Inside the post-primary classroom: Mathematics and science teaching in Second Year

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Chapter 1: Overview of TIMSS 2015

This report presents data relating to the teaching of mathematics and science in Second Year, arising from Ireland's participation in TIMSS 2015 (**T**rends in **I**nternational **M**athematics and **S**cience **S**tudy). The present chapter provides a brief background and overview of the study. The following chapter will provide a more detailed introduction to the current policy landscape in Ireland and an overview of the remainder of the report.

Readers of this report may also be interested in a companion report that was published in December 2017 (Clerkin, Perkins & Chubb, 2017). It addresses similar topics related to the teaching of mathematics and science at primary level (at Fourth Class).

What is TIMSS?

TIMSS is among the largest and most in-depth studies of educational achievement in the world. Fifty-six countries, including Ireland, took part in the most recent cycle of TIMSS, in 2015. In Ireland, 4344 students from 149 schools took part at Fourth Class and 4707 students from 149 schools participated at Second Year. Questionnaires were also completed by the principals and teachers (mathematics and science teachers at Second Year) of these students. TIMSS is designed to assess the mathematics and science skills of students in Fourth grade (equivalent to Fourth Class in Ireland) and Eighth grade (Second Year) in participating countries, thereby providing national and cross-national comparative information for policy-makers and educators. The study is organised under the auspices of the International Association for the Evaluation of Educational Achievement (IEA), a non-profit consortium of research institutes. The Educational Research Centre (ERC) managed Ireland's participation in TIMSS 2015 on behalf of the Department of Education and Skills (DES). TIMSS takes place every four years. The first implementation of TIMSS was in 1995; the most recent, in 2015, was the sixth. Ireland has participated on three occasions – in 1995 and 2015 (at both primary and post-primary levels) and in 2011 (at primary level only).

An initial report for TIMSS 2015 in Ireland was published in November 2016 (Clerkin, Perkins & Cunningham, 2016), timed to coincide with the international launch of the results (Martin, Mullis, Foy & Hooper, 2016; Mullis, Martin, Foy & Hooper, 2016). The initial report focused on describing the achievement of Irish students in Fourth Class and Second Year on the TIMSS mathematics and science assessments and also included a comparison of the Irish curriculum, together with teachers' coverage of various topics in class, relative to the TIMSS assessment frameworks.

Which countries participated in TIMSS 2015?

As noted above, 56 countries participated in the study in at least one grade level (47 at Fourth grade and 39 at Eighth grade).[1] However, in order to facilitate a clear presentation of findings, international

1 Seven benchmarking participants also took part. Benchmarking participants must follow the same procedures and meet the same data quality standards as countries, and can use the resulting (equivalent) data to benchmark their performance against national and international comparators.

comparisons that are presented in tables or graphics in this report will be limited to a small group of countries that are of particular interest as comparators, rather than the full set of countries that took part in the study. This set of countries was selected as a result of high average performance on TIMSS 2015 (and, usually, other recent international assessments) or due to their cultural and linguistic similarities to Ireland. The selected countries are given in Table 1.1, in alphabetical order.

These countries provide the main focus for comparison alongside Ireland and the TIMSS (international) average. Maintaining a consistent group of comparison countries in this manner provides a coherent and stable basis for comparison across differing national and thematic contexts. Other countries may also be referred to in text where especially noteworthy findings are observed.

Table 1.1: Selected comparison countries

	Participated at Grade…	Primary reason for inclusion
Australia	4 and 8	Cultural/linguistic similarity
England	4 and 8	Cultural/linguistic similarity
Hong Kong SAR	4 and 8	High performance
New Zealand	4 and 8	Cultural/linguistic similarity
Rep. of Korea	4 and 8	High performance
Russian Fed.	4 and 8	High performance
Singapore	4 and 8	High performance
Slovenia	4 and 8	High performance (science)
United States	4 and 8	Cultural/linguistic similarity

Readers should note that, when making reference to other countries, the internationally-comparable terms 'Fourth grade' and 'Eighth grade' are used. 'Fourth Class' and 'Second Year' are only ever used to refer specifically to students in Ireland.

How did Irish students perform?

Students' performance on each domain is reported on a scale that is set to an international 'centrepoint' of 500. This centrepoint has been maintained since the first TIMSS, in 1995, as a constant point of reference against which countries can monitor changes in their students' performance over time. It does not change with each cycle, unlike an international average, which would be expected to vary between cycles due to changes in performance within countries and different sets of countries taking part in each assessment year.

In general, Irish students achieved at a reasonably high level in TIMSS 2015, relative to other countries. At both grade levels, Irish students achieved mean mathematics and science scores that were significantly above both the centrepoint and the international average. Fourth Class pupils achieved a mathematics score that was significantly lower than pupils in seven countries, similar to pupils in four countries, and significantly higher than pupils in 37 countries. Performance in science was more modest, with Fourth Class pupils achieving a score that was significantly lower than pupils in 15 countries, similar to nine countries, and significantly higher than 22 countries. Second Year students achieved a mean mathematics score that was significantly lower than students in six countries, similar to five countries, and significantly higher than 27 countries. Their science performance was significantly lower than seven countries, similar to six countries, and significantly higher than 25 countries.

Table 1.2 presents a summary of the differences in performance between students in Ireland

and those in our selected comparison countries, along with the TIMSS average, for both domains at both grade levels. Countries are presented in alphabetical order rather than by mean achievement scores.

Students in four countries – Hong Kong, the Republic of Korea, the Russian Federation and Singapore – achieved higher mean scores than Irish students on both domains and at both grade levels. In some other countries, students achieved a higher score than Irish students in one domain but a lower score in the other domain, either at Fourth grade (United States) or at both grade levels (Slovenia).

Table 1.2: Differences in performance between Ireland and comparison countries

	Fourth grade				Eighth grade			
	Mathematics		Science		Mathematics		Science	
	Sig.	Difference from IRL	Sig.	Difference from IRL	Sig.	Difference from IRL	Sig.	Difference from IRL
Australia	↓	-30	↔	-5	↓	-19	↓	-18
England	↔	-1	↑	7	↔	-5	↔	7
Hong Kong	↑	67	↑	28	↑	71	↑	16
Ireland		547		529		523		530
New Zealand	↓	-57	↓	-23	↓	-31	↓	-17
Rep. of Korea	↑	61	↑	60	↑	82	↑	25
Russian Fed.	↑	17	↑	38	↑	15	↑	14
Singapore	↑	70	↑	62	↑	97	↑	67
Slovenia	↓	-27	↑	14	↓	-7	↑	21
United States	↓	-8	↑	17	↔	-5	↔	0
TIMSS average	↓	-38	↓	-23	↓	-42	↓	-44

Countries are ordered alphabetically.
↑ indicates a significantly higher mean score than Ireland.
↓ indicates a significantly lower mean score than Ireland.
↔ indicates that the score is not significantly different from Ireland's.

The strong focus on trend data in TIMSS also allows us to look beyond within-cycle comparisons. Significant improvements in both mathematics and science were found among Fourth Class pupils in 2015, with most of this improvement occurring since 2011. At Second Year, significant improvements since 1995 were found for science performance, but not for mathematics. It was particularly notable that performance in both domains has increased since 1995 (and since 2011 for Fourth Class pupils) among lower- and medium-performing students, but not among the highest-achieving students. For a more detailed discussion of mathematics and science achievement, and for details on the administration of the survey, readers are referred to the initial report (Clerkin et al., 2016).

Contextual information for Ireland: Research series

This report describes the characteristics of the mathematics and science teachers of Second Year students in Ireland, their classrooms, and some of the teaching practices in which these teachers engage in their Second Year classrooms. It is one of several TIMSS thematic reports that will be released as part of our ERC Research Report Series. TIMSS 2015 provides detailed information on students' personal experiences and attitudes; their home environment; their classroom environment and the teaching practices they experience; the school-level policies and practices that influence

their daily lives; as well as national-level policies and the curricula for both grade levels. The study is designed to allow us to generalise these data to the national populations of Fourth Class and Second Year students, delivering robust information on their educational experiences.

In order to present this wealth of contextual data in the clearest fashion, each thematic report will focus on a particular topic in detail. Topics include the characteristics and practices of teachers in the classroom, student engagement and the broader student experience, interactions between the school and the home, the use of technology for teaching and learning, and structural features of the Irish education system. All reports will be made available for download from www.erc.ie/timss as they are published.[2]

2 An e-appendix accompanying each report will also be available from www.erc.ie/timss, where relevant. These will contain additional statistical information (e.g., standard errors) that may be omitted from the main reports in order to facilitate a clear presentation of findings.

Chapter 2: Recent policy initiatives related to teaching in Ireland

Teachers play an important role in student learning and research has shown that students learn more from experienced and skilled teachers who have relevant content and pedagogical knowledge (Darling-Hammond, 2000; Darling-Hammond & Youngs, 2002). Many countries that have participated in TIMSS over the last 20 years have recognised the importance of a well-qualified teaching profession and have taken steps to raise the requirements for teacher certification and qualification, including for post-primary mathematics and science (Mullis, Martin & Loveless, 2016).

The purpose of this chapter is to provide context for the data presented in the remainder of the report (the main topics of each chapter are listed at the end of this introduction). Here, we outline some recent developments in policy related to the teaching of mathematics and science at lower secondary level. In Ireland, a number of policy initiatives targeted specifically at or relevant to teachers of the junior cycle curriculum have been introduced in recent years, including:

- The *National Strategy to Improve Literacy and Numeracy among Children and Young People, 2011–2020* (DES, 2011, 2017);
- The *Framework for Junior Cycle* (DES, 2015a);
- The new post-primary mathematics curriculum (commonly referred to as Project Maths, and fully introduced to all post-primary schools in 2012);
- The new science curriculum (introduced in 2015);
- The *Digital Strategy for Schools 2015-2020* (DES, 2015b).

