ Combine and interpret information from various types of diagrams, graphs and tables; select relevant information to analyse and draw conclusions; and provide short explanations conveying scientific knowledge.
Intermediate *Students can demonstrate and apply their knowledge of biology, chemistry, physics and Earth science in various contexts.*	475	✓ Demonstrate some knowledge of characteristics and life processes of animals and human health. ✓ Apply knowledge of ecosystems, the interaction of living things and the adaptation of animals to their environments. ✓ Apply some knowledge of the composition of matter and properties of matter. ✓ Show knowledge of some aspects of force, motion and energy. ✓ Apply knowledge of Earth's processes, resources and physical features. ✓ Interpret information from tables, graphs and pictorial diagrams to draw conclusions, apply knowledge to practical situations and communicate their understanding through brief descriptive responses.
Low *Students show some basic knowledge of biology, chemistry, physics and Earth science.*	400	✓ Apply basic knowledge of ecosystems and adaptation of animals to their environment. ✓ Show knowledge of basic facts related to thermal and electrical conductivity and electromagnetism. ✓ Show knowledge of some basic Earth science facts. ✓ Interpret simple pictorial diagrams and apply basic knowledge to practical situations.

Adapted from Martin, Mullis, Foy and Hooper (2016).

Table 5.14 presents the percentage of students in Ireland and in selected comparison countries who reached each of the four Benchmarks. The majority of students in Ireland (94%) reached *at least* the Low Benchmark, while over three-quarters (77%) reached *at least* the Intermediate Benchmark, 43% reached *at least* the High Benchmark and 10% reached the Advanced Benchmark. The corresponding international median percentages were 84% (Low), 64% (Intermediate), 29% (High), and 7% (Advanced) – generally, considerably below those achieved in Ireland.

The percentage of students reaching at least the Low Benchmark in Ireland was about the same as in England (95%) and the United States (93%) and was slightly lower than in Singapore (97%), the highest-achieving country. On the other hand, Ireland had proportionally fewer students

at the High and Advanced benchmarks compared to Singapore (over four times fewer at the Advanced Benchmark). Although Ireland and England did not differ in terms of their mean science performance, Ireland had significantly fewer students at the Advanced Benchmark than England (10% and 14%, respectively).

As was the case for mathematics, the proportion of students at the highest science Benchmark was the same in Ireland and in New Zealand, a country that had a significantly lower mean science score than Ireland.

Table 5.14: Percentages of students reaching each International Benchmark, selected countries – Eighth grade science

	Mean score	Percent of students (cumulative) *(SE)*			
		Low	Intermediate	High	Advanced
Singapore	597	97 *(0.5)*	90 *(1.1)*	74 *(1.7)*	42 *(1.4)*
Korea, Rep. of	556	97 *(0.4)*	85 *(0.8)*	54 *(1.2)*	19 *(1.0)*
Slovenia	551	97 *(0.4)*	84 *(1.0)*	52 *(1.3)*	17 *(1.0)*
Hong Kong SAR	546	96 *(0.8)*	85 *(1.5)*	51 *(2.1)*	12 *(1.3)*
Russian Fed.	544	96 *(0.6)*	81 *(1.8)*	49 *(2.2)*	14 *(1.2)*
England	537	95 *(0.8)*	77 *(1.9)*	45 *(2.1)*	14 *(1.2)*
Ireland	**530**	**94 *(0.9)***	**77 *(1.3)***	**43 *(1.4)***	**10 *(0.7)***
United States	530	93 *(0.7)*	75 *(1.2)*	43 *(1.4)*	12 *(0.9)*
New Zealand	513	88 *(1.0)*	67 *(1.5)*	36 *(1.3)*	10 *(0.9)*
Australia	512	91 *(0.8)*	69 *(1.3)*	34 *(1.2)*	7 *(0.6)*
TIMSS (median)	-	84 *(-)*	64 *(-)*	29 *(-)*	7 *(-)*

There have been increases in the percentages of students in Ireland who reached the Low, Intermediate and High benchmarks since 1995, although this difference was only statistically significant at the Intermediate Benchmark (Table 5.15). On the other hand, the percentage of students in Ireland at the Advanced Benchmark was relatively unchanged since 1995. Of the 16 countries that took part in both 1995 and 2015, eight (including the Republic of Korea, Slovenia, the Russian Federation, the United States and Hong Kong) saw significantly more students reaching at least the Low Benchmark and five (including Singapore, Slovenia and Hong Kong) saw significant increases at the Advanced Benchmark since 1995.

Table 5.15: Overall mean score, and percentage of Second Year students reaching the science International Benchmarks in TIMSS 2015 and 1995

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

Percentages in **bold** are significantly lower than the equivalent in 2015.

Gender differences in scientific Benchmark performance were small, and not statistically significant (Table 5.16).

Table 5.16: Percentages of boys and girls achieving at each Benchmark – Second Year science

	Mean score	Low (400)	Intermediate (475)	High (550)	Advanced (625)
Boys	529	93 *(1.0)*	76 *(1.7)*	42 *(2.1)*	11 *(1.2)*
Girls	531	94 *(1.0)*	79 *(1.4)*	43 *(1.5)*	10 *(0.8)*

Chapter 6:
Performance in content and cognitive domains: Mathematics

This chapter describes the results of the mathematics assessments at both Fourth grade (Fourth Class) and Eighth grade (Second Year). As described in Chapter 1, the mathematics framework is organised around a number of mathematical content areas and cognitive skills (processes) and student performance is described according to each of these dimensions.

At Fourth grade, three content domains were assessed:

- **Number** (including whole numbers; fractions and decimals; and expressions, simple equations and relationships);
- **Geometric Shapes & Measures** (including points, lines and angles; and two- and three-dimensional shapes); and
- **Data Display** (which includes reading, interpreting and representing various forms of data).

At Eighth grade, there are four content domains:

- **Number** (including whole numbers; fractions, decimals and integers; and ratio, proportions and percent);
- **Algebra** (including expressions and operations; equations and inequalities; and relationships and functions);
- **Geometry** (including geometric shapes; geometric measurement; and location and movement); and
- **Data & Chance** (including characteristics of data sets; data interpretation; and chance).

The relative emphases on the content domains differ slightly for Fourth and Eighth grades to reflect the mathematics widely taught at each grade level. For example, Number is emphasised more at Fourth than at Eighth grade. Also, the pre-algebra topics assessed at Fourth grade are included as part of Number, as algebra and geometry are generally not taught as separable areas at primary level. The Data domain focuses on reading and displaying data at Fourth grade, while it includes greater emphasis on interpretation of data and probability or "chance" at the Eighth grade.

Three types of cognitive skills were assessed at both Fourth and Eighth grades. These were:

- **Knowing** (which covers the facts, concepts and procedures that students need to know and includes skills such as recalling, recognising, classifying and retrieving information; carrying out computations; and using measuring instruments);

- **Applying** (which focuses on students' ability to apply knowledge and conceptual understanding to solve problems or answer questions, and includes skills such as determining appropriate operations, strategies and tools for solving problems; representing or modelling problem situations; and implementing strategies and operations to solve problems); and
- **Reasoning** (which includes solving problems in unfamiliar situations, problems in complex contexts and multi-step problems, and involves skills such as analysing; integrating and synthesising; evaluating; drawing conclusions; generalising; and justifying).

While the same types of cognitive skills are assessed at Fourth and Eighth grades, the nature of what is assessed is more complex at Eighth grade.

Each item in the mathematics assessments is classified according to the main content area that underlies the problem and the key cognitive process involved in solving the problem. In this way, student performance can be described for each content area and cognitive process, using only the items from a given domain, thus allowing for comparisons of 'relative' strengths and weaknesses in a country's performance. For example, a high-performing country may have a mean score on (e.g.) Number that is significantly lower than their mean score on the overall mathematics scale, thus indicating a relative weakness in this area *within* that country, while still outperforming most other countries on Number *in absolute terms*.

The performance of students in Ireland across content and cognitive domains, and in selected comparison countries, is presented in the following sections. Statistically significant relative strengths and weaknesses within countries are highlighted.

Fourth Class – content domains

Relative strengths and weaknesses among content domains can be observed within countries by comparing their mean scores on each of the content subscales to their overall performance. The majority of countries were found to have a significant difference in performance across at least one of the content areas. In fact, pupils in just three of all the participating countries (Hong Kong, the Republic of Korea and Poland) achieved a similar level of performance across all three content domains.

Pupils in Ireland showed a relative strength on Number (+4 points) and a relative weakness on Geometric Shapes & Measures (-5 points), when compared to their overall performance (Table 6.1). A similar pattern was observed in Northern Ireland and the United States. Of the twelve comparison countries, five showed relative strength on Number and six on Data Display. Weaknesses on Geometric Shapes & Measures were most common, with pupils in six comparison countries performing significantly less well in this domain and just three countries showing a relative strength on this content area.

Table 6.1: Scale scores *(SE)* on mathematics content domains – Fourth grade

	Overall	Number	Geometric Shapes & Measures	Data Display
Singapore	618	630 *(4.2)*	607 *(4.2)*	600 *(4.1)*
Hong Kong SAR	615	616 *(3.1)*	617 *(3.4)*	611 *(3.8)*
Korea, Rep. of	608	610 *(2.6)*	610 *(2.3)*	607 *(2.6)*
Northern Ireland	570	574 *(3.1)*	566 *(3.3)*	567 *(3.8)*
Russian Fed.	564	567 *(3.3)*	557 *(4.4)*	573 *(3.6)*
Ireland	**547**	**551 *(2.2)***	**542 *(2.9)***	**548 *(3.8)***
England	546	547 *(3.2)*	542 *(3.3)*	552 *(3.2)*
United States	539	546 *(2.2)*	525 *(2.6)*	540 *(2.8)*
Finland	535	532 *(2.1)*	539 *(2.5)*	542 *(3.3)*
Slovenia	520	511 *(1.8)*	530 *(2.1)*	540 *(3.1)*
Australia	517	509 *(3.1)*	527 *(3.3)*	533 *(3.6)*
New Zealand	491	485 *(2.7)*	489 *(2.8)*	506 *(2.9)*

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, boys significantly outperformed girls on Geometric Shapes & Measures by eight points, with no gender differences observed on the other domains (Table 6.2). Significant gender differences were found in about half of the comparison countries on Number and Geometric Shapes & Measures, while just Finland had a significant gender difference on Data Display. Gender differences, where they existed, tended to favour boys, with the exception of Finland, where girls outperformed boys on all three domains.

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

	Number		Geometric Shapes & Measures		Data Display	
	Girls	Boys	Girls	Boys	Girls	Boys
Singapore	632	628	610	605	603	597
Hong Kong SAR	610	621	611	622	608	613
Korea, Rep. of	605	614	608	612	606	608
Northern Ireland	573	576	564	568	566	567
Russian Fed.	567	567	558	556	572	573
Ireland	**549**	**553**	**538**	**546**	**547**	**548**
England	542	552	538	546	555	549
United States	542	549	519	532	538	542
Finland	536	528	545	534	550	534
Slovenia	507	515	530	530	541	539
Australia	503	515	523	531	530	535
New Zealand	483	488	487	490	506	506

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 B1 in Appendix B.

Fourth Class – cognitive domains

In Ireland, Fourth Class pupils displayed a relative strength on Knowing (+7 points) and a relative weakness on Reasoning (-12 points), when average performance in these domains was compared to their overall performance (Table 6.3). Among the comparison countries, those whose pupils

showed a relative strength on Knowing (seven countries) also tended to have a relative weakness on Reasoning, with the exception of the Republic of Korea, where pupils showed a relative strength on both domains. The highest-performing countries tended to display a relative strength on Knowing and a relative weakness on Reasoning, while the comparison countries that performed less well overall tended to show a relative strength on Reasoning and relative weakness on Knowing.

Table 6.3: Scale scores *(SE)* on mathematics cognitive domains – Fourth grade

	Overall	Knowing	Applying	Reasoning
Singapore	618	631 *(4.0)*	619 *(4.0)*	603 *(4.5)*
Hong Kong SAR	615	618 *(3.1)*	621 *(3.1)*	600 *(3.2)*
Korea, Rep. of	608	627 *(2.9)*	595 *(2.1)*	619 *(2.5)*
Northern Ireland	570	582 *(3.9)*	575 *(3.2)*	550 *(3.3)*
Russian Fed.	564	556 *(3.4)*	566 *(3.7)*	570 *(4.0)*
Ireland	**547**	**554 *(2.9)***	**549 *(2.2)***	**535 *(2.7)***
England	546	554 *(3.3)*	544 *(3.2)*	540 *(3.2)*
United States	539	547 *(2.3)*	537 *(2.4)*	531 *(2.5)*
Finland	535	530 *(2.2)*	536 *(2.1)*	540 *(3.1)*
Slovenia	520	517 *(1.9)*	521 *(2.1)*	524 *(2.2)*
Australia	517	509 *(3.5)*	521 *(3.0)*	523 *(3.0)*
New Zealand	491	475 *(2.6)*	497 *(2.5)*	504 *(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 significant gender differences across the three cognitive domains among pupils in Ireland. This was also true for pupils in Singapore, Northern Ireland and Slovenia. Boys significantly outperformed girls on all three cognitive domains in the Republic of Korea, the United States and Australia. Boys also outperformed girls on the Knowing subscale in England and New Zealand, and on the Applying and Reasoning subscales in Hong Kong. Gender differences favoured girls in the Russian Federation (on Reasoning) and Finland (on Applying and Reasoning).

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

	Knowing		Applying		Reasoning	
	Girls	Boys	Girls	Boys	Girls	Boys
Singapore	633	628	621	618	605	600
Hong Kong SAR	614	621	615	626	595	604
Korea, Rep. of	624	630	592	599	612	624
Northern Ireland	577	587	576	575	548	551
Russian Fed.	557	556	566	567	573	567
Ireland	**552**	**556**	**547**	**550**	**532**	**538**
England	548	560	542	547	537	543
United States	545	550	532	542	528	534
Finland	532	528	542	530	547	534
Slovenia	514	520	518	523	522	526
Australia	503	515	516	526	519	528
New Zealand	471	480	497	497	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 B2 in Appendix B.

Second Year – content domains

In Ireland, Second Year students displayed relative strengths on the Number (+21 points) and Data & Chance (+10 points) content domains, and relative weaknesses on Algebra (-22 points) and Geometry (-20 points) (Table 6.5). Similar patterns were observed in England (a country with similar overall mathematics performance to Ireland), Australia and New Zealand (two countries that performed significantly less well than Ireland, overall). Among the comparison countries, most showed relative strengths on the Number and Data & Chance content areas, while just three had a relative strength on Algebra (the Republic of Korea, the Russian Federation and the United States) and Geometry (the Republic of Korea, Hong Kong and Slovenia).

Table 6.5: Scale scores *(SE)* on mathematics content domains – Eighth grade

	Overall	Number	Algebra	Geometry	Data & Chance
Singapore	621	629 *(3.2)*	623 *(3.4)*	617 *(3.5)*	617 *(3.4)*
Korea, Rep. of	606	601 *(2.4)*	612 *(2.9)*	612 *(3.4)*	600 *(2.4)*
Hong Kong SAR	594	594 *(4.9)*	593 *(4.7)*	602 *(5.1)*	597 *(5.9)*
Russian Fed.	538	533 *(4.5)*	558 *(5.2)*	536 *(5.6)*	507 *(5.0)*
Ireland	**523**	**544 *(3.3)***	**501 *(2.8)***	**503 *(3.1)***	**534 *(3.8)***
United States	518	520 *(3.1)*	525 *(3.1)*	500 *(3.2)*	522 *(3.5)*
England	518	528 *(4.5)*	492 *(4.7)*	514 *(4.1)*	541 *(4.7)*
Slovenia	516	524 *(2.4)*	498 *(2.5)*	522 *(2.8)*	525 *(2.7)*
Australia	505	511 *(3.2)*	491 *(3.4)*	500 *(3.1)*	519 *(3.1)*
New Zealand	493	500 *(3.5)*	475 *(3.5)*	488 *(3.2)*	509 *(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.

Boys significantly outperformed girls on the Number content domain in Ireland and in five other comparison countries, while girls achieved a higher mean score than boys on this content area in Singapore (Table 6.6). There were no gender differences in Ireland on the other content domains. Among the comparison countries, gender differences tended to be confined to the Number and Algebra content domains, although boys significantly outperformed girls on the Data & Chance subscale in the Russian Federation. In four comparison countries (Singapore, the Republic of Korea, the United States and Slovenia), girls had significantly higher mean Algebra scores than boys.

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

	Number		Algebra		Geometry		Data & Chance	
	Girls	Boys	Girls	Boys	Girls	Boys	Girls	Boys
Singapore	633	625	630	615	621	613	621	614
Korea, Rep. of	594	608	616	608	613	611	599	601
Hong Kong SAR	590	598	593	593	601	602	593	601
Russian Fed.	523	542	559	558	534	537	500	514
Ireland	**540**	**549**	**502**	**500**	**500**	**507**	**530**	**538**
United States	515	524	529	521	499	501	520	523
England	524	531	497	488	519	509	544	539
Slovenia	516	531	503	494	522	523	525	524
Australia	506	517	492	489	500	500	518	520
New Zealand	496	503	479	470	489	488	511	506

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 B3 in Appendix B.

Second Year – cognitive domains

Students in Ireland were found to have a relative strength on Knowing (+4 points), along with students in four comparison countries (Singapore, Hong Kong, the Russian Federation and the United States) (Table 6.7). While students in the four comparison countries were also found to have a relative weakness on the higher-order Reasoning items, this was not the case among students in Ireland. However, students in Ireland did demonstrate a relative weakness on the Applying cognitive domain (-3 points). In just two of the comparison countries (England and New Zealand) students were found to have a relative weakness on Knowing items and a relative strength (along with students in Australia) on Reasoning tasks.

Table 6.7: Scale scores *(SE)* on mathematics cognitive domains – Eighth grade

	Overall	Knowing	Applying	Reasoning
Singapore	621	633 *(3.4)*	619 *(3.2)*	616 *(3.7)*
Korea, Rep. of	606	607 *(2.8)*	606 *(2.8)*	608 *(2.7)*
Hong Kong SAR	594	600 *(5.1)*	595 *(4.5)*	591 *(5.1)*
Russian Fed.	538	543 *(5.6)*	541 *(4.6)*	528 *(5.0)*
Ireland	**523**	**527 *(3.0)***	**520 *(3.0)***	**521 *(3.1)***
United States	518	528 *(3.5)*	515 *(3.2)*	514 *(3.1)*
England	518	513 *(4.1)*	519 *(4.1)*	522 *(4.4)*
Slovenia	516	518 *(2.4)*	514 *(2.1)*	516 *(2.7)*
Australia	505	504 *(3.1)*	502 *(3.0)*	512 *(3.1)*
New Zealand	493	488 *(3.4)*	493 *(3.3)*	499 *(3.5)*

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 across the cognitive domains among Second Year students in Ireland (Table 6.8). Among the comparison countries, gender differences across cognitive domains were only observed in Singapore (with girls outperforming boys in each cognitive domain) and the Russian Federation (with boys outperforming girls in each cognitive domain).

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

	Knowing		Applying		Reasoning	
	Girls	Boys	Girls	Boys	Girls	Boys
Singapore	641	626	623	616	621	612
Korea, Rep. of	608	606	605	607	606	609
Hong Kong SAR	599	601	593	597	587	595
Russian Fed.	538	548	535	546	522	533
Ireland	**526**	**529**	**517**	**524**	**520**	**523**
United States	529	527	513	516	512	516
England	517	509	520	519	524	521
Slovenia	518	518	512	516	515	516
Australia	505	504	500	504	511	513
New Zealand	487	489	494	492	501	496

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 B4 in Appendix B.

Chapter 7:
Performance in content and cognitive domains: Science

This chapter presents the results of the science assessment with reference to students' performance on particular scientific topics (content areas) and processes (cognitive domains). As for mathematics, the assessment frameworks for science in TIMSS 2015 were based around a number of specified subdomains that described each of these content and cognitive areas. At Fourth grade, the science content domains were:

- **Life Science** (including topics such as the characteristics and life processes of organisms; life cycles, reproduction, and heredity; the interactions between organisms and their environments; ecosystems; and human health);
- **Physical Science** (including the classification and properties of matter, and changes in matter; forms of energy and energy transfer; and forces and motion); and
- **Earth Science** (including the Earth's structure, physical characteristics, and resources; Earth's processes and history; and Earth in the solar system). The Earth Science domain includes much of the material that is taught as geography in Irish classrooms.

At Eighth grade, the content domains were:

- **Biology** (including 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** (including physical states and changes in matter; energy transformation and transfer; light and sound; electricity and magnetism; and forces and motion);
- **Chemistry** (including the composition of matter; properties of matter; and chemical change); and
- **Earth Science** (including Earth's structure and physical features; Earth's processes, cycles, and history; Earth's resources, their use, and conservation; and Earth in the solar system and the universe). As at Fourth grade, much of this content is considered to be part of the geography curriculum in Ireland.

At both grade levels, the same three cognitive processes were assessed (albeit to a greater degree of difficulty in the Eighth grade assessment). These were:

- **Knowing** (including skills such as recalling or recognising information; describing; and providing examples);
- **Applying** (including skills such as comparing, contrasting, and classifying; relating knowledge of a concept to a situation; using models or diagrams; interpreting information; and providing explanations for natural phenomena); and

- **Reasoning** (including higher-order skills such as analysing a problem; synthesising information to answer a question; formulating hypotheses and predicting changes; designing investigations or experiments; evaluating results; drawing conclusions; generalising information beyond specific scenarios; and justifying conclusions).

Every item in the assessment belonged to one of these content domains and one of these cognitive domains. Thus, as well as the overall science scale score presented previously, subscale performance (using only the items within a given content or cognitive domain) can be calculated. This allows comparison of 'relative' strengths and weaknesses in a country's performance. For example, a very high-performing country might have a lower score on (e.g.) Life Science than on the other scientific domains, thereby outperforming most other countries on Life Science *in absolute terms*, but showing Life Science to be a relative weakness *within* that country.

The following sections present students' performance in Ireland and in the selected comparison countries from this perspective, with relative (i.e., within-country) strengths and weaknesses highlighted. All of the differences highlighted below are statistically significant.

Fourth Class – content domains

Almost all participating countries were found to have a significant difference in performance on at least one of the content areas. Pupils in only two countries (the Russian Federation and Croatia) achieved a similar level of performance across all three domains.

In Ireland, Fourth Class pupils displayed a relative strength – using the overall Irish performance as a reference point – on Earth Science topics (+6 points) and a relative weakness on Physical Science topics (-5 points) (Table 7.1). A similar pattern was found in Finland. Among our comparison countries, weaknesses on Physical Science and Earth Science were most common. Pupils in Singapore displayed a relatively large weakness in Earth Science (-44 points compared to their overall score), albeit while still achieving at a very high level.

Table 7.1: Scale scores *(SE)* on science content domains – Fourth grade

	Overall	Life Science	Physical Science	Earth Science
Singapore	590	607 *(4.4)*	603 *(3.7)*	546 *(3.7)*
Korea, Rep. of	589	581 *(1.9)*	597 *(2.0)*	591 *(4.1)*
Russian Fed.	567	569 *(3.1)*	567 *(3.6)*	562 *(4.7)*
Hong Kong SAR	557	550 *(3.7)*	555 *(3.5)*	574 *(3.1)*
Finland	554	556 *(2.6)*	547 *(2.3)*	560 *(2.6)*
United States	546	555 *(2.3)*	537 *(2.6)*	539 *(2.4)*
Slovenia	543	545 *(2.3)*	546 *(2.4)*	531 *(4.1)*
England	536	536 *(2.5)*	540 *(2.7)*	527 *(3.3)*
Ireland	**529**	**531 *(2.4)***	**524 *(2.8)***	**535 *(3.0)***
Australia	524	531 *(3.0)*	516 *(2.7)*	520 *(3.3)*
Northern Ireland	520	521 *(2.7)*	514 *(2.6)*	522 *(3.0)*
New Zealand	506	511 *(2.7)*	497 *(2.5)*	506 *(3.4)*

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.

Fourth Class boys in Ireland significantly outperformed girls on Earth Science (a difference of 15 points), with no significant gender differences found on the other domains. Among our comparison

countries, gender differences (where they existed) tended to favour boys in Earth Science and Physical Science, and to favour girls in Life Science (Table 7.2). Finland was a slight exception to this pattern, with girls outperforming boys on both Life Science and Earth Science items.

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

	Life Science		Physical Science		Earth Science	
	Girls	Boys	Girls	Boys	Girls	Boys
Singapore	610	604	603	604	541	552
Korea, Rep. of	581	582	589	605	578	603
Russian Fed.	573	565	565	569	560	565
Hong Kong SAR	550	550	548	561	565	582
Finland	566	546	550	545	565	556
United States	555	555	534	541	535	544
Slovenia	547	543	539	553	520	541
England	539	533	537	543	523	532
Ireland	**532**	**529**	**521**	**527**	**527**	**542**
Australia	535	527	513	519	516	524
Northern Ireland	524	518	510	518	522	522
New Zealand	518	505	496	499	502	510

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 B5 in Appendix B.