The introduction of these initiatives has brought with them a number of measures that have implications for teachers of junior cycle mathematics and science in terms of their teaching practices in the classroom, the structure of their lessons, and their initial teacher education.

Qualification routes and requirements

The *National Strategy to Improve Literacy and Numeracy* (DES, 2011, 2017) was launched in 2011 and introduced a number of measures designed to improve performance in literacy and numeracy among primary and post-primary students. Particularly relevant to the teaching profession are the objectives to increase the duration of initial teacher education courses for post-primary teachers (the Postgraduate Diploma in Education) to two years and to ensure that all initial teacher education programmes include topics relevant to literacy and numeracy development.

Specific to mathematics teaching, a Professional Diploma in Mathematics for Teaching was introduced in 2012 to address concerns related to the teaching of mathematics at post-primary level. It is designed to up-skill and qualify out-of-field teachers of mathematics who are currently employed in schools. As of 2016, 550 teachers (three cohorts) had completed the diploma (Lane, Faulkner & Smith, 2016). The problem of out-of-field teaching in the area of mathematics has been linked to the underperformance of post-primary students in mathematics as well as the low uptake of Higher Level mathematics, and it is thought to disproportionately affect junior cycle students (Ní Ríordáin & Hannigan,

2009). The Teaching Council specifies that the minimum requirement for the teaching of mathematics at post-primary level is a degree-level qualification in which the study of mathematics comprises at least a third of the degree and which ensures the holder has sufficient knowledge, skills and understanding to teach to the highest level in post-primary education (Teaching Council, 2012). However, in their study of out-of-field teaching in post-primary mathematics education, Ní Ríordáin and Hannigan (2009) estimated that 48% of mathematics teachers did not hold a recognised teaching qualification in that subject. More recently, a survey of mathematics teachers in schools that participated in PISA 2012 in Ireland indicated that about 60% of these teachers had completed a degree which included the study of mathematics up to final year (Cosgrove, Perkins, Shiel, Fish & McGuinness, 2012).

At the same time, the STEM Education Review Group (2016) has noted that 'the need to augment science education has not been addressed sufficiently' (p. 29). Of particular concern is that more than half of junior cycle science teachers are qualified in Biology, while about a third are qualified in Chemistry and less than one-fifth are qualified in Physics (STEM Education Review Group, 2016). Such an imbalance in the proportions of teachers qualified in biology, physics and chemistry may have implications in terms of teachers' confidence in teaching the different science subjects, and has been linked to the 'dominance' of Biology in Leaving Certificate Science (Childs, 2014, p. 16). The STEM Education Review Group (2016) has called for this imbalance in the proportions of teachers qualified in various fields of science to be addressed urgently.

Curriculum change

The teaching and learning of mathematics at post-primary level have been subject to a number of changes in recent years with the introduction of all strands of the mathematics curriculum (through the Project Maths initiative) in all schools in September 2012. In 2012, a survey of teachers of mathematics was conducted as part of the administration of PISA in Ireland. All mathematics teachers in the selected schools were asked about their views on the teaching and learning of mathematics and the implementation of Project Maths. Cosgrove et al. (2012) describe the findings of this survey.

One of the key elements of the current mathematics curriculum is a greater emphasis on an investigative approach, meaning that students should take a more active role in their learning of mathematics. As such, the introduction of this curriculum was as much about changing teaching and learning practices as it was about changing content. Teachers highlighted that implementing the new teaching approaches within the available instructional time was challenging, and it was recommended that timetabling arrangements for mathematics be reviewed to consider longer single or double class periods (Cosgrove et al., 2012).

The introduction of the Project Maths initiative in classrooms was supported through out-of-school in-service training (10 days over three years), in-school support provided by the Project Maths Development Team, and voluntary evening, weekend and summer schools. In March 2012, just before all strands of the new mathematics curriculum were fully rolled out, post-primary teachers in Ireland reported engaging in an average of 45 hours of both formal and informal continuing professional development (CPD) related to mathematics over the previous three years, most of which (an average of 20 hours) was related to formal CPD on Project Maths (Cosgrove et al., 2012). In the same survey, 46% of mathematics teachers indicated that lack of time outside of school hours prevented participation in CPD related to mathematics, while 24% cited a lack of time during school hours as an impediment. Teachers were also asked to rate their level of confidence in teaching various aspects of Project Maths at junior cycle. About half of teachers indicated that they were very confident in teaching statistics; geometry and trigonometry; and probability. On the other hand, fewer than a quarter reported being very

confident in catering for students of varying mathematical ability; organising classes so that students can use concrete materials; supporting students with learning difficulties in mathematics; facilitating students' independence in problem solving/doing mathematics; analysing students' problem-solving strategies; and engaging students in assessing their own progress/performance in mathematics.

The *National Strategy to Improve Literacy and Numeracy* (DES, 2011, 2017) specified that the time devoted to the teaching of mathematics be increased to a minimum of five periods per week (i.e., one per day) by 2013, although the amount of time in a class period may vary across schools and is not specified in the strategy. A year previous to this indicative date, in 2012, teachers reported teaching an average of 2.92 hours of mathematics a week to Second Year students, although it is not clear how these teaching hours were distributed across the school timetable (Cosgrove et al., 2012).

There have also been recent changes for junior cycle science with the introduction of the revised science curriculum, as part of the wider review of the junior cycle. One of the concerns raised about the new junior cycle is that science will not be a core subject and therefore minimum instructional time in science will be reduced from 240 to 200 hours over three years (Childs, 2014). TIMSS 2015 (and therefore the data presented in this report) predates the implementation of the new curriculum in schools and CPD for science teachers on the revised curriculum, which commenced in 2016. Nevertheless, even though a greater amount of contact time was specified in the previous science syllabus (introduced in 2003), results from PISA 2006 indicate that students in Ireland had relatively less exposure to science lessons than students in other countries. Just 16% of 15-year-olds indicated that they spent four hours or more a week attending regular science lessons, compared to an OECD average of 29% (OECD, 2007) and just over 8% did not study science at all (Eivers, Shiel & Cunningham, 2008). Furthermore, the amount of time devoted to the instruction of science in primary schools in Ireland, which is the lowest among TIMSS countries and has halved since 2011 (from 63 hours to 32 hours in 2015), has been linked with Ireland's weaker performance in science relative to mathematics at primary level (Clerkin et al., 2017).

The 2003 science syllabus, which was the syllabus in use at the time of the TIMSS 2015 study, differed from its predecessor in a number of ways, including a greater emphasis on student investigation and practical work. A survey of junior cycle science teachers, administered in conjunction with PISA 2006 in Ireland, found that 87% of teachers felt their use of the investigative approach to teaching science had increased under the 2003 science syllabus (relative to the previous syllabus) and a clear majority (over 80%) felt that students' use of the investigative approach, as well as engagement in practical work, had also increased (Eivers, Shiel & Cheevers, 2006). This survey also reported that over 80% of teachers of Third Year science students reported placing either some or a lot of emphasis on developing skills such as applying scientific knowledge to a given situation; explaining conclusions and the scientific evidence on which they are based; and interpreting scientific evidence and drawing conclusions. With regard to classroom activities, most teachers reported that, in at least half of lessons, the teacher related scientific concepts to examples in the real world (78%), and students performed experiments by following instructions (56%) and drew conclusions from experiments (65%). On the other hand, almost half of teachers reported that students hardly ever or never designed an experiment to answer a scientific question, and over 70% hardly ever or never read articles about science in sources other than their usual textbooks.

Assessment and use of ICT

Childs (2014) highlighted a number of concerns about the 2003 junior cycle science course, including a lack of technical assistance in schools for science teachers and a lack of preparation for the assessment

of practical work. Eivers et al. (2006) echoed these concerns, with over 70% of teachers indicating that a lack of technical support (e.g., laboratory assistant) impeded their teaching of science, and almost 55% reporting that they were dissatisfied or very dissatisfied with the information provided on assessment procedures as part of the CPD they attended related to the revised syllabus.

One of the most significant changes in the new junior cycle is the broadening of the approach to assessment (DES, 2015a). As well as a State-certified examination and a written assessment task, both of which will be corrected by the State Examinations Commission, assessment in each subject will also include two classroom-based assessments that are facilitated by the students' teachers. The DES (2015a) note that the successful implementation of the new assessment procedures 'will depend on skills and abilities of teachers and their collaborative engagement with their subject department colleagues' (p. 35). However, the concerns expressed among junior cycle science (Childs, 2014) and mathematics teachers (Cosgrove et al., 2012) about their lack of preparation for the assessment of these courses indicates that teachers feel the need for considerable support in this area.

The *Framework for Junior Cycle* (DES, 2015a) also envisages greater use of ICT in junior cycle classes. The *Digital Strategy for Schools 2015-2020* (DES, 2015b) sets out the DES' vision for further integrating ICTs in teaching, learning and assessment in schools in Ireland. This strategy aims to ensure that all teachers are equipped with the 'knowledge, skills and confidence to integrate ICT into their practice' (p. 6). The 2013 ICT census (Cosgrove, Butler, Leahy, Shiel, Kavanagh & Creaven, 2014) noted that while schools are relatively well-resourced to use ICTs, students are less well-resourced in terms of having access to ICTs during lessons in classroom settings (rather than, for example, in a computer room). This study found that insufficient time for planning and preparation, lack of technical support, and low levels of teacher knowledge and confidence were the main obstacles identified by principals to using ICTs to support teaching and learning in post-primary classrooms in Ireland.

The remainder of this report describes the mathematics and science teachers of Second Year students that participated in TIMSS 2015, including their gender, qualifications and teaching experience (Chapter 3); some structural characteristics of the mathematics and science classrooms they teach (Chapter 4); different aspects of the teaching of mathematics (Chapter 5) and science (Chapter 6), including teachers' engagement in professional development, confidence in various aspects of mathematics and science teaching, and engagement in various collaborative practices; and some of the challenges reported by teachers, both in the classroom and in the wider school environment, together with teachers' views of their own career satisfaction (Chapter 7). The report ends by considering some of the main conclusions drawn from these findings (Chapter 8).

> The information provided here is reported at the student level, unless specified otherwise. TIMSS 2015 is designed to be representative of students, meaning that we can say that the experience of the students that took part in TIMSS 2015 is representative of the experience of Second Year students more generally. However, the teachers and principals who took part in the study are not necessarily representative of all teachers and principals in Ireland. Therefore, we say that "25% of students were taught by teachers who did X" rather than "25% of teachers did X". In this way, the following chapters present generalisable information describing *students'* experience of education in Ireland.
>
> Due to rounding, some percentages may not sum exactly to 100% so, in a small number of cases, the percentages referred to in text may vary slightly from percentages presented in tables.

Chapter 3: Characteristics of teachers

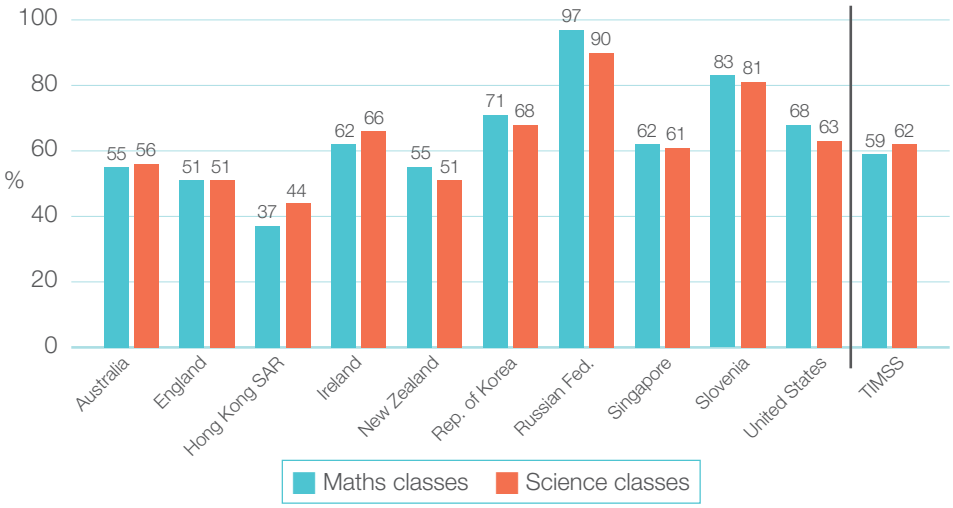
This chapter describes some characteristics of Eighth grade mathematics and science teachers, including gender, teaching experience, and qualifications.

Gender

In Ireland, about two-thirds of Second Year students had a female teacher for mathematics (62%) or science (66%) lessons. These are higher proportions than were reported for Ireland in TIMSS 1995, although to a greater extent for science (54% in 1995) than for mathematics (58%). These percentages are broadly in line with the findings that 65% of junior cycle mathematics teachers (in 2012) and 61% of science teachers (in 2006) in PISA schools were female (Cosgrove et al., 2012; Eivers et al., 2006).

On average across TIMSS countries, a majority of students were taught mathematics and science by female teachers (59% and 62%, respectively; Figure 3.1). Among our comparison countries, the proportion of students taught by female teachers was closer to half in Australia, England and New Zealand, for both mathematics and science. In Hong Kong, relatively few students had a female teacher for mathematics (37%) or science (44%) lessons. Conversely, almost all students in the Russian Federation were taught by females in their mathematics (97%) and science (90%) classes.

Figure 3.1: Percentage of students taught by female teachers for mathematics and science lessons



Age and teaching experience

Second Year students tended to have somewhat younger teachers for mathematics than their international peers – 22% had a mathematics teacher who was under 30 years old, compared to 17% of students across all TIMSS countries (Table 3.1). About 40% of students in Ireland had a mathematics teacher who was over the age of 40, while this was the case for about half of students

internationally (51%). Internationally, the age profile for science teachers was very similar to that seen for mathematics. However, in Ireland, Second Year students were more likely to have a teacher aged 40 or older for science (51%) than for mathematics (40%).

Table 3.1: Percentage of students taught by teachers of various ages

		Under 25	25-29	30-39	40-49	50-59	60 or more
Mathematics	IRL	4	18	38	24	14	2
	TIMSS	3	14	32	27	19	5
Science	IRL	3	17	30	32	17	2
	TIMSS	3	14	32	28	18	4

In Ireland, students' mathematics teachers reported an average of 14.5 years of teaching experience, slightly below the TIMSS average of 15.5 years (Table 3.2). For science, students had teachers with an average of 15.4 years of experience, which was slightly above the TIMSS average (14.9 years). For both domains, the median years of teaching experience in Ireland was below the TIMSS median, albeit to a greater degree for mathematics than for science.[3]

Table 3.2: Years of teaching experience (mean and median)

	Mathematics		Science	
	Mean	**Median**	**Mean**	**Median**
Australia	15.9	12.0	13.3	11.0
England	10.5	7.0	11.1	8.0
Hong Kong SAR	14.1	11.0	14.7	14.0
Ireland	14.5	12.0	15.4	13.0
New Zealand	17.2	14.0	15.1	12.0
Rep. of Korea	14.2	12.0	15.0	13.0
Russian Fed.	22.9	24.0	23.3	24.0
Singapore	8.8	6.0	8.4	6.0
Slovenia	21.3	21.0	22.0	23.0
United States	14.1	12.0	12.7	12.0
TIMSS	15.5	14.3	14.9	13.7

Qualifications

Two-thirds of Second Year students were taught by teachers whose highest qualification was a Bachelor's degree (66% for both mathematics and science), which are similar to the international averages of 66% for mathematics teachers and 64% for science teachers.[4] However, postgraduate degrees (including, for example, a Master's, PhD, or EdD, but not post-graduate diplomas) were slightly more common in Ireland than across TIMSS as a whole. In Ireland, 32% of students had a mathematics teacher with an additional postgraduate degree (TIMSS: 25%), while 31% had a science teacher with an additional postgraduate degree (TIMSS: 28%). In three of our comparison countries, a majority of students were taught by teachers holding postgraduate degrees – the United

3 The *mean* is what is often colloquially known as the 'average' (e.g., the mean of 3, 4, and 5 is (3+4+5)/3=4). The median is the 'middle' value in a list of numbers that has been ordered from low to high (e.g., the median of 2, 3, 5, 8, and 13 is 5).

4 A further 1% of students in Ireland, and 2% on average across TIMSS countries, were taught by teachers who indicated that they had no formal education beyond upper secondary.

States (58% for mathematics and 56% for science), Slovenia (60% for mathematics and science), and the Russian Federation (64% for mathematics and 74% for science). On the other hand, this was true for relatively few students in Australia (20% for mathematics and 19% for science) and England (17% for mathematics and 26% for science).

Teachers were also asked to indicate their *main or major* areas of study during their third-level education (Table 3.3). It should be noted that a definition of *main or major* area of study was not given as part of the teacher questionnaires and relied on teachers' interpretation of the question, so the fact that a particular area was not identified as a major area of study does not necessarily mean that it was not studied at all. Also, teachers who have followed the same training route (e.g., a mathematics degree followed by a teaching qualification) may report different interpretations of what constitutes their main or major areas of study, and therefore may be classified differently (in this example, either as mathematics as a solo main area of study, or as both mathematics *and* mathematics education). Conversely, it is possible that teachers who are classified together in these data may have followed different training routes (e.g., teachers who 'majored in mathematics education but not mathematics' could be teachers who took the concurrent route, or could be teachers who took the consecutive route and whose degree did not include mathematics but who studied mathematics education as part of a diploma or Master's).

With that caveat in mind, relative to the TIMSS average, students in Ireland were more likely to be taught mathematics by a teacher whose main area of study was something *other* than mathematics or mathematics education (Table 3.3). This was the case for 22% of students in Ireland, while the corresponding TIMSS average was 13%. One-third of students in Ireland (33%) had mathematics teachers who reported *both* mathematics and mathematics education as major areas of study in their education, while a further 36% indicated that mathematics was a main area of study but mathematics education was not. Both of these percentages are similar to the corresponding TIMSS averages. Just 8% of students in Ireland were taught by a mathematics teacher who specialised in mathematics education but not mathematics, compared to 13% internationally.

Elsewhere, large proportions of students were also taught by teachers who reported that mathematics was their main area of study. For example, over 80% of students in England and Singapore had a mathematics teacher who specialised in mathematics or mathematics education during their third level education, as did almost every student in the Russian Federation.

Table 3.3: Percentage of students, by mathematics teachers' major or main areas of study

	Major in maths and maths education	Major in maths but not in maths education	Major in maths education but not in mathematics	All other majors
Australia	46	18	14	22
England	44	37	4	15
Hong Kong SAR	42	25	9	23
Ireland	33	36	8	22
New Zealand	29	30	7	34
Rep. of Korea	18	30	49	3
Russian Fed.	58	41	0	1
Singapore	53	31	6	10
Slovenia	39	40	20	1
United States	35	12	22	31
TIMSS	36	36	13	13

In contrast to mathematics, only 4% of students in Ireland were taught science by a teacher whose main area of study was something other than science or science education (TIMSS average: 7%) (Table 3.4). Forty-four percent of students in Ireland had a science teacher who majored in both science and science education (TIMSS average: 32%), while 49% were taught by a teacher who had studied at least one science subject, but not science education, as a major area (similar to the TIMSS average of 47%).