Fourth Class – cognitive domains

Fourth Class pupils were found to perform at a broadly similar level across the three cognitive domains, with none appearing as a relative strength or weakness. The two highest-performing countries, Singapore and the Republic of Korea, both displayed relative strengths in Applying and Reasoning and relative weaknesses in Knowing (Table 7.3). Among the other comparison countries that achieved higher overall scores than Ireland, three (the Russian Federation, the United States, and Slovenia) had weaknesses in Reasoning, and two (Hong Kong and the United States) were relatively stronger in the Knowing domain. As well as Singapore and the Republic of Korea, strengths in Reasoning were apparent in Australia (where pupils achieved a similar level of overall performance to Ireland) and in New Zealand (significantly below Irish performance).

Table 7.3: Scale scores *(SE)* on science cognitive domains – Fourth grade

	Overall	Knowing	Applying	Reasoning
Singapore	590	574 *(4.1)*	599 *(4.0)*	605 *(3.6)*
Korea, Rep. of	589	582 *(2.2)*	594 *(1.9)*	594 *(2.2)*
Russian Fed.	567	569 *(3.9)*	568 *(3.3)*	561 *(3.8)*
Hong Kong SAR	557	562 *(3.0)*	554 *(3.3)*	552 *(4.1)*
Finland	554	556 *(3.1)*	553 *(2.4)*	552 *(2.3)*
United States	546	548 *(2.5)*	546 *(2.2)*	542 *(2.7)*
Slovenia	543	541 *(2.6)*	546 *(2.9)*	538 *(2.7)*
England	536	533 *(2.6)*	538 *(2.7)*	539 *(2.7)*
Ireland	**529**	**529 *(2.5)***	**530 *(2.5)***	**526 *(2.9)***
Australia	524	523 *(3.3)*	522 *(2.7)*	527 *(3.0)*
Northern Ireland	520	518 *(2.9)*	519 *(2.9)*	520 *(2.6)*
New Zealand	506	504 *(2.8)*	502 *(3.1)*	514 *(2.4)*

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.

On average, boys performed significantly better than girls on Knowing items in Ireland and in five other comparison countries (Table 7.4). There were no significant gender differences in Ireland on the other cognitive domains. In four countries (Singapore, the Russian Federation, Finland and New Zealand), girls outperformed boys on higher-order Reasoning skills. As was the case with the content domains, gender differences in Finland tended to favour girls, with Finnish girls outperforming boys on all three cognitive domains.

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

	Knowing		Applying		Reasoning	
	Girls	Boys	Girls	Boys	Girls	Boys
Singapore	569	579	598	600	610	600
Korea, Rep. of	572	591	587	600	595	593
Russian Fed.	565	572	569	567	565	556
Hong Kong SAR	553	569	549	558	555	550
Finland	560	552	561	545	559	546
United States	545	552	544	548	542	541
Slovenia	533	549	543	549	539	537
England	530	537	539	536	543	534
Ireland	**523**	**534**	**527**	**533**	**529**	**523**
Australia	522	524	523	522	532	523
Northern Ireland	516	521	518	520	524	516
New Zealand	505	503	502	502	521	507

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 B6 in Appendix B.

Second Year – content domains

Second Year students in Ireland were found to have relative strengths in the Biology (+4 points) and Earth Science (+12 points) content areas, and weaknesses in Chemistry (-13 points) and Physics (-5 points). The same pattern of performance was also found in many of our comparison countries, including the United States, New Zealand, Australia and (with the exception of Biology) Hong Kong (Table 7.5). Eighth grade students in the Russian Federation, by contrast, showed the opposite pattern of performance, with a strength in Chemistry and weaknesses in Biology and Earth Science. In general, Chemistry was found to be a relative weakness for almost all of our comparison countries (the Russian Federation and Slovenia being the exceptions).

Table 7.5: Scale scores *(SE)* on science content domains – Eighth grade

	Overall	Biology	Chemistry	Physics	Earth Science
Singapore	597	609 *(3.5)*	593 *(3.6)*	608 *(3.1)*	565 *(3.6)*
Korea, Rep. of	556	554 *(2.2)*	550 *(2.5)*	564 *(2.8)*	554 *(2.7)*
Slovenia	551	548 *(2.8)*	552 *(2.6)*	545 *(2.9)*	564 *(2.9)*
Hong Kong SAR	546	549 *(4.7)*	536 *(4.1)*	540 *(4.1)*	558 *(4.3)*
Russian Fed.	544	539 *(4.4)*	558 *(4.9)*	548 *(4.2)*	532 *(4.7)*
England	537	542 *(4.0)*	529 *(4.5)*	535 *(3.9)*	536 *(4.0)*
Ireland	**530**	**534 *(2.9)***	**517 *(3.6)***	**525 *(3.2)***	**542 *(3.1)***
United States	530	540 *(2.9)*	519 *(3.2)*	516 *(2.9)*	535 *(3.1)*
New Zealand	513	520 *(3.5)*	498 *(3.5)*	508 *(3.2)*	517 *(3.6)*
Australia	512	522 *(2.8)*	493 *(3.3)*	505 *(2.7)*	522 *(2.9)*

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.

Gender differences were quite pronounced at Eighth grade, with boys outperforming girls on Earth Science and in Physics in most of our comparison countries, as well as in Ireland (Table 7.6). There were fewer gender differences in the Biology and Chemistry content areas, but where they existed they tended to favour girls. Girls outperformed boys on these areas in several countries, including (for both content areas) Ireland and Slovenia. England was the only one of our comparison countries to show similar levels of performance among both boys and girls across the four content areas.

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

	Biology		Chemistry		Physics		Earth Science	
	Girls	Boys	Girls	Boys	Girls	Boys	Girls	Boys
Singapore	612	607	598	588	605	611	557	572
Korea, Rep. of	552	556	554	547	563	565	547	561
Slovenia	558	539	559	546	539	551	560	569
Hong Kong SAR	547	550	537	535	530	549	543	571
Russian Fed.	544	534	558	558	538	557	528	536
England	546	538	534	523	532	539	532	540
Ireland	**540**	**528**	**524**	**510**	**518**	**532**	**536**	**548**
United States	542	538	520	518	508	524	526	544
New Zealand	526	513	500	495	502	515	510	524
Australia	524	520	494	492	496	513	514	530

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 B7 in Appendix B.

Second Year – cognitive domains

The final section in this chapter looks at performance on the science cognitive areas at Eighth grade. In Ireland, Second Year students were relatively weaker on Knowing items (-7 points) but performance on Applying and Reasoning items was in line with their overall achievement. Knowing and Applying were relative weaknesses for several countries, and Reasoning was a weakness for students in Singapore, the Russian Federation and the United States (Table 7.7). By contrast, Reasoning was a relative strength for students in the Republic of Korea, Hong Kong, England and New Zealand. It is of interest to note that, although both countries achieved the same overall score (530), students in Ireland and the United States demonstrated differing profiles of cognitive strengths and weaknesses.

Table 7.7: Scale scores *(SE)* on science cognitive domains – Eighth grade

	Overall	Knowing	Applying	Reasoning
Singapore	597	594 *(3.4)*	600 *(3.4)*	595 *(3.2)*
Korea, Rep. of	556	555 *(2.9)*	552 *(2.2)*	560 *(2.8)*
Slovenia	551	558 *(2.6)*	547 *(2.3)*	550 *(2.3)*
Hong Kong SAR	546	547 *(3.7)*	541 *(4.3)*	550 *(4.4)*
Russian Fed.	544	558 *(5.2)*	538 *(4.6)*	538 *(3.9)*
England	537	523 *(4.1)*	538 *(3.9)*	545 *(4.0)*
Ireland	**530**	**523 *(3.2)***	**533 *(3.0)***	**532 *(3.0)***
United States	530	532 *(3.4)*	531 *(2.8)*	526 *(2.8)*
New Zealand	513	503 *(3.2)*	513 *(3.5)*	520 *(3.3)*
Australia	512	510 *(2.7)*	512 *(2.9)*	513 *(2.8)*

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 fewer gender differences at Eighth grade in the cognitive domains than were apparent for the content areas (Table 7.8). The most marked pattern was that boys outperformed girls in the Knowing domain in several countries (including Singapore, the Republic of Korea, Hong Kong, the United States and Australia). In Slovenia, unusually, girls outperformed boys on both Applying and Reasoning items. There were no significant gender differences in the cognitive domains among Second Year students in Ireland.

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

	Knowing		Applying		Reasoning	
	Girls	Boys	Girls	Boys	Girls	Boys
Singapore	589	598	601	599	595	594
Korea, Rep. of	549	561	550	554	562	559
Slovenia	555	561	551	544	557	544
Hong Kong SAR	537	556	536	545	548	552
Russian Fed.	555	560	537	540	535	540
England	520	525	543	534	545	545
Ireland	**519**	**527**	**536**	**530**	**534**	**531**
United States	524	539	530	532	525	527
New Zealand	499	507	515	512	523	516
Australia	505	516	512	513	511	515

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 B8 in Appendix B.

Chapter 8:
Curriculum coverage in TIMSS

In TIMSS 2015, measures were taken to determine how closely the content of the assessments matched the curricula of participating countries. First, each country carried out a Test-Curriculum Matching Analysis (TCMA). This information was used to investigate whether average student performance on *all* items differed from performance on the subset of items included in their national curriculum. Second, teachers were asked to provide information on the topics they had covered in their lessons by the time of the TIMSS assessment.

The results of the TCMA in Ireland are presented here, followed by a summary of performance in Ireland and selected comparison countries on all items compared with the subsets of items considered consistent with each country's curriculum. Finally, teacher reports of coverage of the TIMSS mathematics and science topics are presented.

The Test-Curriculum Matching Analysis in Ireland

In Ireland, subject experts were asked to provide their judgment as to whether the content of each item in the TIMSS assessments was likely to have been covered by most students in the relevant grade level. For both mathematics and science, there is a curriculum for Third and Fourth classes (combined) which could be used as a reference point. However, at post-primary level, there are no specific curricula for Second Year mathematics and science. Instead, for both subjects, the content to be covered is outlined in a three-year curriculum that covers the full Junior Cycle. As a result, the subject experts had to provide their professional opinion on whether the topics in the TIMSS Eighth grade assessments would have been covered by most students in Ireland by the end of Second Year.

An additional curricular issue arising from the TCMA in Ireland was related to the Earth Science domain in TIMSS. Some of the items in this domain are not on the science curricula in Ireland, but would be covered in geography. Consequently, the subject experts for both Fourth Class and Second Year in Ireland were asked to classify the 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 results of the TCMA for the Fourth grade mathematics items are summarised by content domain and overall in Table 8.1. In general, the Fourth grade mathematics items were quite consistent with the Fourth Class curriculum, with more than 80% of TIMSS items in each content domain (and 88% overall) considered to be included in the curriculum.

Table 8.1: TCMA overall and by content domain – Fourth grade mathematics items			
	N items	N included in curriculum	% included in curriculum
Number	89	79	89
Geometric Shapes & Measures	56	49	88
Data Display	24	20	83
Overall	169	148	88

Similarly, 90% of the TIMSS Fourth grade science items were regarded as included in the Fourth Class curriculum. However, as Table 8.2 shows, there was some variation across content domains. All of the TIMSS items assessing Physical Science were judged to be covered by the Fourth Class curriculum, while the corresponding percentage for Earth Science items was 70%. This included any items that would have been familiar to pupils through the geography curriculum.

Further analysis revealed that the TIMSS Earth Science items that were not considered to be included in the Fourth Class curriculum were spread evenly across the three topic areas.[9] In terms of cognitive processes, most of the items not included in the curriculum assessed the Knowing or Applying domains. Only one TIMSS item assessing Reasoning in Earth Science was not considered to be covered in the Fourth Class curriculum.

Table 8.2: TCMA overall and by content domain – Fourth grade science items			
	N items	N included in curriculum	% included in curriculum
Life Science	74	67	91
Physical Science	61	61	100
Earth Science	33	23	70
Overall	168	151	90

Eighth grade items – mathematics and science

The results of the TCMA in Ireland for the Eighth grade mathematics items are shown in Table 8.3. For two of the content domains (Number and Data & Chance) all of the items were identified as being covered by most students by the end of Second Year. Most of the items not considered to be covered by most students by the end of Second Year were in the content domain of Algebra, but even so, 90% of the TIMSS Algebra items were judged to have been taught by the end of Second Year to most students.

Table 8.3: TCMA overall and by content domain – Eighth grade mathematics items			
	N items	N included in curriculum	% included in curriculum
Number	64	64	100
Algebra	61	55	90
Geometry	43	42	98
Data & Chance	41	41	100
Overall	209	202	97

9 The three topic areas for Fourth grade Earth Science were: Earth's structure, physical characteristics and resources; Earth's processes and history; and Earth in the solar system.