Similar patterns were observed in England, the Republic of Korea, New Zealand and the Russian Federation. Many more students in Australia (63%) were taught science by a teacher who specialised in both a science subject (or subjects) and science education. In contrast, 21% of students in the United States were taught science by teacher whose main area of study was neither science nor science education.

Table 3.4: Percentage of students, by science teachers' major or main areas of study

	Major in science and science education	Major in science but not in science education	Major in science education but not in science	All other majors
Australia	63	21	8	8
England	47	49	1	3
Hong Kong SAR	42	37	12	10
Ireland	44	49	2	4
New Zealand	47	45	1	7
Rep. of Korea	42	51	7	0
Russian Fed.	50	48	1	1
Singapore	54	41	2	3
Slovenia	18	77	2	3
United States	35	26	18	21
TIMSS	32	47	11	7

Teachers also indicated which particular areas of science they had studied as a main focus.[5] Second Year students in Ireland were more likely than students internationally to have teachers who had studied biology (67% vs 43%) and chemistry (50% vs 40%) as a main area. Fewer Irish students' (24%) science teachers reported physics as a main area of study, compared to 32% internationally. Only 8% of students in Ireland had a science teacher who had studied Earth science as a main area, compared to 16% internationally.

5 For a full presentation of teachers' main or major areas of study, see the accompanying e-appendix (www.erc.ie/timss).

Chapter 4: Characteristics of mathematics and science classrooms

This chapter describes the mathematics and science classrooms in which Second Year students learn, in terms of class size and the prevalence of language difficulties.

The mathematics classroom

The average size of Second Year mathematics classes, as reported by teachers, was 24.3 students, somewhat smaller than the Eighth grade international average of 28.5 (Table 4.1). There was considerable variation in class size among Ireland's comparison countries, with Slovenia (16.7) reporting the lowest and Singapore (35.8), the Republic of Korea (31.6) and Hong Kong (30.5) among the highest.

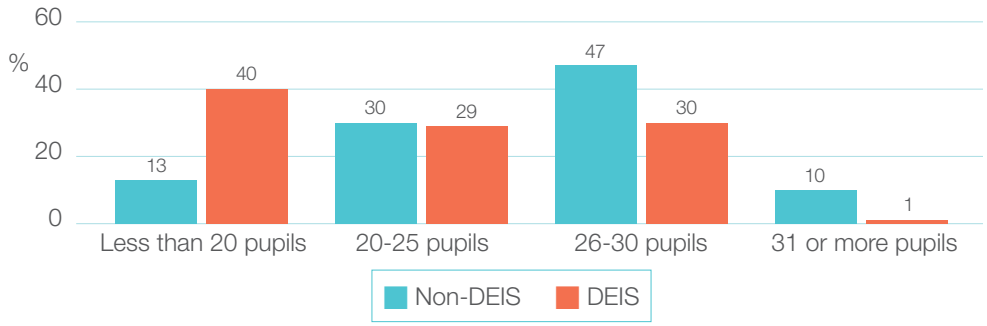
Table 4.1: Mean class size and mean number of students with difficulties understanding the (spoken) language of the test, mathematics classes

	Class size	N students with language difficulties
Australia	25.2	0.7
England	26.2	0.8
Hong Kong SAR	30.5	2.9
Ireland	24.3	1.0
New Zealand	25.3	1.0
Rep. of Korea	31.6	0.9
Russian Fed.	23.2	0.2
Singapore	35.8	1.0
Slovenia	16.7	0.8
United States	27.8	1.3
TIMSS	28.5	3.4

Class size in Ireland varied by schools' DEIS status (Figure 4.1).[6] In non-DEIS schools, 13% of students were in mathematics classes with fewer than 20 students, compared to 40% of those attending DEIS schools. One in ten mathematics students in non-DEIS schools were taught in very large mathematics classes (31 or more students), while this was the case for 1% of students in DEIS schools.

6 'DEIS schools' are those in receipt of extra supports intended to address high levels of educational disadvantage through the School Support Programme component of the DEIS (*Delivering Equality of opportunity In Schools*) scheme.

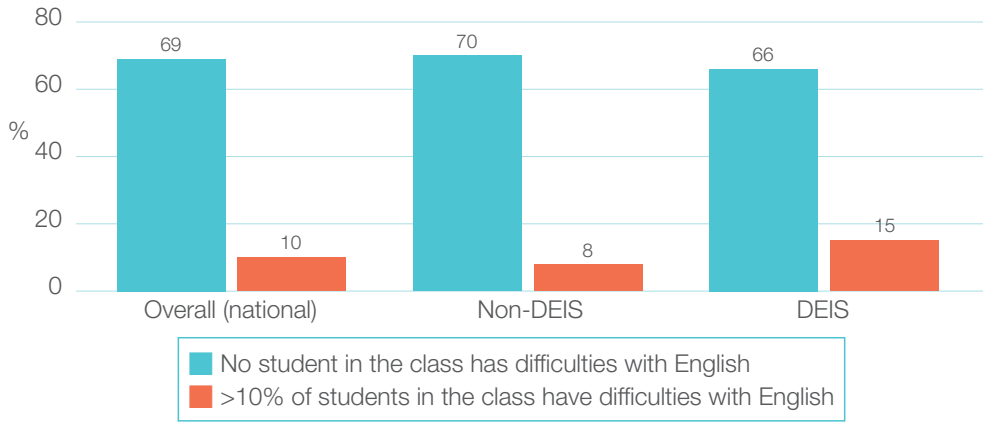
Figure 4.1: Variation in number of students taught by Second Year maths teachers, by DEIS status



Mathematics teachers were also asked about the presence of language difficulties in the classroom (Table 4.1). In Ireland, the average number of students reported to be experiencing language difficulties was 1.0, compared to a TIMSS average of 3.4 students. The prevalence of students with language difficulties in mathematics classes in New Zealand (1.0) and Singapore (1.0) was similar to Ireland, while the Russian Federation had the lowest number of students per class (0.2) experiencing difficulties understanding the language of the test. Conversely, teachers in Hong Kong reported that about three students in the average class experienced language difficulties.

While one student, on average, experienced language difficulties in Irish mathematics classes, these students were not distributed equally across all classes. Nationally, 69% of students in Ireland were in mathematics classes where *no* students had difficulty understanding spoken English (Figure 4.2). However, 10% of students were in classes where language difficulties were relatively prevalent (defined here as more than one-tenth of their classmates having difficulties understanding English). Such clustering was more common in DEIS schools. Fifteen percent of students in DEIS schools attended a mathematics class where language difficulties were prevalent, compared to 8% of students in non-DEIS schools.[7]

Figure 4.2: Percentage of students in maths classes where no Second Year students or where >10% of Second Year students have difficulties understanding English, overall and by DEIS status



7 Note that, while a greater degree of clustering could indicate a higher level of challenge for teachers, it may also be the case that a teacher could teach more students who have language difficulties but as a smaller proportion of the whole class (e.g., two students with language difficulties are 17% of a class of 12 students, but three students with language difficulties are 10% of a class of 30 students). This caveat is important to remember given the smaller overall class sizes found in DEIS schools.

The science classroom

Science classes in Ireland were markedly smaller than the international average. The average Second Year science class had 22.2 students, compared to 28.7 internationally (Table 4.2). Among Ireland's comparison countries, the largest science classes were found in Singapore (35.9) and the Republic of Korea (34.0), while the smallest were in Slovenia (21.3).

Table 4.2: Mean class size and mean number of students with difficulties understanding the (spoken) language of the test, science classes

	Class size	N students with language difficulties
Australia	25.4	1.3
England	25.8	1.0
Hong Kong SAR	31.5	3.6
Ireland	22.2	1.0
New Zealand	25.9	1.0
Rep. of Korea	34.0	0.9
Russian Fed.	23.2	0.2
Singapore	35.9	1.7
Slovenia	21.3	1.3
United States	28.5	2.1
TIMSS	28.7	3.6

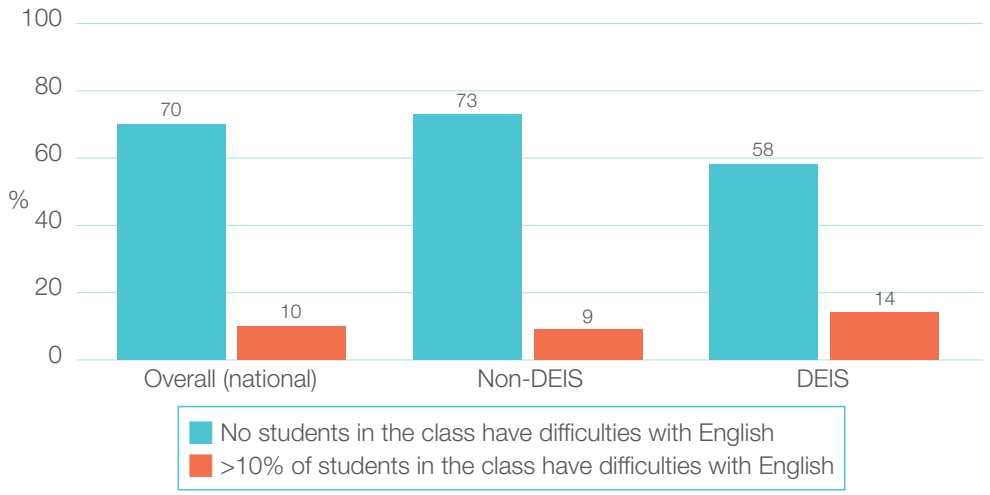
The size of science classes in Ireland varied by schools' DEIS status, but there was less variation than was found for mathematics classes. Most Second Year students, in both non-DEIS and DEIS schools, were in science classes with 20-25 students (both 69%). However, science students in DEIS schools were more likely to be in a class with fewer than 20 students than their peers in non-DEIS schools (30% vs 17%). There were no reports of students being taught in very large science classes (31+ students) in either category.