In contrast, as Table 8.4 shows, only 72% of the TIMSS Eighth grade science items were regarded as being covered by most students by the end of Second Year. There were also marked differences across content domains. More than 80% of the TIMSS Chemistry items were judged to be covered by most students by the end of Second Year, compared with only 59% of Biology items. The Biology items that were not considered to be covered by most students by the end of Second Year were distributed across the six topic areas.[10] Many of the items that were unlikely to be taught to most students by the end of Second Year were in the Knowing and Applying cognitive domains.

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

	N items	N included in curriculum	% included in curriculum
Biology	75	44	59
Chemistry	43	36	84
Physics	53	41	77
Earth Science	44	33	75
Overall	215	154	72

Comparing performance according to the Test-Curriculum Matching Analysis

Fourth grade – mathematics and science

Table 8.5 summarises performance on subsets of the Fourth grade mathematics items for Ireland and selected comparison countries. The first column gives the average percent correct for each country on *all* of the Fourth grade mathematics items included in the assessment.[11] Each remaining cell in the table shows the average percent correct for the country on that row, based only on the subset of items judged to be included in the Fourth grade mathematics curriculum of the country listed on the top.

Reading down diagonally shows each country's average percent correct on the items considered included in their own curriculum (marked in bold). The shaded *row* shows the average percent correct for pupils in Ireland on the items judged to be covered in the curriculum of each of the comparison countries. The shaded *column* shows the average percent correct for the comparison countries on the items judged to be covered in the Fourth Class mathematics curriculum in Ireland. The last row shows the total number of items considered to be included in each country's curriculum. This is reported as the number of score points, rather than the number of individual items.[12]

As the table shows, the average percent correct for Fourth Class pupils in Ireland varied very little across the subsets of items. Most notably, when the analysis was restricted to only those items identified as included in the Fourth Class mathematics curriculum, the average percent correct for

10 The six topic areas for Eighth grade Biology were: Characteristics and life processes of organisms; Cells and their functions; Life cycles, reproduction and heredity; Diversity, adaptation and natural selection; Ecosystems; and Human health.

11 Countries are listed in descending order of average percent correct. In some cases, this order varies slightly from the rankings based on average scale scores because percent correct figures do not take into account the difficulty of the items that were answered correctly.

12 Some items are worth two score points for a fully correct answer (i.e., two for full credit and one for partial credit). Therefore, the total number of available score points is greater than the number of individual items.

Fourth Class pupils only increased by one percentage point (59% to 60%). Similarly, the average percent correct for all of the comparison countries was, at most, one percentage point higher on Ireland's subset of items, compared with the full set of mathematics items.

Table 8.5: Average percent correct on all items versus items in the curriculum, selected countries – Fourth grade mathematics

Country	Average % correct on all items (*SE*)	Hong Kong SAR	Singapore	Korea, Rep. of	Northern Ireland	Russian Fed.	Ireland	England	United States	Finland	Slovenia	Australia	New Zealand
Hong Kong SAR	75 *(0.7)*	**75**	75	75	75	75	75	75	75	75	75	75	76
Singapore	74 *(0.8)*	74	**76**	75	74	74	75	75	75	75	74	74	74
Korea, Rep. of	73 *(0.5)*	74	74	**76**	73	74	74	74	74	75	75	74	74
Northern Ireland	64 *(0.7)*	64	64	64	**65**	65	65	65	65	64	65	64	65
Russian Fed.	63 *(0.9)*	62	61	63	63	**67**	63	62	63	63	65	63	64
Ireland	59 *(0.6)*	59	59	59	59	59	**60**	59	59	59	60	59	60
England	58 *(0.7)*	58	58	57	58	59	59	**59**	59	58	60	58	60
United States	57 *(0.5)*	57	57	57	57	57	57	57	**57**	57	58	57	58
Finland	55 *(0.5)*	54	54	55	55	55	55	55	55	**56**	56	55	57
Slovenia	51 *(0.5)*	51	50	50	52	53	52	51	52	52	**54**	51	54
Australia	51 *(0.7)*	51	50	50	51	51	52	51	51	51	53	**52**	54
New Zealand	45 *(0.5)*	44	43	43	45	45	45	45	45	45	46	45	**47**
TIMSS average	50 *(0.1)*	50	50	50	50	52	51	50	51	51	52	50	52
Number of items (score points) included in curriculum	178	140	138	137	169	118	156	158	170	166	154	144	132

Adapted from Mullis, Martin, Foy and Hooper (2016).

The same analysis is presented for the TIMSS Fourth grade science items in Table 8.6. Again, the average percent correct among Fourth Class pupils in Ireland did not vary substantially on most of the subsets of items. The largest difference in performance was on the items included in Finland's curriculum. The average percent correct for Fourth Class pupils in Ireland on this subset was 57%, compared with 53% on the full set of mathematics items. However, on the subset of items identified as covered by the Fourth Class curriculum in Ireland, the performance of Fourth Class pupils was identical to that on the full item set (53% correct). Most of the comparison countries also had similar performance across items subsets. The most notable exceptions were Singapore and the Republic of Korea, where, on average, pupils performed markedly better on the subset of items included in their own curriculum than on the full item set. In Singapore the difference was 14 percentage points (81% correct versus 67%). The corresponding difference in the Republic of Korea was nine percentage points (75% versus 66%). Although both were among the highest-performing countries for Fourth grade science, a relatively small proportion of TIMSS items were judged to be included in their respective Fourth grade science curricula (54 of 180 score points in Singapore, and 61 in the Republic of Korea).

Table 8.6: Average percent correct on all items versus items in the curriculum, selected countries – Fourth grade science

Country	Average % correct on all items *(SE)*	Singapore	Korea, Rep. of	Russian Fed	Hong Kong SAR	Finland	United States	Slovenia	England	Ireland	Australia	Northern Ireland	New Zealand
Singapore	67 *(0.8)*	**81**	70	67	68	72	67	68	69	68	69	69	70
Korea, Rep. of	66 *(0.4)*	67	**75**	68	66	70	67	67	67	66	68	68	68
Russian Fed.	62 *(0.7)*	61	65	**63**	62	66	62	62	62	61	62	63	62
Hong Kong SAR	60 *(0.6)*	60	62	61	**60**	65	60	61	59	59	60	61	62
Finland	58 *(0.4)*	56	62	60	58	**62**	59	59	59	58	59	60	60
United States	57 *(0.4)*	54	60	59	57	61	**57**	58	58	57	59	60	59
Slovenia	56 *(0.4)*	56	60	58	57	62	57	**58**	57	57	58	59	60
England	55 *(0.5)*	53	57	56	55	59	55	56	**56**	55	55	57	57
Ireland	53 *(0.5)*	50	55	54	53	57	53	55	53	**53**	54	55	55
Australia	52 *(0.6)*	51	55	54	52	56	52	53	53	52	**53**	55	54
Northern Ireland	51 *(0.5)*	48	53	53	51	55	51	53	52	51	52	**54**	54
New Zealand	49 *(0.5)*	45	51	50	49	52	49	50	49	48	50	51	**51**
TIMSS average	50 *(0.1)*	49	52	51	50	54	50	51	50	50	51	52	52
Number of items (score points) included in curriculum	180	54	61	113	146	113	170	154	140	160	131	136	113

Adapted from Martin, Mullis, Foy and Hooper (2016).

Eighth grade – mathematics and science

Table 8.7 presents the analysis of performance on the Eighth grade mathematics items. The performance of Second Year students in Ireland did not vary considerably on the subsets of items, with the exception of the subset of items identified as included in the Eighth grade mathematics curriculum in New Zealand. On the subset of items covered by the New Zealand curriculum, the mean percent correct for students in Ireland was 54%, compared to 49% for the full TIMSS item pool. All of the other comparison countries also performed slightly better on New Zealand's subset of items than on the full set of mathematics items. This was the smallest subset of items in the analysis, with only 177 of 221 score points identified as being included in the Eighth grade mathematics curriculum in New Zealand. This was in contrast to Ireland, where items worth 214 score points were judged to be taught to most students by the end of Second Year. Performance on these items among Second Years in Ireland was just one percentage point higher than on the full set of mathematics items (50% versus 49%). All of the comparison countries also performed similarly on Ireland's subset of items as on the full set of mathematics items with, at most, one percentage point in the difference.

Table 8.7: Average percent correct on all items versus items in the curriculum, selected countries – Eighth grade mathematics

Country	Average % correct on all items *(SE)*	Singapore	Korea, Rep. of	Hong Kong SAR	Russian Fed.	Ireland	United States	England	Slovenia	Australia	New Zealand
Singapore	74 *(0.8)*	**74**	74	75	75	74	74	74	74	74	76
Korea, Rep. of	69 *(0.6)*	70	**70**	70	70	70	69	69	69	70	72
Hong Kong SAR	68 *(1.1)*	68	68	**69**	69	68	68	68	68	68	70
Russian Fed.	53 *(1.3)*	53	53	54	**55**	53	53	53	53	53	54
Ireland	49 *(0.7)*	50	50	50	51	**50**	49	49	50	51	54
United States	48 *(0.8)*	49	49	48	49	49	**49**	48	48	49	51
England	48 *(1.1)*	48	48	48	49	49	48	**48**	48	49	52
Slovenia	47 *(0.5)*	47	48	48	48	48	47	47	**48**	48	51
Australia	45 *(0.7)*	45	45	45	46	46	45	45	45	**46**	49
New Zealand	42 *(0.8)*	42	43	42	43	43	42	42	42	43	**46**
TIMSS average	42 *(0.1)*	42	42	42	43	42	42	42	42	42	44
Number of items (score points) included in curriculum	221	215	210	190	203	214	218	221	202	210	177

Adapted from Mullis, Martin, Foy and Hooper (2016).

Table 8.8 shows the analysis of performance on the Eighth grade science items for Ireland and selected comparison countries. Second Year students in Ireland performed similarly on the items considered to be taught to the majority of students by the end of Second Year (51% correct) as on the full set of TIMSS Eighth grade science items (50%). All of the comparison countries also performed similarly on Ireland's subset of items as on the full science assessment with, at most, a difference of one percentage point. Again, there was a trend across all comparison countries for slightly higher performance on the items selected by New Zealand as being covered in their science curriculum. Notably, of the comparison countries, only New Zealand and Singapore had fewer items (score points) than Ireland that were classified as being included in the Eighth grade science curriculum.

Table 8.8: Average percent correct on all items versus items in the curriculum, selected countries – Eighth grade science

Country	Average % correct on all items *(SE)*	Singapore	Korea, Rep. of	Slovenia	Russian Fed.	Hong Kong SAR	England	United States	Ireland	New Zealand	Australia
Singapore	64 *(0.7)*	**68**	66	65	64	66	65	65	65	67	65
Korea, Rep. of	56 *(0.5)*	56	**58**	56	55	56	56	56	56	58	56
Slovenia	55 *(0.5)*	54	56	**57**	54	56	55	56	55	57	56
Russian Fed.	54 *(0.9)*	53	54	55	**54**	54	54	54	53	55	54
Hong Kong SAR	53 *(0.8)*	54	54	54	53	**55**	54	53	53	57	54
England	51 *(0.8)*	51	51	52	51	51	**52**	51	51	54	52
United States	50 *(0.6)*	50	50	52	49	50	50	**50**	50	53	51
Ireland	50 *(0.5)*	49	51	51	50	50	50	50	**51**	53	51
New Zealand	47 *(0.6)*	47	47	48	46	47	47	47	46	**50**	47
Australia	47 *(0.5)*	46	47	48	46	46	47	47	46	50	**47**
TIMSS average	44 *(0.1)*	43	44	44	43	44	43	44	43	46	44
Number of items (score points) included in curriculum	233	150	176	204	194	182	211	224	167	166	206

Adapted from Martin, Mullis, Foy and Hooper (2016).

Teacher reports of TIMSS topic coverage

In TIMSS, each content domain in mathematics and science is composed of a number of more specific topic areas. The Teacher Questionnaire for both Fourth and Eighth grades included questions on whether these mathematics and science topics had yet been covered in class. Teachers were asked whether each topic had been 'mostly taught before this year', 'mostly taught this year', or 'not yet taught or just introduced'. This latter category also included topics that were not in the curriculum.

The tables in this section summarise coverage for mathematics and science overall and for each content domain (averaged across topics). Results are presented for Ireland, alongside the international average, in terms of the percentages of students whose teachers reported that the topics had been mostly taught in the assessment year or in the year before. Appendix C provides data on the coverage of each individual mathematics and science topic area, as reported by teachers of Fourth Class and Second Year students in Ireland.

Fourth grade – mathematics and science

Table 8.9 shows that, overall, Ireland compared favourably with the international average for TIMSS Fourth grade mathematics topic coverage. In particular, teacher reports indicated that the content domain of Number was well covered in Ireland. The main exception was the topic 'use of fractions', which involves adding, subtracting, comparing and ordering fractions. More than one-third of Fourth Class pupils (37%) were taught by teachers who indicated that this topic had not been covered or had just been introduced (see Appendix C).