The extent to which language difficulties manifested in the science classroom was similar to those reported by mathematics teachers. In Ireland, teachers reported that an average of 1.0 student per science class experienced language difficulties, compared to an international average of 3.6 students. Similar results were reported in England (1.0), New Zealand (1.0), and the Republic of Korea (0.9). Hong Kong had the highest average (3.6 students) while the Russian Federation had the lowest number of students experiencing language difficulties (0.2).

However, as with mathematics, students experiencing language difficulties were not distributed equally across science classes (Figure 4.3). In Ireland, 70% of students were in science classes where no student experienced difficulties with English, and this percentage was lower in DEIS (58%) than in non-DEIS (73%) schools. Students in DEIS schools were also slightly more likely to attend science classes with a relatively high concentration of students with language difficulties than those in non-DEIS schools (14% for DEIS schools vs 9% for non-DEIS).

As noted earlier, it is important to consider the smaller overall class size found in DEIS schools when interpreting these findings, as some teachers may teach more students who have language difficulties but as a smaller proportion of the whole class. These data may also be confounded to some degree with variation in schools' DEIS status by school type (voluntary secondary, ETB, community/comprehensive) and overall school size.

Figure 4.3: Percentage of students in science classes where no Second Year students or where >10% of Second Year students have difficulties understanding English, overall and by DEIS status



Chapter 5: Teaching of mathematics

This chapter presents information on several aspects of teachers' practices in relation to the teaching of mathematics, including the amount of instructional time per annum, teaching and assessment practices used, coverage of topics assessed as part of TIMSS, use of ICTs, as well as confidence teaching mathematics, participation in continuing professional development and engagement in collaborative practices.

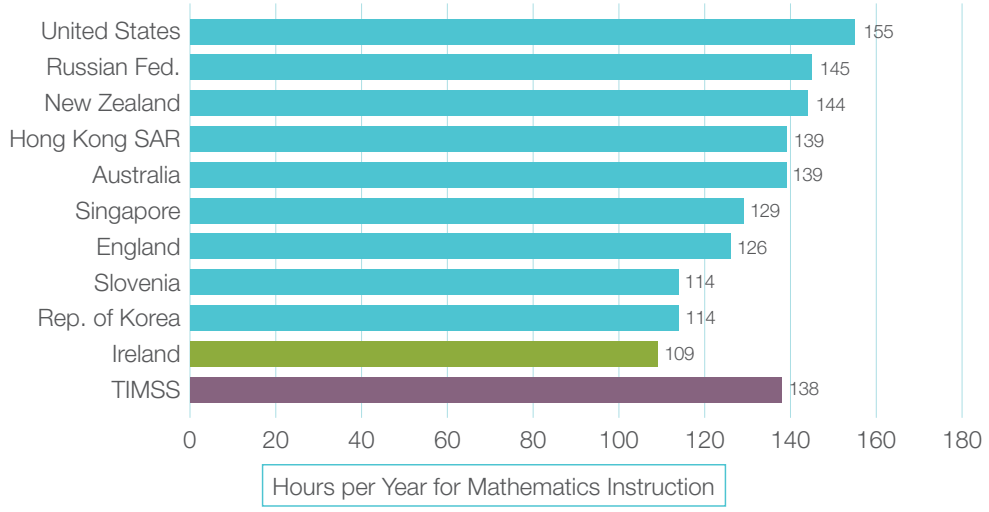
Instructional time

Second Year students received 109 hours of mathematics instruction over the course of the year, or about 11% of the total available instructional time. The corresponding international average was 138 hours, representing about 14% of instructional time.

Ireland reported the lowest figure for the time spent on mathematics in Eighth grade among our comparison countries (Figure 5.1) and the fourth-lowest figure among all countries in TIMSS. Similar figures were reported in the Republic of Korea, one of the higher-performing countries (114 hours; 12% of instructional time).

The absolute number of hours spent teaching mathematics varied widely across all TIMSS countries, from 99 hours per annum (Sweden) to 194 hours (South Africa). In relative terms, the percentage of time spent on mathematics instruction ranged from a low of 9% (Thailand) to a high of 18% (Canada).

Figure 5.1: Annual instructional hours devoted to mathematics lessons, reported by teachers



Teaching practices

Teachers were presented with a list of seven teaching practices and asked how frequently they engaged in each. In Ireland and across TIMSS as a whole, linking new content to students' prior knowledge was the activity most frequently engaged in (teachers of 94% of students in Ireland and

91% internationally did so in at least half of lessons) (Table 5.1). Among our comparison countries, only Hong Kong and the Republic of Korea had fewer than 90% of students whose teachers reported engaging in this activity in at least half of lessons (80% in Hong Kong and 63% in the Republic of Korea). Asking students to explain their answers was also very common (featuring in at least half of lessons for 86% of students in Ireland and 85% internationally) as was asking them to express their ideas in class (Ireland: 78%; TIMSS: 85%).

Relative to other activities, and to other countries, students in Ireland were least likely to be asked to decide their own problem-solving procedures, with only half (52%) of Second Year students asked to do so regularly,[8] compared to 70% internationally. Asking students to decide their own problem-solving procedures was particularly common in the Russian Federation (79% in at least half of lessons), the United States (78%), Slovenia (71%) and the Republic of Korea (68%). Teachers in Ireland were also less likely to ask their students to engage in regular classroom discussions (Ireland: 55%; TIMSS: 67%), an activity that was particularly common in the United States (84%), England (75%), New Zealand (74%) and Australia (70%).

On the other hand, teachers of 61% of students in Ireland indicated that they regularly asked them to complete challenging exercises that required them to go beyond their direct instruction. This is well above the TIMSS average (48%) and the percentages reported in the Republic of Korea (51%), Slovenia (44%), the Russian Federation (33%) and Hong Kong (30%).

Relating lessons to daily life was a reasonably regular feature of mathematics lessons in Ireland and across TIMSS countries as a whole (60% of students in Ireland, and 66% internationally). However, there was considerable variation among our comparison countries, with 81% of students in Slovenia, 51% of students in England and just 29% of students in Hong Kong having teachers who related lessons to their daily lives regularly.

Table 5.1: Percentages of students whose mathematics teachers engaged in various teaching practices

		Every or almost every lesson	About half of lessons	Some lessons	Never
Relate the lesson to students' daily lives	IRL	28	32	40	<1
	TIMSS	36	30	34	<1
Ask students to explain their answers	IRL	60	26	14	0
	TIMSS	59	26	15	<1
Encourage classroom discussions among students	IRL	26	29	39	5
	TIMSS	39	28	31	2
Link new content to students' prior knowledge	IRL	70	24	6	0
	TIMSS	69	22	8	<1
Ask students to complete challenging exercises that require them to go beyond the instruction	IRL	18	43	35	3
	TIMSS	19	29	46	6
Ask students to decide their own problem solving procedures	IRL	16	36	42	7
	TIMSS	35	35	28	2
Encourage students to express their ideas in class	IRL	51	27	20	2
	TIMSS	59	26	14	<1

8 'Regular' (or 'common') is used in text here as shorthand for 'in at least half of lessons'.

Teachers were also asked to describe the frequency with which they engaged in some subject-specific teaching practices (Table 5.2). These reports show that, in their mathematics lessons, Second Year students were most frequently asked to listen to the teacher explaining new content (91% in at least half of lessons), listen to their teacher explain how to solve problems (82%), and work through problems with guidance from their teacher (85% individually or with peers on a regular basis, and 79% with the whole class on a regular basis). The frequency of engaging in these practices in Ireland is in line with corresponding TIMSS averages, although there was some variation among comparison countries.

Compared to their peers in other countries, students in Ireland were less likely to take written tests or quizzes, with only 12% doing so in at least half of their lessons (TIMSS: 39%). The frequency of taking written tests or quizzes varied substantially across comparison countries; 47% of students regularly took tests/quizzes in the Russian Federation, but just 7% in Slovenia. Memorising rules, procedures, and facts was much more common among students in Slovenia (80%), the Russian Federation (74%), Australia (64%) and on average across TIMSS countries (64%) than in Ireland (36%). Working on problems for which there was no immediately obvious solution was also more common internationally (31%) than in Ireland (20%).

Table 5.2: Percentage of students experiencing various teaching practices in mathematics lessons

		Every or almost every lesson	About half the lessons	Some lessons	Never
Listen to me explain new mathematics content	IRL	62	29	9	0
	TIMSS	65	22	12	1
Listen to me explain how to solve problems	IRL	53	29	18	<1
	TIMSS	60	25	14	1
Memorise rules, procedures, and facts	IRL	14	22	57	8
	TIMSS	36	28	33	3
Work problems (individually or with peers) with my guidance	IRL	50	35	13	1
	TIMSS	52	34	14	<1
Work problems together in the whole class with direct guidance from me	IRL	39	40	20	2
	TIMSS	42	34	23	1
Work problems (individually or with peers) while I am occupied by other tasks	IRL	12	19	35	34
	TIMSS	15	19	34	33
Work on problems for which there is no immediately obvious method of solution	IRL	2	18	60	20
	TIMSS	9	22	55	14
Take a written test or quiz	IRL	3	9	86	2
	TIMSS	17	22	60	1
Work in mixed ability groups	IRL	15	25	44	17
	TIMSS	18	24	48	9
Work in same ability groups	IRL	9	16	51	24
	TIMSS	10	20	50	20

Assessment

A clear pattern emerged with regard to mathematics teachers' preferred methods for assessing their students' learning. Most Second Year students (87%) had a teacher who placed *major emphasis* on classroom tests to monitor their students' progress, somewhat higher than the corresponding international average (75%) (Table 5.3). Less emphasis was placed on classrooms tests in most of our comparison countries. An exception was the Russian Federation, where 94% of students were taught by teachers who placed a *major emphasis* on this form of assessment.

Teachers in Ireland were less likely than the international average to place a major emphasis on the assessment of students' ongoing work (58% of students versus 72% on average across TIMSS).

National or regional achievement tests were not seen as a major source of information on students' progress by mathematics teachers in Ireland, with the teachers of more than half of students (54%) giving them *little or no emphasis,* compared to 23% internationally. Such tests were given much more emphasis in the Russian Federation (where 90% of students' teacher placed a *major emphasis* on them) and in England (70%). It is noteworthy that 46% of students in Ireland had teachers who reported placing *some* or *major* emphasis on such tests given that, at the time of this survey, no nationally-standardised tests of mathematics were available for Second Year students. Although a definition of what constitutes national or regional tests was not provided as part of the study, it is possible that teachers were referring, for example, to tests developed within networks of schools, standardised tests developed abroad, or tests developed for other grade levels (e.g., past examples of Junior Certificate papers).

Table 5.3: Percentage of students, by mathematics teachers' emphasis on various forms of assessment

		Major emphasis	Some emphasis	Little or no emphasis
Assessment of students' ongoing work	IRL	58	36	6
	TIMSS	72	27	1
Classroom tests (e.g., teacher-made or textbook tests)	IRL	87	13	1
	TIMSS	75	24	1
National or regional achievement tests	IRL	13	33	54
	TIMSS	36	41	23

Curriculum coverage

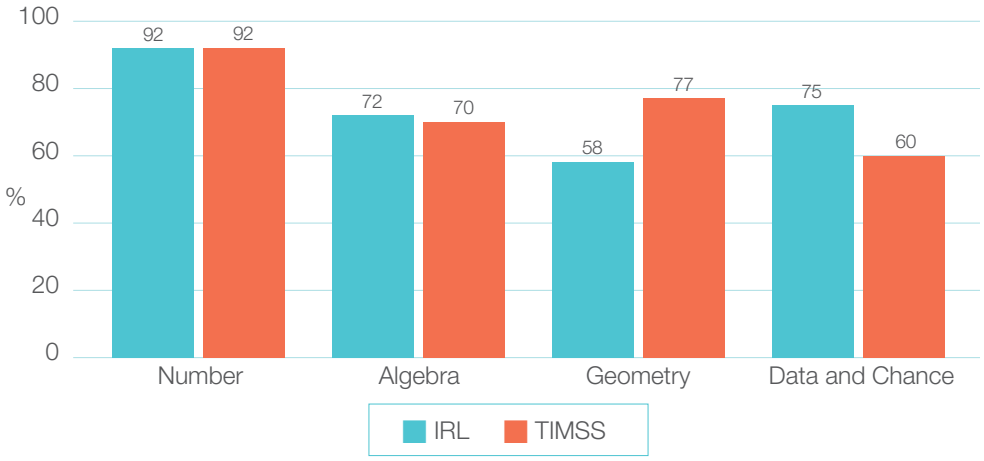
Teachers were presented with a list of 20 specific topics spanning the four TIMSS mathematics content areas; for example, 'Computing with rational numbers' (Number) or 'Properties of functions' (Algebra). For each one, teachers were asked if the topic had mostly been taught before Second Year, mostly taught during Second Year, or if the topic had not yet been taught or had just been introduced.[9]

Students were most likely to have been taught Number content by the time of the TIMSS testing; 92% of students in Ireland, and internationally, had covered the TIMSS Number topics (either in a

9 Figure 5.2 presents summary percentages for each content area. A more detailed list of percentages for each of the 20 topics is included in the accompanying e-appendix (www.erc.ie/timss).

lower grade level or during Second Year) (Figure 5.2). Teacher reports also indicated that most students had been taught Algebra topics, both in Ireland (72%) and internationally (70%). Relative to their international peers, students in Ireland were comparatively more likely to have covered Data & Chance topics by Second Year (75% vs 60%), but were less likely to have covered Geometry topics (58% vs 77%).

Figure 5.2: Coverage of mathematics topics by Second Year students, by content area



Use of ICT

Access to computers or tablets was slightly below average in Ireland. One-quarter of Second Year students (25%) had *some* access to a computer or a tablet during their mathematics lessons, compared to a TIMSS average of 32% (Table 5.4). Among our comparison countries, access to computers during mathematics lessons was lowest in Slovenia (19%) and highest in Australia (62%). Relatively few students in Ireland had access to their own computer in school (Ireland: 6%; TIMSS: 9%) or to a set of computers shared by the class (Ireland: 3%; TIMSS: 11%). Typically, access to computers in Ireland was shared across the school (Ireland: 20%; TIMSS: 26%).

In Australia, 38% of students had access to their own computer in schools (the highest among our comparison countries), while 13% were in a class that had a set of computers that students could share. On the other hand, just under 3% of students in the Republic of Korea had access to their own computer, but 24% had access to a set of computers shared by the class.

Table 5.4: Percentage of students who have access to a computer or tablet in lessons, and use of computers *at least monthly* for various activities in lessons

	% students	% students whose teachers have them use computers at least monthly for various activities			
	Yes	Explore maths principles & concepts	Practise skills & procedures	Look up ideas & information	Process & analyse data
Australia	62	51	52	48	44
England	29	17	23	17	13
Hong Kong SAR	21	13	12	13	12
Ireland	25	11	12	10	10
New Zealand	47	36	35	35	33
Rep. of Korea	39	25	22	24	19
Russian Fed.	47	36	41	42	34
Singapore	35	27	27	23	19
Slovenia	19	12	14	13	13
United States	39	27	31	29	26
TIMSS	32	21	23	22	19

In addition to below average access, use of computers in the classroom in Ireland was well below the international average. Teachers were asked about the frequency with which students used computers to explore mathematical concepts, practise skills and procedures, look up information, and process and analyse data. Only about one-tenth of students in Ireland (10-12%) did each activity at least once a month, compared to about one-fifth of students (19-23%) internationally (Table 5.4).

Computers were used most regularly in mathematics lessons in Australia (roughly half of students used computers for each activity at least once a month). By contrast, computer usage in mathematics lessons was notably low in Japan, where only 3-6% of students used them monthly despite 43% of students having access to computers during lessons.

Confidence teaching mathematics

Almost all Second Year students were taught by mathematics teachers who were highly confident that they could address students' comprehension of mathematics (92% *high* or *very high* confidence) (Table 5.5). Most students also had a teacher who was confident in their ability to make mathematics relevant to students (83%), to adapt their teaching to engage students' interest (82%), to inspire learning in mathematics (80%), or to help students appreciate the value of mathematics (80%).

Irish teachers' confidence was generally similar to the international average in most areas, although lower confidence was expressed in relation to showing students a variety of problem-solving strategies (81% in Ireland compared to an international average of 87%), and confidence for assessing students' comprehension was higher in Ireland (92%) than on average across TIMSS countries (84%).

Generally, confidence in teaching mathematics was high among our comparison countries, with some exceptions. For example, only 44% of students in Hong Kong had mathematics teachers who reported high/very high confidence in developing students' higher-order skills, compared to a TIMSS average of 71% and 74% in Ireland. Also, while 76% of students in Ireland had mathematics teachers who had high or very high confidence in providing challenging talks for the highest-achieving students, this was the case for just 58% of students in Singapore and 56% in Hong Kong.

Table 5.5: Percentage of students, by teachers' confidence with various aspects of mathematics teaching

		Very high	High	Medium	Low
Inspiring students to learn maths	IRL	33	47	20	1
	TIMSS	39	44	16	1
Providing challenging tasks for the highest-achieving students	IRL	22	54	22	2
	TIMSS	28	46	24	2
Adapting my teaching to engaging students interest	IRL	28	54	17	1
	TIMSS	29	53	17	1
Helping students appreciate the value of learning maths	IRL	27	53	18	2
	TIMSS	34	49	15	1
Assessing student comprehension of maths	IRL	38	54	8	0
	TIMSS	30	54	15	1
Improving understanding of struggling students	IRL	29	52	17	1
	TIMSS	25	50	24	1
Making maths relevant to students	IRL	29	54	17	<1
	TIMSS	28	49	22	1
Developing students' higher-order thinking skills	IRL	20	54	23	3
	TIMSS	23	48	26	2
Showing students a variety of problem solving strategies	IRL	31	50	17	2
	TIMSS	38	49	12	1

Finally, mathematics teachers were presented with a list of 20 content areas (e.g., 'properties of functions' as part of Algebra and 'concepts of irrational numbers' as part of Number). In Ireland and on average across TIMSS countries, the percentage of students whose mathematics teacher felt *not well prepared* to teach any given topic was very low (less than 1.1% for all topics in Ireland and less than 2.2% on average across TIMSS countries).[10]

Participation in Continuing Professional Development

Teachers in all countries were asked to indicate whether they had participated in any continuing professional development (CPD) related to several specified areas in the two years leading up to the survey in 2015. Second Year teachers reported high levels of involvement in mathematics-related CPD compared to their counterparts in many other countries (Table 5.6). This contrasts with the data from TIMSS 1995, when teachers in Ireland reported among the lowest frequency of engagement in professional reading and development (Beaton, Mullis, Martin, Gonzalez, Kelly & Smith, 1996) and is, presumably, at least partly due to the implementation of Project Maths over that period. Most students in Ireland (86%) were taught by a teacher who had attended at least six hours of mathematics-related CPD within the previous two years, compared to 68% internationally. Only 3% of Irish students' teachers had attended no recent mathematics CPD (TIMSS: 15%).