In contrast to Number, the content domain of Geometric Shapes & Measures was less well

covered. For example, 60% of pupils were taught by teachers who reported that they had not covered 'reflections and rotations' with their pupils. However, these topics are not explicitly included in the Primary School Mathematics Curriculum, a fact that is evident from the TCMA classifications for Fourth Class (where items on reflections of shapes were judged to be outside the intended curriculum). It is worth noting that, while coverage of Geometric Shapes & Measures was relatively low in Ireland (66% of pupils averaged across topics), it was broadly in line with the international average (68% of pupils).

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

	All mathematics (17 topics) % *(SE)*	Number (8 topics) % *(SE)*	Geom. Shapes & Measures (7 topics) % *(SE)*	Data Display (2 topics) % *(SE)*
Ireland	81 *(1.0)*	92 *(0.8)*	66 *(1.7)*	94 *(1.9)*
TIMSS	76 *(0.2)*	83 *(0.1)*	68 *(0.2)*	78 *(0.4)*

Percentages of pupils mostly taught before or in the assessment year, averaged across topics.
International data from Mullis, Martin, Foy and Hooper (2016).

Coverage of the TIMSS Fourth grade science topics was reported as being high by teachers of Fourth Class pupils. As Table 8.10 shows, larger percentages of pupils in Ireland were taught by teachers who had covered each content domain, compared with the international average. The difference was most pronounced for the Physical Science content domain, with nearly three-quarters (74%) of Fourth Class pupils taught by teachers who reported covering this area, compared with an average of 59% of Fourth grade pupils internationally.

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

	All science (23 topics) % *(SE)*	Life Science (7 topics) % *(SE)*	Physical Science (9 topics) % *(SE)*	Earth Science (7 topics) % *(SE)*
Ireland	75 *(1.3)*	78 *(1.6)*	74 *(1.4)*	74 *(2.3)*
TIMSS	65 *(0.2)*	72 *(0.2)*	59 *(0.3)*	66 *(0.3)*

Percentages of pupils mostly taught before or in the assessment year, averaged across topics.
International data from Martin, Mullis, Foy and Hooper (2016).

Second Year – mathematics and science

Table 8.11 shows the coverage of TIMSS topics for Second Year students in Ireland and Eighth grade students internationally. As above, the percentages are averaged across topics within each content domain. The pattern for Second Year mathematics differed somewhat from Fourth Class. Coverage of overall mathematics was similar to the international average, but there were some differences across content domains.

Most notably, according to their teachers, only 58% of Second Year students had covered the Geometry content domain, compared with 77% of students internationally. A number of Geometry topics had not yet been covered by substantial proportions of students in Ireland. For example, teacher reports indicated that only 45% of Second Year students had covered 'congruent figures and similar triangles' (international average: 70%), while only 37% had covered 'translation, reflection and rotation' (international average: 69%).

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

	All mathematics (20 topics) % *(SE)*	Number (5 topics) % *(SE)*	Algebra (6 topics) % *(SE)*	Geometry (6 topics) % *(SE)*	Data & Chance (3 topics) % *(SE)*
Ireland	73 *(1.0)*	92 *(0.8)*	72 *(1.5)*	58 *(1.8)*	75 *(2.3)*
TIMSS	76 *(0.1)*	92 *(0.1)*	70 *(0.2)*	77 *(0.2)*	60 *(0.4)*

Percentages of students mostly taught before or in the assessment year, averaged across topics.
International data from Mullis, Martin, Foy and Hooper (2016).

Table 8.12 presents the coverage of the TIMSS Eighth grade science topics. Coverage was slightly lower than for Eighth grade mathematics. This is consistent with the results of the TCMA in Ireland presented earlier, where proportionally fewer Eighth grade science than mathematics items were considered to be covered by the end of Second Year. As with mathematics, there was substantial variation across the different content domains. Chemistry was well covered, with the exception of 'chemical change' and 'the role of electrons in chemical bonds' – both topics that a sizeable number of students in many countries had not yet covered. In contrast, coverage of Biology and Physics topics was slightly lower in Ireland than the international average.

Coverage of Earth Science departed markedly from the international average. Only one-third of students (34%) were in classes where this topic area was reported to have been covered. This is likely to be due, in part, to the curricular issue raised earlier whereby some content considered to be part of science in TIMSS is taught through the geography curriculum in Ireland. Thus, these percentages (based on reports from science teachers) are about what had been taught in science class and do not take into account any content encountered in geography classes.

Analysis by individual topic revealed that very few students had covered the topic 'Earth in the solar system and the universe'. In this case, 84% of Second Year students were taught by science teachers who reported that this had not been covered. This topic did not feature in the Junior Certificate science curriculum at the time of the TIMSS assessments. However, there is a new 'Earth and Space' strand in the online specification for the revised Junior Certificate science curriculum.[13]

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

	All science (22 topics) % *(SE)*	Biology (7 topics) % *(SE)*	Chemistry (6 topics) % *(SE)*	Physics (5 topics) % *(SE)*	Earth Science (4 topics) % *(SE)*
Ireland	66 *(0.8)*	66 *(1.3)*	84 *(1.3)*	69 *(1.4)*	34 *(2.1)*
TIMSS	73 *(0.2)*	73 *(0.2)*	76 *(0.2)*	72 *(0.3)*	68 *(0.3)*

Percentages of students mostly taught before or in the assessment year, averaged across topics.
International data from Martin, Mullis, Foy and Hooper (2016).

13 Online specification available at http://curriculumonline.ie/Junior-cycle/Junior-Cycle-Subjects/Science.

Chapter 9:
Summary

This chapter summarises students' mathematics and science achievement in the TIMSS 2015 assessment in Ireland, as presented in the preceding chapters. The main findings of an analysis of the Irish curricula compared to the TIMSS assessment frameworks are also reviewed. The chapter concludes by alerting readers to forthcoming reports that will draw more closely on the wealth of contextual data arising from the other data sources that are described in Chapter 1.

Overall performance at Fourth Class

Fourth Class pupils in Ireland achieved a mean score of 547 in mathematics and 529 in science, both of which were significantly above the corresponding TIMSS centrepoints (500).[14] Seven countries (including Singapore, the Republic of Korea, Hong Kong and the Russian Federation) had significantly higher mathematics performance than Ireland at Fourth grade, while 15 countries (including Finland, the United States, Slovenia and England, as well as those already mentioned for mathematics) significantly outperformed Ireland in science. Pupils in Ireland performed significantly less well than pupils in Northern Ireland in mathematics, but significantly better in science.

Fourth Class pupils in Ireland achieved significantly higher mean mathematics and science scores in 2015 than in 2011 (527 for mathematics and 516 for science) and 1995 (523 for mathematics and 515 for science).

In Ireland, although boys achieved slightly higher mean scores than girls for mathematics (by four points) and science (five points) at Fourth Class, these differences were not statistically significant. Across all countries that participated in TIMSS at Fourth grade in 2015, average mathematics performance was similar for boys and girls (505 for both boys and girls), while girls outperformed boys in science (508 and 504, respectively).

Both boys and girls in Fourth Class have seen improvements in mathematics and science performance since 1995, with most of the gains in achievement occurring between 2011 and 2015. Boys in Ireland saw an improvement of 20 points in their mean mathematics score since 2011, and, since 1995, an improvement of 28 points in total. Similarly, the mean mathematics scores of girls in Ireland improved by 19 points since 2011 and 20 points since 1995. For science, there was an improvement of 16 points for boys since 2011 and 1995, while the mean science performance for girls improved by 11 points since 2011 and 14 points since 1995.

14 As noted in earlier chapters, the centrepoint for each domain represents the average of all participating countries in TIMSS 1995, and has been used since then as a constant reference point against which to measure change over time. It is not an international average for the current cycle.

Overall performance at Second Year

Second Year students in Ireland achieved mean scores in mathematics (523) and science (530) which were both significantly above the corresponding TIMSS centrepoints (500). Six countries (including Singapore, the Republic of Korea, Hong Kong and the Russian Federation) achieved significantly higher mean mathematics scores than Ireland, while seven countries significantly outperformed students in Ireland in science (including Slovenia in addition to the six countries that performed significantly better in mathematics). Although not statistically significant, Ireland's mathematics performance improved by about 5 points since 1995, while there was a significant improvement of 12 points in the mean science performance of students in Ireland.

While Second Year boys in Ireland outperformed girls by five points on mathematics (526 and 521, respectively) and girls had a mean score that was two points higher than that of boys on science (531 and 529, respectively), these differences are not statistically significant. Across all countries that participated in TIMSS, girls outperformed boys by ten points in science (491 and 481, respectively) and by three points in mathematics (483 and 480, respectively). The mean mathematics score for boys in Ireland increased by one point since 1995, while girls saw an improvement of nine points. For science, boys' mean performance increased by two points and girls' mean performance increased by 21 points.

Distribution of performance

Mathematics and science performance can also be described in terms of the spread or the distribution of performance, from lower- to higher-achieving students. The general pattern in Ireland for both domains and grade levels is that the lowest-achieving students tend to perform relatively well, while performance among the highest-achieving students is somewhat poorer when compared to their peers in countries with similar overall performance.

At Fourth grade, the performance of the lowest-achieving pupils (i.e., those at the 5th percentile) in mathematics is somewhat higher in Ireland than that of the corresponding pupils in England (a country with similar mean mathematics performance to Ireland) but is similar to the performance of the lowest-achieving pupils in Northern Ireland (who had significantly higher overall mathematics performance than pupils in Ireland). On the other hand, the highest-achieving (i.e., those at the 95th percentile) pupils in mathematics at Fourth grade in Ireland are underperforming relative to their peers in England and Northern Ireland. There have, however, been improvements in the mathematics performance of lower- and higher-achieving pupils in Ireland since 1995, although the improvements are particularly marked among the lower-achieving pupils.

For science at Fourth grade, the lowest-achieving students in Ireland are performing relatively better than their counterparts in Australia (a country with similar overall science performance at Fourth grade) and in Northern Ireland (who performed significantly less well overall in science than pupils in Ireland). On the other hand, while the performance of the highest-achieving students in science in Ireland is somewhat better than that of pupils in Northern Ireland, it is very slightly lower than the performance of these pupils in Australia. Since 1995, there has been a considerable improvement in the performance of lower-achieving students in science at Fourth grade in Ireland, but a slight disimprovement among the higher-achieving students.

A similar pattern emerges for mathematics at Eighth grade. The lowest-achieving students in mathematics in Ireland performed somewhat better than their counterparts in the United States and similarly to the corresponding students in England (two countries with similar overall mathematics performance to Ireland at Eighth grade). On the other hand, the performance of the highest-achieving students in Ireland is somewhat lower than their counterparts in England and the United States. The performance of the highest-achieving students in Ireland is similar to the performance of these students in Australia and New Zealand, two countries that had lower overall mean mathematics performance compared to Ireland. Also, performance of the lowest-achieving students in mathematics in Ireland has improved since 1995, although there has been a small disimprovement among the higher-achieving students in this time.

For science at Eighth grade, the lowest-performing students in science in Ireland are performing at similar levels to those in the United States, but slightly less well than the corresponding students in England, two countries that have similar overall science performance to Ireland. At the other end of the achievement distribution, the performance of the highest-achieving students in science in Ireland is somewhat lower than their counterparts in England and the United States. As with mathematics, there has been an improvement in the performance of lower-achieving students in science at Second Year, while performance has declined somewhat among the highest-achieving students.

Performance at International Benchmarks

At Fourth Class, pupils' performance at the internationally-defined Benchmarks was generally stronger for mathematics than for science. About 14% of pupils reached the Advanced Benchmark for mathematics and more than half (51%) reached the High Benchmark, while 7% and 40%, respectively, reached these Benchmarks for science. Only 3% of pupils did not reach the Low Benchmark in mathematics, compared to 4% in science.

The percentage of pupils reaching each of the mathematics Benchmarks was higher in Ireland than at the international median (for example, 14% reached the Advanced benchmark in Ireland compared to 6% internationally). However, a number of countries had significantly higher percentages reaching the higher Benchmarks than Ireland, most notably including Singapore (50% Advanced and 80% High) and Hong Kong (45% Advanced and 84% High). In other words, in a handful of higher-performing countries, a similar percentage of pupils reached the Advanced Benchmark as reached the High Benchmark in Ireland, and reached the High Benchmark as reached the Intermediate Benchmark in Ireland. Northern Ireland (27%) and England (17%) also had higher percentages of pupils at the Advanced Benchmark for mathematics than Ireland. As suggested by the overall distribution of performance (discussed earlier), however, the relatively greater proportion of higher-achieving pupils in England – where average performance was similar to Ireland – was accompanied by a greater proportion who did not reach the High, Intermediate, or Low Benchmarks, compared to Ireland.