10 A full presentation of teachers' preparedness for each of the 20 topics is given in the accompanying e-appendix (www.erc.ie/timss).

Table 5.6: Percentage of students, by teachers' participation in mathematics-related CPD in the two years prior to TIMSS					
	None	Less than 6 hours	6-15 hours	16-35 hours	More than 35 hours
IRL	3	11	35	35	17
TIMSS	15	16	25	20	23

With regard to specific aspects of their teaching, 94% of Second Year students had a mathematics teacher who reported recent engagement in CPD relating to mathematics content, and 91% were taught by a teacher who had recently engaged in CPD about the mathematics curriculum (Table 5.7). In both cases, these were the highest percentages found in any TIMSS country. Similarly, high percentages of students in Ireland were taught by teachers who had recently had CPD on mathematics pedagogy or instruction (78%) or focusing on improving students' critical thinking and problem-solving skills (71%) – again, well above the corresponding international averages. By contrast, CPD relating to mathematics assessment (40%) or addressing the needs of individual students (35%) was attended slightly less frequently in Ireland than the international averages.

Table 5.7: Percentages of students, by teachers' participation in CPD related to specified aspects of mathematics teaching							
	Content	Instruction	Curriculum	Integrating IT into lessons	Assessment	Improving critical thinking	Addressing individuals' needs
IRL	94	78	91	65	40	71	35
TIMSS	56	59	50	50	44	45	42

Collaborative practices

As well as formal models of professional development (such as in-service days) teachers can engage in more informal professional development on an ongoing or ad hoc basis through collaboration, mentoring, or exchange of information with colleagues. Teachers' reports from TIMSS 2015 illustrate the extent to which these informal collaborative practices feature as part of post-primary teachers' regular professional activities (Table 5.8). More than half of students in Ireland, and on average across TIMSS countries, had a mathematics teacher who reported that they *often* or *very often* worked alongside other teachers in implementing the curriculum (Ireland: 63%; TIMSS: 57%), discussed how to teach particular topics with their colleagues (Ireland: 56%; TIMSS: 64%), shared their teaching experiences with colleagues (Ireland: 54%: TIMSS: 66%), or planned or prepared instructional materials together (Ireland: 51%, TIMSS: 58%).

On the other hand, 72% of Second Year students had a mathematics teacher who *never or almost never* visited another classroom to observe a colleague teaching, while 22% *never or almost never* worked to try new ideas with their colleagues. Both of these collaborative practices, in particular, were much less common in Ireland than internationally (TIMSS: 27% and 9% *never* or *almost never* doing so, respectively). Also, almost one-tenth of Second Year students (8%) were taught by a teacher who *never or almost never* discussed the teaching of a given mathematics topic with another teacher, compared to just 3% of students internationally. Similar patterns were also noted in TALIS 2008 (Gilleece, Shiel, Perkins & Proctor, 2009), with teachers in Ireland placing relatively less emphasis on professional collaboration (for example, teaching jointly as a team in the same class) compared with exchange and coordination for teaching activities (for example, exchanging teaching materials with colleagues).

Substantial variation in collaborative activity was found among our comparison countries. For example, about three-quarters of students in the Russian Federation (74%), Slovenia (76%) and Australia (77%) had teachers who *very often* or *often* discussed how to teach a particular topic with other teachers, compared to 54% in Hong Kong. Visiting another classroom to learn more about teaching was more common in the Republic of Korea and the Russian Federation (where 40% and 50% of students, respectively, had teachers who did so *often* or *very often*) than in other comparison countries (where fewer than 20% of students' teachers did so).

Table 5.8: Percentage of students, by teachers' engagement in various collaborative practices

		Very often	Often	Sometimes	Never or almost never
Discuss how to teach a particular topic	IRL	22	34	36	8
	TIMSS	26	39	32	3
Collaborate in planning or preparing instructional materials	IRL	22	29	38	11
	TIMSS	21	37	34	7
Share what I have learned about my teaching experiences	IRL	18	36	34	12
	TIMSS	24	42	31	4
Visit another classroom to learn more about teaching	IRL	2	3	23	72
	TIMSS	9	21	43	27
Work together to try out new ideas	IRL	9	19	51	22
	TIMSS	16	32	43	9
Work as a group to implement the curriculum	IRL	24	39	31	6
	TIMSS	21	36	34	9
Work with teachers from other grades to ensure continuity in learning	IRL	15	28	40	17
	TIMSS	15	32	38	15

Chapter 6: Teaching of science

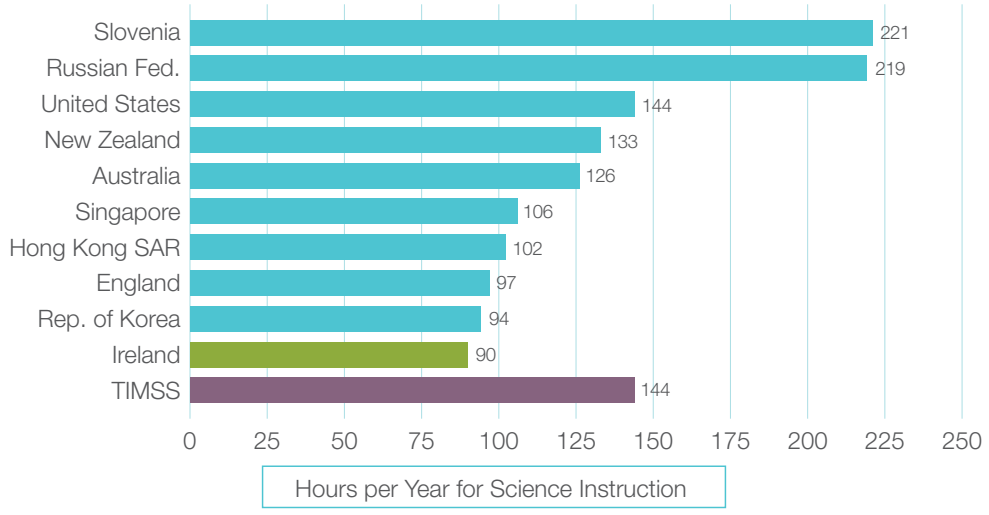
This chapter describes aspects of the teaching of science in Second Year.

Instructional time

Students in Ireland received 90 hours of science instruction (9% of total instructional time) during Second Year. The international average was 144 hours per year, representing 14% of instructional time (Figure 6.1). The amount of time spent on science in Ireland was the third-lowest of all countries, with science instruction ranging from 71 hours per annum (Italy) to 311 hours (Malta). Italy (7%) and Malta (32%) also marked the lowest and highest percentages of time spent on science, relative to total instructional time.

It is worth noting that the nine countries that reported spending the most time (from 160 hours in Morocco to 311 hours in Malta) all teach science as multiple subjects in lower secondary school (i.e., teaching 'physics' and 'biology' classes, rather than 'science' classes that include both topics). This group includes two of our comparison countries, Slovenia and the Russian Federation, where more time was allocated to science instruction (combining the time given for various science subjects) than to mathematics. Teachers in Singapore, the Republic of Korea, Hong Kong, and England reported that 10% of instructional time was spent on science, close to the corresponding figure in Ireland.

Figure 6.1: Annual instructional time devoted to science lessons, reported by teachers



Teaching practices

Second Year students were asked to explain their answers in science class on a regular basis (91% doing so in at least half of lessons) (Table 6.1). This is broadly in line with practice in science lessons in Australia (92%), the United States (93%) and England (94%), but is more frequent than in Korea (66%) and Hong Kong (70%). Most students in Ireland also had science teachers who reported that

they regularly asked students to express their ideas in class (81%), related the lessons to students' daily lives (88%), and linked new content presented in the classroom to students' prior knowledge (96%). These percentages were generally broadly similar to the international averages.

In contrast, students in Ireland were relatively rarely asked to decide their own problem-solving procedures during their science lessons (43%), a practice which is more frequent in England (56%), the Russian Federation (64%) and the United States (67%), and on average across TIMSS countries (59%). On the other hand, 56% of students in Ireland had science teachers who asked them to complete challenging exercises that required them to go beyond their direct instruction in at least half of lessons (compared to 49% in the Russian Federation, 38% in the Republic of Korea, and 35% in Hong Kong).

Table 6.1: Percentages of students whose science teachers engaged in various teaching practices

		Every or almost every lesson	About half of lessons	Some lessons	Never
Relate the lesson to students' daily lives	IRL	65	23	12	0
	TIMSS	59	26	15	<1
Ask students to explain their answers	IRL	59	32	9	0
	TIMSS	55	29	15	<1
Encourage classroom discussions among students	IRL	36	28	33	2
	TIMSS	40	29	30	1
Link new content to students' prior knowledge	IRL	73	22	4	0
	TIMSS	67	25	8	<1
Ask students to complete challenging exercises that require them to go beyond the instruction	IRL	15	41	42	2
	TIMSS	17	31	46	5
Ask students to decide their own problem solving procedures	IRL	13	30	47	9
	TIMSS	26	33	38	3
Encourage students to express their ideas in class	IRL	57	24	18	<1
	TIMSS	59	27	14	<1

The most frequently-used science-specific teaching practices involved asking students to listen to new science content be explained (86%), conduct experiments or investigations (77%), and asking them to use evidence from experiments or investigations to support conclusions (68%) (Table 6.2). Over half of students were also regularly (i.e., in at least half of lessons) involved in other aspects of experimentation, such as presenting (59%) and interpreting (61%) data. With the exception of explaining new content, each of these practices occurred more frequently in science lessons in Ireland than on average across TIMSS countries.