In contrast to the findings for mathematics, Irish performance at the Fourth Class science Benchmarks was generally in line with the international median at each cutpoint. Again, a number of higher-performing countries reported substantial percentages of pupils at the higher Benchmarks, although to a lesser extent than for mathematics. In the Republic of Korea, for example, almost all pupils reached at least the Intermediate Benchmark, while three-quarters reached the High

Benchmark. The country with the greatest percentage of pupils at the Advanced Benchmark (37%) was Singapore. Despite strong performance in mathematics, relatively few pupils (5%) in Northern Ireland reached the Advanced Benchmark for science.

Overall, performance at each level of the distribution has improved over time at Fourth Class. A significantly greater percentage of Fourth Class pupils reached each of the mathematics Benchmarks in 2015 than in either 1995 or 2011, and a significantly greater percentage reached the Low, Intermediate and High science Benchmarks than in TIMSS 2011 (with no change at the Advanced Benchmark). For example, 97% of Fourth Class pupils reached at least the Low Benchmark in 2015 (compared to 91% in 1995) and 14% reached the Advanced Benchmark (compared to 10%).

At post-primary, the pattern was somewhat different than at primary level. Seven percent of Second Year students reached the Advanced Benchmark for mathematics, while 5% of students internationally reached this Benchmark. By comparison, some countries with a similar overall score to Ireland had more students reaching this level (e.g., the United States and England, both with 10% of students). Again, high percentages of students in Singapore (54%) and the Republic of Korea (43%) reached the Advanced Benchmark, and thus were able to demonstrate the most advanced skills included in the assessment. Thirty-eight percent of students in Ireland reached the High Benchmark, 76% reached the Intermediate Benchmark, and 94% reached the Low Benchmark. These figures were not significantly different from the percentages reaching each Benchmark in Ireland in TIMSS 1995. With the exception of the Advanced Benchmark, a substantially greater percentage of students in Ireland reached each of these cutpoints than at the international median.

In the science assessment, one in ten students in Ireland reached the Advanced Benchmark and 43% reached the High Benchmark. As with mathematics, 6% of students did not reach the lowest Benchmark, indicating that they could not consistently demonstrate the most basic skills assessed during the test. However, a greater percentage of students reached the Intermediate Benchmark in 2015 (77%) than in 1995 (70%), suggesting that more students are able to demonstrate limited scientific knowledge. There was no change at any of the other three Benchmark levels. Internationally, with the exception of Singapore (42% at the Advanced level), Benchmark performance on the Eighth grade science test was somewhat more moderate than for mathematics. For example, 19% of students in the Republic of Korea and 12% in Hong Kong reached the Advanced Benchmark. In Slovenia (the highest-performing European country), 17% of students reached the Advanced Benchmark and 52% reached the High Benchmark, compared to 10% and 43% in Ireland.

Performance on the content and cognitive domains

The performance of students in Ireland on each of the content and cognitive subscales is summarised in Table 9.1 and Table 9.2. These tables present the domains that were identified as national strengths or weaknesses relative to the overall Irish performance. Some general patterns can be observed.

In the content areas (Table 9.1), students in Ireland were relatively strong at both Fourth Class and Second Year on mathematics items addressing the Number subdomain (which includes dealing with whole numbers, fractions, simple relationships between numbers, and so on). By contrast, items dealing with Geometric Shapes & Measures (at Fourth Class) and Geometry (at Second Year) posed more difficulty for both groups of students. Algebra, which is incorporated into the Number

domain at primary level, is addressed separately in the post-primary assessment and was also found to be a relative weakness at Second Year. While performance on Data Display was in line with overall performance at Fourth Class, Data & Chance was an area of relative strength at Second Year.

In science, Earth Science was a relative strength at both grade levels, while Physical Science (at Fourth Class) and Physics (at Second Year) were found to be relative weaknesses. Chemistry, which is included in Physical Science in the Fourth Class assessment, was also found to be a weakness among Second Year students. Finally, students' performance on Life Science items at Fourth Class was in line with their overall scientific achievement. However, Biology (the equivalent domain at Second Year) was a relative strength among the older cohort.

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	*Geometric Shapes & Measures*	*Data Display*	*Number*	*Physical Science*	*Life Science*	*Earth Science*
Second Year	*Algebra, Geometry*	-	*Number, Data & Chance*	*Chemistry, Physics*	-	*Earth Science, Biology*

Turning to the cognitive domains (Table 9.2), items that assessed Knowing skills (lower-order processes such as recognising, recalling, and classifying) were found to be a relative strength at both grade levels in the mathematics assessment. Reasoning was a relative weakness at Fourth Class and Applying was in line with overall performance, while the opposite pattern was observed among Second Year students.

Fewer differences were found in the science assessment. The performance of students in Ireland was very similar across all three cognitive areas, at both grade levels, with the exception of Knowing at Second Year (which was a relative weakness).

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*	*Applying*	*Knowing*	-	*Knowing, Applying, Reasoning*	-
Second Year	*Applying*	*Reasoning*	*Knowing*	*Knowing*	*Applying, Reasoning*	-

Some gender differences were found on these subscales in Ireland, with boys outperforming girls on the Geometric Shapes & Measures content area for mathematics at Fourth Class, and Number at Second Year. There were no significant gender differences on any of the other mathematics content areas, or on any of the cognitive areas in the mathematics assessment.

For science, boys outperformed girls on Earth Science items at Fourth Class and on Physics and

Earth Science items at Second Year, while girls outperformed boys on Chemistry and Biology items at Second Year. Boys displayed an advantage on the Knowing cognitive domain at Fourth Class. There were no other differences in performance on the cognitive subscales at either grade level.

Curriculum analysis

The Test-Curriculum Matching Analysis (TCMA) – performed by subject experts in Ireland – revealed that the vast majority of the content in the Fourth grade mathematics and science assessments was judged to be covered by most Fourth Class pupils in Ireland. In science, coverage was lowest for the TIMSS content domain of Earth Science, even though the TCMA took account of any content that Fourth Class pupils would have encountered in their geography lessons. At Eighth grade, all but seven of the TIMSS mathematics items were judged to come under topics that would have been covered by most students by the end of Second Year in Ireland. In contrast, only 72% of Eighth grade science items were considered to be covered by most Second Year students in Ireland. In particular, many of the Biology items were not considered to be covered by most students by the end of Second Year.

The TCMA also showed the extent of the variation among comparison countries in terms of the number of items that were considered as being covered in their national curricula. Ireland was typically among the top half of comparison countries in terms of the number of items considered covered by students. The exception to this was Eighth grade science, where only Singapore and New Zealand judged fewer items to be covered by their students by the end of Eighth grade than was the case for Ireland. The TCMA showed that students in Ireland had similar performance on the subsets of items that they were judged to have covered as on the full sets of TIMSS items. This was the case for both Fourth Class and Second Year students, and for both mathematics and science.

In most cases, the average percent correct for Ireland and the comparison countries did not vary substantially based on the subsets of items included in each country's national curriculum. The most striking exceptions were in Fourth grade science, where students in Singapore and the Republic of Korea performed markedly better on the subsets of items included in their own curricula than on the full set of Fourth grade science items. Singapore and Korea had by far the lowest curriculum coverage for Fourth grade science, according to the TCMA, yet they were the two highest-performing countries on that assessment.

The results of the TCMA were supplemented by teacher reports of TIMSS topic coverage among Fourth Class pupils and Second Year students in Ireland. Teachers of Fourth Class pupils reported higher coverage of the TIMSS mathematics and science topics *overall* than the international average. This was also the case for each content domain, except for the Fourth grade mathematics content domain of Geometric Shapes & Measures, where coverage was similar to the international average (66% of pupils versus 68%). A large difference emerged in Geometry at Eighth grade, where mathematics teachers of Second Year students reported that Geometry had been covered by 58% of students in Ireland, compared with 77% of students internationally. In contrast, at both Fourth Class and Second Year, the mathematics content domain of Number had been covered by more than 90% of students, according to their teachers. Coverage of Eighth grade science topics *overall* was slightly lower in Ireland than internationally. This was due, in part, to the fact that the Earth Science domain had been covered by only 34% of Second Year students, according to their science teachers, while the international average percentage was double this at 68%. In this regard, it

should be noted again that much of the content included in the Earth Science domain in TIMSS is covered by the geography curriculum in Ireland, so students may have been taught some of the relevant content by teachers other than their science teacher.

Forthcoming national publications for TIMSS 2015

This report is the first in a series of national publications that present the findings of TIMSS 2015 for Ireland. A number of thematic reports, which will focus on contextual as well as achievement data for Ireland and selected comparison countries, will be published throughout 2017. Topics for these thematic reports will include:

- Students' engagement in class and attitudes to school, both in general and with particular reference to mathematics and science.
- Interaction between the school and the home.
- The characteristics of Fourth Class and Second Year teachers in Ireland and their classrooms, including qualifications, teaching practices, curriculum coverage, professional development, the challenges faced by teachers, and their job satisfaction.
- Structural characteristics of the Irish education system, including school characteristics, instructional time, resources and technology, and discipline and safety.
- Students' use of ICT at home and in school, and teachers' use of ICT in the classroom.
- A comparison of the TIMSS and PISA studies in 2015, including a discussion of the similarities and differences between the two studies in terms of structure and content.

These reports will be made available for download on www.erc.ie/timss throughout 2017.

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Appendix A:
National Advisory Committees

As noted in the Preface, the implementation of TIMSS 2015 was supported by the valuable contributions of the members of the two National Advisory Committees – one guiding the study implementation at Fourth Class, and the other doing so for Second Year. The members of the committees are named below, with gratitude from the report authors.

Fourth Class

At November 2016, the members of the National Advisory Committee for primary level were (in alphabetical order):

- 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).
- Eamonn Moran (Department of Education and Skills) (replacing Breda Naughton from August 2016).
- Eddie Fox (Educate Together) (replacing Fionnuala Ward from August 2016).
- Eemer Eivers (Educational Research Centre).
- Máirín Ní Chéileachair (Gaelscoileanna).
- Mia Treacy (Professional Development Service for Teachers).
- Seán Delaney (Marino Institute of Education).
- Suzanne Cobbe (Catholic Primary Schools Management Association).
- Yvonne Keating (Department of Education and Skills) (Chair) (replacing Caitríona Ní Bhriain from November 2015).

Second Year

At November 2016, the members of the National Advisory Committee for post-primary level were (in alphabetical order):

- Barry Slattery (National Council for Curriculum and Assessment).
- Conor Galvin (University College Dublin).
- Declan Cahalane (Department of Education and Skills).
- Eemer Eivers (Educational Research Centre).
- Elizabeth Oldham (Trinity College Dublin).
- Gerry Hyde (State Examinations Commission) (replacing Hugh McManus from April 2016).
- Liz O'Neill (Department of Education and Skills).

- Maurice O'Reilly (St Patrick's College, Drumcondra).
- Odilla Finlayson (Dublin City University).
- Philip Matthews (Trinity College Dublin).
- Rachel Cunningham (Educational Research Centre).
- Rachel Linney (National Council for Curriculum and Assessment).
- Rachel Perkins (Educational Research Centre).
- Ruth Richards (Department of Education and Skills) (replacing Seamus Knox from July 2015).
- Suzanne Dillon (Department of Education and Skills) (Chair) (replacing Pádraig MacFhlannchadha from July 2016).
- Tom McCloughlin (St Patrick's College, Drumcondra).

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

Mathematics – Fourth Class – content domains

Table B1: Mean scores of girls and boys and associated standard errors in mathematics content domains – Fourth grade

	Number		Geometric Shapes & Measures		Data Display	
	Girls	Boys	Girls	Boys	Girls	Boys
Singapore	632 *(4.3)*	628 *(4.7)*	610 *(4.5)*	605 *(4.5)*	603 *(4.2)*	597 *(5.2)*
Hong Kong SAR	610 *(4.1)*	621 *(3.1)*	611 *(4.5)*	622 *(3.8)*	608 *(4.4)*	613 *(4.3)*
Korea, Rep. of	605 *(2.7)*	614 *(2.9)*	608 *(2.7)*	612 *(3.0)*	606 *(2.7)*	608 *(4.1)*
Northern Ireland	573 *(4.1)*	576 *(3.1)*	564 *(4.1)*	568 *(3.9)*	566 *(4.5)*	567 *(4.2)*
Russian Fed.	567 *(3.8)*	567 *(3.5)*	558 *(4.5)*	556 *(4.8)*	572 *(4.3)*	573 *(4.1)*
Ireland	**549 *(2.6)***	**553 *(3.0)***	**538 *(3.2)***	**546 *(3.7)***	**547 *(5.5)***	**548 *(4.1)***
England	542 *(3.4)*	552 *(3.9)*	538 *(3.6)*	546 *(3.9)*	555 *(4.1)*	549 *(3.9)*
United States	542 *(2.2)*	549 *(2.7)*	519 *(2.5)*	532 *(3.0)*	538 *(3.2)*	542 *(2.8)*
Finland	536 *(2.9)*	528 *(2.6)*	545 *(2.5)*	534 *(2.9)*	550 *(3.8)*	534 *(3.6)*
Slovenia	507 *(2.2)*	515 *(2.4)*	530 *(2.5)*	530 *(2.6)*	541 *(3.7)*	539 *(3.5)*
Australia	503 *(3.3)*	515 *(4.2)*	523 *(3.7)*	531 *(3.8)*	530 *(4.6)*	535 *(5.6)*
New Zealand	483 *(3.1)*	488 *(3.1)*	487 *(3.7)*	490 *(2.7)*	506 *(3.3)*	506 *(3.5)*

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

Mathematics – Fourth Class – cognitive domains

Table B2: Mean scores of girls and boys and associated standard errors in mathematics cognitive domains – Fourth grade

	Knowing		Applying		Reasoning	
	Girls	Boys	Girls	Boys	Girls	Boys
Singapore	633 *(4.5)*	628 *(4.1)*	621 *(4.3)*	618 *(4.4)*	605 *(4.9)*	600 *(4.9)*
Hong Kong SAR	614 *(4.8)*	621 *(3.0)*	615 *(4.1)*	626 *(3.3)*	595 *(4.6)*	604 *(3.5)*
Korea, Rep. of	624 *(3.1)*	630 *(3.3)*	592 *(2.2)*	599 *(2.6)*	612 *(3.8)*	624 *(3.6)*
Northern Ireland	577 *(5.4)*	587 *(3.9)*	576 *(4.3)*	575 *(3.2)*	548 *(4.6)*	551 *(3.5)*
Russian Fed.	557 *(4.0)*	556 *(3.8)*	566 *(3.9)*	567 *(3.9)*	573 *(4.2)*	567 *(4.3)*
Ireland	**552 *(3.6)***	**556 *(3.5)***	**547 *(2.8)***	**550 *(3.0)***	**532 *(3.7)***	**538 *(3.4)***
England	548 *(3.8)*	560 *(3.8)*	542 *(3.9)*	547 *(3.5)*	537 *(3.3)*	543 *(4.2)*
United States	545 *(2.5)*	550 *(2.7)*	532 *(2.4)*	542 *(2.8)*	528 *(2.7)*	534 *(2.9)*
Finland	532 *(2.9)*	528 *(2.9)*	542 *(2.7)*	530 *(2.4)*	547 *(3.1)*	534 *(3.9)*
Slovenia	514 *(2.8)*	520 *(2.7)*	518 *(2.6)*	523 *(2.6)*	522 *(2.9)*	526 *(3.3)*
Australia	503 *(3.5)*	515 *(4.7)*	516 *(3.5)*	526 *(3.5)*	519 *(3.5)*	528 *(3.8)*
New Zealand	471 *(3.1)*	480 *(3.1)*	497 *(2.8)*	497 *(3.2)*	503 *(3.5)*	504 *(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 B3: Mean scores of girls and boys and associated standard errors in mathematics content domains – Eighth grade

	Number		Algebra		Geometry		Data & Chance	
	Girls	Boys	Girls	Boys	Girls	Boys	Girls	Boys
Singapore	633 *(3.5)*	625 *(3.8)*	630 *(3.4)*	615 *(4.5)*	621 *(3.7)*	613 *(4.3)*	621 *(3.7)*	614 *(4.2)*
Korea, Rep. of	594 *(2.7)*	608 *(2.9)*	616 *(3.1)*	608 *(3.6)*	613 *(3.4)*	611 *(4.3)*	599 *(2.7)*	601 *(3.2)*
Hong Kong SAR	590 *(5.2)*	598 *(6.3)*	593 *(4.7)*	593 *(6.2)*	601 *(5.2)*	602 *(6.6)*	593 *(6.7)*	601 *(7.1)*
Russian Fed.	523 *(5.1)*	542 *(4.4)*	559 *(5.7)*	558 *(5.0)*	534 *(6.3)*	537 *(5.5)*	500 *(5.1)*	514 *(5.5)*
Ireland	**540** ***(3.2)***	**549** ***(4.7)***	**502** ***(2.8)***	**500** ***(4.0)***	**500** ***(3.1)***	**507** ***(4.3)***	**530** ***(4.1)***	**538** ***(5.1)***
United States	515 *(3.3)*	524 *(3.2)*	529 *(3.3)*	521 *(3.3)*	499 *(3.5)*	501 *(3.3)*	520 *(3.8)*	523 *(3.7)*
England	524 *(5.9)*	531 *(5.3)*	497 *(5.8)*	488 *(5.5)*	519 *(5.1)*	509 *(5.0)*	544 *(5.5)*	539 *(5.7)*
Slovenia	516 *(2.8)*	531 *(2.8)*	503 *(3.5)*	494 *(2.4)*	522 *(3.5)*	523 *(3.4)*	525 *(3.2)*	524 *(3.2)*
Australia	506 *(4.1)*	517 *(3.5)*	492 *(4.3)*	489 *(3.7)*	500 *(4.0)*	500 *(3.6)*	518 *(4.1)*	520 *(3.6)*
New Zealand	496 *(3.4)*	503 *(5.1)*	479 *(3.4)*	470 *(4.9)*	489 *(3.2)*	488 *(4.8)*	511 *(3.8)*	506 *(5.0)*

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

Mathematics – Second Year – cognitive domains

Table B4: Mean scores of girls and boys and associated standard errors in mathematics cognitive domains – Eighth grade

	Knowing		Applying		Reasoning	
	Girls	Boys	Girls	Boys	Girls	Boys
Singapore	641 *(3.8)*	626 (3.9)	623 *(3.5)*	616 *(3.7)*	621 *(4.4)*	612 *(4.2)*
Korea, Rep. of	608 *(2.9)*	606 *(3.6)*	605 *(2.8)*	607 *(3.7)*	606 *(3.3)*	609 *(3.7)*
Hong Kong SAR	599 *(5.2)*	601 *(6.5)*	593 *(4.5)*	597 *(6.0)*	587 *(5.2)*	595 *(6.5)*
Russian Fed.	538 *(6.2)*	548 *(5.5)*	535 *(5.2)*	546 *(4.5)*	522 *(5.6)*	533 *(5.0)*
Ireland	**526** *(2.9)*	**529** *(4.2)*	**517** *(2.7)*	**524** *(4.4)*	**520** *(3.4)*	**523** *(4.3)*
United States	529 *(3.7)*	527 *(3.6)*	513 *(3.4)*	516 *(3.4)*	512 *(3.1)*	516 *(3.4)*
England	517 *(5.2)*	509 *(4.8)*	520 *(5.1)*	519 *(4.8)*	524 *(5.2)*	521 *(5.2)*
Slovenia	518 *(2.8)*	518 *(2.8)*	512 *(2.7)*	516 *(2.5)*	515 *(3.0)*	516 *(3.2)*
Australia	505 *(3.8)*	504 *(3.4)*	500 *(3.9)*	504 *(3.6)*	511 *(3.8)*	513 *(3.7)*
New Zealand	487 *(3.2)*	489 *(4.7)*	494 *(3.1)*	492 *(4.8)*	501 *(3.3)*	496 *(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 B5: Mean scores of girls and boys and associated standard errors in science content domains – Fourth grade

	Life Science		Physical Science		Earth Science	
	Girls	Boys	Girls	Boys	Girls	Boys
Singapore	610 *(4.5)*	604 *(5.0)*	603 *(4.0)*	604 *(4.4)*	541 *(4.0)*	552 *(4.2)*
Korea, Rep. of	581 *(2.8)*	582 *(2.3)*	589 *(2.1)*	605 *(2.4)*	578 *(4.1)*	603 *(5.3)*
Russian Fed.	573 *(3.6)*	565 *(3.5)*	565 *(3.9)*	569 *(4.0)*	560 *(4.7)*	565 *(5.7)*
Hong Kong SAR	550 *(5.2)*	550 *(3.7)*	548 *(4.2)*	561 *(4.2)*	565 *(4.3)*	582 *(4.0)*
Finland	566 *(2.2)*	546 *(3.9)*	550 *(2.2)*	545 *(3.1)*	565 *(2.8)*	556 *(3.1)*
United States	555 *(2.7)*	555 *(2.4)*	534 *(2.9)*	541 *(2.8)*	535 *(2.6)*	544 *(2.8)*
Slovenia	547 *(2.3)*	543 *(3.5)*	539 *(2.9)*	553 *(3.3)*	520 *(6.1)*	541 *(3.3)*
England	539 *(2.8)*	533 *(3.6)*	537 *(2.9)*	543 *(3.2)*	523 *(4.2)*	532 *(4.0)*
Ireland	**532 *(3.1)***	**529 *(3.7)***	**521 *(3.8)***	**527 *(3.9)***	**527 *(3.8)***	**542 *(4.1)***
Australia	535 *(3.1)*	527 *(3.8)*	513 *(2.9)*	519 *(3.6)*	516 *(4.1)*	524 *(4.0)*
Northern Ireland	524 *(3.5)*	518 *(3.3)*	510 *(3.6)*	518 *(3.1)*	522 *(4.0)*	522 *(3.7)*
New Zealand	518 *(3.1)*	505 *(3.4)*	496 *(3.0)*	499 *(3.0)*	502 *(4.4)*	510 *(3.3)*

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

Science – Fourth Class – cognitive domains

Table B6: Mean scores of girls and boys and associated standard errors in science cognitive domains – Fourth grade

	Knowing		Applying		Reasoning	
	Girls	Boys	Girls	Boys	Girls	Boys
Singapore	569 *(4.2)*	579 *(5.1)*	598 *(4.3)*	600 *(4.4)*	610 *(4.3)*	600 *(3.7)*
Korea, Rep. of	572 *(2.9)*	591 *(2.6)*	587 *(2.7)*	600 *(2.0)*	595 *(2.0)*	593 *(3.3)*
Russian Fed.	565 *(4.0)*	572 *(4.7)*	569 *(3.5)*	567 *(3.5)*	565 *(4.0)*	556 *(4.3)*
Hong Kong SAR	553 *(3.8)*	569 *(3.8)*	549 *(4.1)*	558 *(4.0)*	555 *(6.1)*	550 *(4.0)*
Finland	560 *(3.3)*	552 *(3.5)*	561 *(2.6)*	545 *(2.9)*	559 *(3.1)*	546 *(2.6)*
United States	545 *(2.6)*	552 *(2.8)*	544 *(2.4)*	548 *(2.6)*	542 *(2.4)*	541 *(3.5)*
Slovenia	533 *(3.1)*	549 *(2.9)*	543 *(3.1)*	549 *(3.4)*	539 *(3.1)*	537 *(3.2)*
England	530 *(3.6)*	537 *(3.1)*	539 *(3.4)*	536 *(2.7)*	543 *(3.1)*	534 *(4.7)*
Ireland	**523 *(3.5)***	**534 *(3.1)***	**527 *(3.2)***	**533 *(3.1)***	**529 *(3.8)***	**523 *(3.5)***
Australia	522 *(3.6)*	524 *(4.2)*	523 *(3.5)*	522 *(3.6)*	532 *(3.8)*	523 *(3.9)*
Northern Ireland	516 *(3.8)*	521 *(3.3)*	518 *(3.2)*	520 *(3.9)*	524 *(3.1)*	516 *(4.1)*
New Zealand	505 *(3.6)*	503 *(2.9)*	502 *(3.9)*	502 *(3.3)*	521 *(3.7)*	507 *(3.2)*

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

Science – Second Year – content domains

Table B7: Mean scores of girls and boys and associated standard errors in science content domains – Eighth grade

	Biology		Chemistry		Physics		Earth Science	
	Girls	Boys	Girls	Boys	Girls	Boys	Girls	Boys
Singapore	612 *(3.6)*	607 *(4.4)*	598 *(3.9)*	588 *(4.4)*	605 *(3.6)*	611 *(3.9)*	557 *(4.9)*	572 *(4.4)*
Korea, Rep. of	552 *(2.5)*	556 *(2.7)*	554 *(2.6)*	547 *(3.4)*	563 *(3.1)*	565 *(3.4)*	547 (3.6)	561 *(3.8)*
Slovenia	558 *(3.0)*	539 *(3.1)*	559 *(3.2)*	546 *(3.4)*	539 *(3.8)*	551 *(3.2)*	560 *(3.3)*	569 *(3.4)*
Hong Kong SAR	547 *(4.8)*	550 *(5.5)*	537 *(4.7)*	535 *(5.1)*	530 *(4.4)*	549 *(5.2)*	543 *(4.7)*	571 *(5.0)*
Russian Fed.	544 *(4.8)*	534 *(4.8)*	558 *(5.4)*	558 *(5.6)*	538 *(4.8)*	557 *(4.6)*	528 *(5.2)*	536 *(4.9)*
England	546 *(5.0)*	538 *(4.7)*	534 *(5.4)*	523 *(5.3)*	532 *(4.6)*	539 *(4.8)*	532 *(4.8)*	540 *(4.8)*
Ireland	**540 *(2.9)***	**528 *(4.0)***	**524 *(3.5)***	**510 *(5.3)***	**518 *(3.9)***	**532 *(3.9)***	**536 *(3.5)***	**548 *(4.1)***
United States	542 *(2.9)*	538 *(3.2)*	520 *(3.7)*	518 *(3.5)*	508 *(3.0)*	524 *(3.4)*	526 *(3.5)*	544 *(3.3)*
New Zealand	526 *(3.4)*	513 *(4.7)*	500 *(3.8)*	495 *(4.8)*	502 *(3.9)*	515 *(4.4)*	510 *(3.8)*	524 *(5.1)*
Australia	524 *(3.4)*	520 *(3.3)*	494 *(4.2)*	492 *(3.5)*	496 *(3.3)*	513 *(3.0)*	514 *(3.5)*	530 *(3.4)*

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

Science – Second Year – cognitive domains

Table B8: Mean scores of girls and boys and associated standard errors in science cognitive domains – Eighth grade

	Knowing		Applying		Reasoning	
	Girls	Boys	Girls	Boys	Girls	Boys
Singapore	589 *(3.4)*	598 *(4.5)*	601 *(3.8)*	599 *(4.5)*	595 *(3.5)*	594 *(4.2)*
Korea, Rep. of	549 *(2.8)*	561 *(3.7)*	550 *(2.3)*	554 *(2.8)*	562 *(2.8)*	559 *(3.4)*
Slovenia	555 *(2.8)*	561 *(3.7)*	551 *(2.4)*	544 *(2.9)*	557 *(3.1)*	544 *(3.1)*
Hong Kong SAR	537 *(4.1)*	556 *(4.6)*	536 *(4.7)*	545 *(5.5)*	548 *(4.8)*	552 *(5.3)*
Russian Fed.	555 *(5.4)*	560 *(5.6)*	537 *(5.1)*	540 *(4.7)*	535 *(4.5)*	540 *(4.5)*
England	520 *(4.7)*	525 *(5.1)*	543 *(4.7)*	534 *(5.0)*	545 *(4.8)*	545 *(4.7)*
Ireland	**519 *(3.2)***	**527 *(4.6)***	**536 *(3.1)***	**530 *(4.4)***	**534 *(2.8)***	**531 *(4.6)***
United States	524 *(3.6)*	539 *(3.6)*	530 *(3.1)*	532 *(3.1)*	525 *(2.9)*	527 *(3.0)*
New Zealand	499 *(3.3)*	507 *(4.4)*	515 *(3.6)*	512 *(4.6)*	523 *(3.7)*	516 *(4.3)*
Australia	505 *(3.2)*	516 *(3.1)*	512 *(3.5)*	513 *(3.4)*	511 *(3.3)*	515 *(3.2)*

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

Appendix C:
Teacher reports of topic coverage

Mathematics – Fourth Class

Table C1: Percentages of pupils taught the TIMSS mathematics topics – Fourth Class

		Mostly taught before this year % *(SE)*	Mostly taught this year % *(SE)*	Not yet taught or just introduced* % *(SE)*
Number	Concepts of whole numbers	74 *(3.6)*	26 *(3.6)*	0 *(-)*
	Operations with whole numbers	58 *(4.3)*	42 *(4.3)*	0 *(-)*
	Multiples, factors, odd and even numbers	51 *(4.7)*	40 *(4.4)*	9 *(1.9)*
	Concepts of fractions	28 *(3.8)*	72 *(3.8)*	<1 *(0.3)*
	Using fractions	6 *(2.3)*	57 *(3.9)*	37 *(4.0)*
	Concepts of decimals	7 *(2.1)*	88 *(2.8)*	5 *(2.0)*
	Number sentences	57 *(4.4)*	38 *(4.5)*	6 *(1.9)*
	Number patterns	54 *(4.5)*	39 *(4.1)*	6 *(2.5)*
Geometric Shapes and Measures	Lines: Measuring, length, parallel, perpendicular	26 *(3.6)*	67 *(3.9)*	7 *(2.4)*
	Comparing and drawing angles	4 *(1.5)*	57 *(4.0)*	38 *(4.0)*
	Informal coordinate systems	5 *(1.7)*	18 *(3.2)*	78 *(3.5)*
	Properties of geometric shapes	44 *(4.0)*	39 *(3.9)*	17 *(2.4)*
	Reflections and rotations	11 *(2.8)*	29 *(4.0)*	60 *(4.4)*
	Relationships between 2-D and 3-D shapes	33 *(3.6)*	53 *(4.0)*	14 *(2.7)*
	Areas, perimeters and volumes	6 *(1.9)*	67 *(3.2)*	27 *(3.2)*
Data Display	Reading and representing data	42 *(4.0)*	52 *(4.1)*	6 *(1.9)*
	Drawing conclusions from data	36 *(4.0)*	58 *(4.2)*	6 *(1.9)*

*This category includes topics not on the curriculum.
Due to rounding, percentages do not always add to 100.

Science – Fourth Class

Table C2:	Percentages of pupils taught the TIMSS science topics – Fourth Class			
		Mostly taught before this year % *(SE)*	Mostly taught this year % *(SE)*	Not yet taught or just introduced* % *(SE)*
Life Science	Characteristics of living things	50 *(3.9)*	44 *(3.8)*	7 *(2.4)*
	Major body structures	21 *(3.2)*	58 *(4.1)*	22 *(3.8)*
	Life cycles	62 *(4.2)*	25 *(3.5)*	12 *(2.8)*
	Heredity and environment	12 *(2.0)*	32 *(4.4)*	55 *(4.2)*
	Physical features/behaviours and survival	19 *(2.9)*	57 *(4.1)*	24 *(3.6)*
	Relationships in communities and ecosystems	24 *(3.3)*	56 *(4.1)*	20 *(3.1)*
	Human health	25 *(4.0)*	62 *(4.4)*	13 *(3.1)*
Physical Science	States of matter	26 *(3.8)*	53 *(3.7)*	21 *(3.3)*
	Classifying materials	14 *(2.8)*	54 *(4.3)*	32 *(3.8)*
	Mixtures	14 *(2.6)*	40 *(4.0)*	45 *(3.8)*
	Chemical changes	18 *(3.1)*	28 *(3.6)*	54 *(4.1)*
	Common sources of energy	29 *(4.2)*	66 *(4.3)*	5 *(1.1)*
	Light and sound	26 *(3.7)*	55 *(4.4)*	19 *(3.1)*
	Electricity and circuits	20 *(3.6)*	46 *(4.4)*	34 *(4.0)*
	Properties of magnets	37 *(4.1)*	48 *(4.0)*	15 *(2.7)*
	Forces that cause objects to move	23 *(3.5)*	65 *(3.9)*	12 *(2.2)*
Earth Science	Features of Earth's landscape	18 *(3.2)*	59 *(4.2)*	24 *(3.6)*
	Water on Earth	21 *(3.7)*	60 *(4.4)*	19 *(3.3)*
	Weather	35 *(4.0)*	57 *(3.9)*	8 *(2.4)*
	Fossils	15 *(2.9)*	29 *(4.0)*	56 *(4.5)*
	Objects in the solar system	26 *(4.0)*	54 *(4.9)*	19 *(3.9)*
	Earth's rotation	18 *(3.0)*	56 *(4.1)*	26 *(3.6)*
	Seasons	14 *(2.4)*	53 *(4.2)*	32 *(3.9)*

*This category includes topics not on the curriculum.
Due to rounding, percentages do not always add to 100.

Mathematics – Second Year

Table C3:	Percentages of students taught the TIMSS mathematics topics – Second Year			
		Mostly taught before this year % *(SE)*	Mostly taught this year % *(SE)*	Not yet taught or just introduced* % *(SE)*
Number	Computing with whole numbers	95 *(1.1)*	4 *(1.0)*	<1 *(0.3)*
	Comparing and ordering rational numbers	84 *(2.2)*	14 *(2.1)*	2 *(0.7)*
	Computing with rational numbers	83 *(2.5)*	16 *(2.4)*	1 *(0.8)*
	Concepts of irrational numbers	33 *(2.8)*	35 *(3.2)*	32 *(2.6)*
	Problem solving with percents or proportions	56 *(2.9)*	39 *(2.8)*	5 *(1.4)*
Algebra	Simplifying and evaluating expressions	38 *(2.3)*	62 *(2.2)*	<1 *(0.3)*
	Linear equations and inequalities	19 *(2.3)*	75 *(2.6)*	6 *(1.3)*
	Simultaneous equations	2 *(0.8)*	72 *(2.7)*	26 *(2.6)*
	Patterns and sequences	16 *(2.6)*	47 *(3.3)*	38 *(3.4)*
	Representation of functions	3 *(0.8)*	46 *(3.1)*	51 *(3.2)*
	Properties of functions	2 *(0.9)*	48 *(3.0)*	50 *(2.9)*
Geometry	Properties of angles and shapes	35 *(3.2)*	42 *(3.2)*	23 *(2.7)*
	Congruent figures and similar triangles	6 *(1.3)*	39 *(3.2)*	55 *(3.0)*
	Relationship between 2-D and 3-D shapes	5 *(1.2)*	36 *(3.2)*	59 *(3.3)*
	Measurement formulae	7 *(1.3)*	63 *(2.9)*	30 *(2.8)*
	Points on the Cartesian plane	33 *(2.8)*	45 *(3.3)*	22 *(2.6)*
	Translation, reflection and rotation	12 *(2.1)*	25 *(2.9)*	63 *(3.4)*
Data and Chance	Characteristics of data sets	25 *(2.5)*	55 *(3.5)*	20 *(2.9)*
	Interpreting data sets	16 *(2.0)*	52 *(3.3)*	32 *(2.9)*
	Judging, predicting and determining chances of possible outcomes	30 *(2.7)*	45 *(3.3)*	24 *(2.6)*

*This category includes topics not on the curriculum.
Due to rounding, percentages do not always add to 100.

Science – Second Year

Table C4:	Percentages of students taught the TIMSS science topics – Second Year			
		Mostly taught before this year % *(SE)*	Mostly taught this year % *(SE)*	Not yet taught or just introduced* % *(SE)*
Biology	Major taxonomic groups of organisms	69 *(3.5)*	9 *(2.1)*	22 *(3.0)*
	Major organs and organ systems	31 *(3.2)*	67 *(3.3)*	2 *(0.7)*
	Cells, their structure and functions	63 *(3.2)*	33 *(3.1)*	4 *(1.4)*
	Life cycles, sexual reproduction and heredity	7 *(2.0)*	52 *(4.0)*	41 *(3.9)*
	Role of variation and adaptation in survival/ extinction	5 *(1.4)*	22 *(2.8)*	73 *(3.1)*
	Interdependence and factors affecting population in ecosystems	11 *(2.1)*	26 *(2.9)*	63 *(3.3)*
	Human health	28 *(3.2)*	38 *(3.8)*	34 *(3.3)*
Chemistry	Classification, composition and particulate structure of matter	62 *(3.3)*	35 *(3.5)*	4 *(1.3)*
	Physical and chemical properties of matter	76 *(3.1)*	22 *(3.0)*	2 *(0.7)*
	Mixtures and solutions	79 *(3.1)*	20 *(3.1)*	2 *(0.7)*
	Common acids and bases	21 *(3.0)*	70 *(3.1)*	9 *(2.2)*
	Chemical change	9 *(1.7)*	48 *(3.5)*	43 *(3.6)*
	Role of electrons in chemical bonds	2 *(0.7)*	59 *(4.1)*	39 *(4.1)*
Physics	Physical states and changes in matter	59 *(3.7)*	23 *(2.7)*	18 *(3.0)*
	Energy forms, transformation, heat and temperature	44 *(3.3)*	43 *(3.4)*	13 *(2.5)*
	Properties/behaviours of light and sound	19 *(3.0)*	57 *(3.5)*	24 *(2.9)*
	Electric circuits, magnets and electromagnets	1 *(0.4)*	16 *(2.8)*	83 *(2.8)*
	Forces and motion	18 *(2.7)*	64 *(3.5)*	18 *(2.8)*
Earth Science	Earth's structure and physical features	6 *(1.6)*	25 *(3.1)*	69 *(3.3)*
	Earth's processes, cycles and history	8 *(1.8)*	27 *(2.9)*	65 *(3.0)*
	Earth's resources, their use and conservation	18 *(2.6)*	38 *(3.5)*	45 *(3.2)*
	Earth in the solar system and the universe	6 *(1.7)*	10 *(2.4)*	84 *(2.8)*

*This category includes topics not on the curriculum.
Due to rounding, percentages do not always add to 100.

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