A substantial proportion of Second Year students were asked to read textbooks (42%) or to memorise facts and principles (52%) in at least half of their science lessons. These practices were still more common in other countries (66% and 60%, respectively). Irish students were less likely to be asked to conduct field work outside of class on a regular basis (5%) than their international peers (15%). However, a higher proportion of students internationally were *never* asked to do field work (26%) than in Ireland (10%).

The presentation and interpretation of data from experiments or investigations, and the use of evidence to support conclusions, were reported much more frequently in Ireland by 'new' teachers

(those with less than two years' teaching experience); 80-92% of their students were asked to do so in at least half of lessons, compared to 47-70% of students taught by more experienced teachers.

Table 6.2: Percentage of students experiencing various teaching practices in science lessons

		Every or almost every lesson	About half the lessons	Some lessons	Never
Listen to me explain new science content	IRL	59	27	12	2
	TIMSS	60	26	13	1
*Observe natural phenomena (e.g., the weather or a plant growing) and describe what they see	IRL	14	39	42	4
	TIMSS	26	37	35	2
*Watch me demonstrate an experiment or investigation	IRL	10	31	56	3
	TIMSS	25	28	44	3
*Design or plan experiments or investigations	IRL	7	33	50	10
	TIMSS	13	29	52	6
*Conduct experiments or investigations	IRL	20	57	21	1
	TIMSS	15	35	47	2
*Present data from experiments or investigations	IRL	12	47	37	3
	TIMSS	14	31	52	4
*Interpret data from experiments or investigations	IRL	13	48	39	1
	TIMSS	16	34	47	3
*Use evidence from experiments or investigations to support conclusions	IRL	15	53	30	1
	TIMSS	19	35	43	3
Read textbooks or other resource materials	IRL	23	19	47	11
	TIMSS	35	31	30	3
Have students memorise facts and principles	IRL	25	27	42	5
	TIMSS	30	30	35	5
Use scientific formulas and laws to solve routine problems	IRL	13	38	46	2
	TIMSS	25	34	37	4
*Do field work outside the class	IRL	1	4	85	10
	TIMSS	4	11	59	26
Take a written test or quiz	IRL	5	19	74	1
	TIMSS	18	26	54	1
Work in mixed ability groups	IRL	27	28	42	3
	TIMSS	21	30	44	5
Work in same ability groups	IRL	5	7	46	42
	TIMSS	8	20	49	23

Items marked with an asterisk (*) are those addressing *active scientific methods* (see Table 6.3).

Some of these items were used to form a composite measure that describes the extent to which scientific investigation is emphasised in science lessons. This measure reflects the use of *active scientific methods* (or scientific investigation), i.e., observing natural phenomena, watching the teacher demonstrate experiments, designing experiments, conducting experiments, presenting data from experiments, interpreting data from experiments, using experimental evidence to draw conclusions, and doing field work outside the classroom.

As shown in Table 6.3, about 20% of students in Ireland (27% internationally) were in classes where the teacher was categorised as emphasising science investigation in *about half the lessons or more*, with the remainder doing so less frequently. Looking at our comparison countries, scientific investigation was emphasised to a relatively high degree in Hong Kong, where 25% of students were exposed to active scientific methods in *about half or more than half of their science lessons*. This was less often the case in high-performing Singapore (8%) and the Russian Federation (11%). In most of these countries, and at the TIMSS average, there was a slight positive association between the use of active scientific investigation and performance on the TIMSS assessment.

Table 6.3: Percentage of students and science achievement, by teachers' emphasis on active scientific methods

	About half the lessons or more		Less than half of the lessons	
	% students	Mean	% students	Mean
Australia	16	520	84	515
England	18	547	82	536
Hong Kong SAR	25	565	75	539
Ireland	20	540	80	535
New Zealand	10	516	90	516
Rep. of Korea	16	555	84	556
Russian Fed.	11	556	89	543
Singapore	8	617	92	595
Slovenia	14	553	86	551
United States	21	541	79	531
TIMSS	27	490	73	485

Assessment

Classroom tests were the most common form of assessment used by science teachers, with 82% of Second Year students (and 72% of Eighth grade students internationally) having a teacher who placed *major emphasis* on monitoring students' progress this way (Table 6.4). Classroom tests were also frequently used in the Russian Federation (86%), but were relatively uncommon in the Republic of Korea (67%). Assessment of students' ongoing work received less emphasis among Second Year science teachers as a source of information on students' progress, being a *major* source of information for the teachers of 44% of students. This was much lower than the corresponding TIMSS average (69%).

National or regional achievement tests were regarded as the least important source of information on students' progress in science, both in Ireland and on average across TIMSS countries, although there was much variation among our comparison countries. For example, 83% of students in the Russian Federation, and 60% in England, had a teacher who placed a major emphasis on national or regional tests. On the other hand, such tests were given major emphasis by the teachers of just 7% of students in Australia and Hong Kong. As noted in Chapter 5, some teachers in Ireland may have included tests developed within networks of schools, standardised tests developed in other countries, or tests developed for other grade levels, such as Junior Certificate papers, in this category.

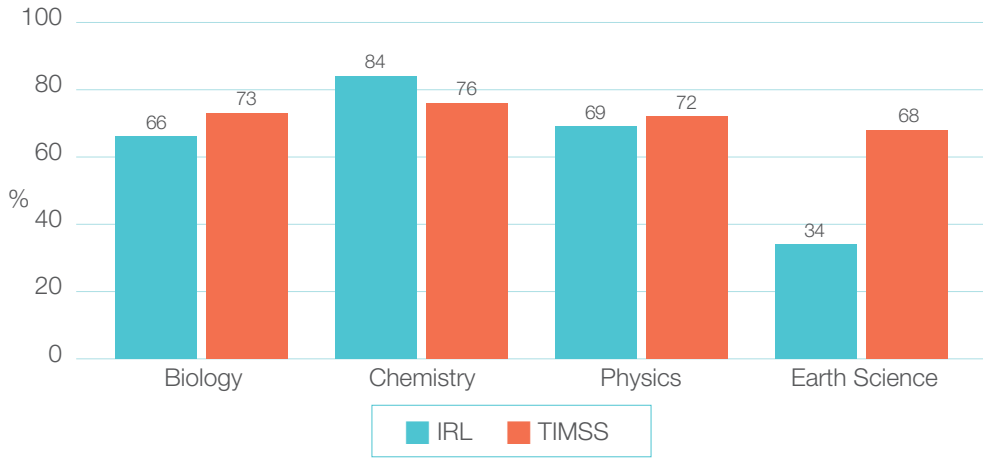
Table 6.4: Percentage of students, by science teachers' emphasis on various forms of assessment

		Major Emphasis	Some emphasis	Little or no emphasis
Assessment of students' ongoing work	IRL	44	50	7
	TIMSS	69	30	2
Classroom tests (e.g., teacher-made or textbook tests)	IRL	82	18	<1
	TIMSS	72	26	1
National or regional achievement tests	IRL	29	22	49
	TIMSS	35	39	27

Curriculum coverage

According to teachers' reports, Second Year students received relatively high coverage of Chemistry topics (84%), both compared to the TIMSS average for Chemistry (76%) and compared to the other content areas within Ireland (Figure 6.2).[11] About two-thirds of Physics (69%) and Biology (66%) topics were reported to have been covered by Second Year, and about one-third of the Earth Science (34%) topics. The corresponding TIMSS averages were slightly higher for Physics (72%) and Biology (73%), and much higher for Earth Science (68%). However, in interpreting the latter figure, readers should bear in mind that much of the content that is categorised as Earth Science in TIMSS is taught as Geography in Ireland, and so would not necessarily be expected to have been covered in science classes (which are the classes that science teachers are asked to report on).

Figure 6.2: Coverage of science topics by Second Year students, by content area



Use of ICT

About one-quarter of Second Year students (26%) had some access to computers or tablets during their science lessons (Table 6.5). Internationally, access to computers in science lessons ranged

11 Twenty-two topics were specified across the four main content areas – for example, 'Differences among major taxonomic groups of organisms' (Biology), 'Mixtures and solutions' (Chemistry), 'Forces and motion' (Physics), and 'Earth's structure and physical features' (Earth science). The associated tables are included in the accompanying e-appendix (www.erc.ie/timss).

(among our comparison countries) from 21% in Hong Kong to 66% in Australia. A minority of Second Year students (10-17%) used computers on a regular (at least monthly) basis to study natural phenomena through simulations, carry out scientific procedures or experiments, practise skills or procedures, look up information, or to process and analyse data. In Australia and the Russian Federation (the comparison countries with most access to computers during science lessons) computers were mostly used to look up ideas and information, with over 60% of students doing so in at least half of science lessons.

Table 6.5: Percentage of students who have access to a computer or tablet in lessons, and use of computers *at least monthly* for various activities in lessons

	% students	% students whose teachers have them use computers at least monthly				
	Yes	Practise skills & procedures	Look up ideas & information	Scientific procedures/ experiments	Study natural phenomena through simulations	Process & analyse data
Australia	66	53	65	47	49	55
England	48	23	44	18	24	28
Hong Kong	21	12	17	12	15	14
Ireland	26	12	17	10	12	11
New Zealand	60	38	56	26	40	35
Rep. of Korea	50	25	30	28	28	26
Russian Fed.	64	54	60	46	40	50
Singapore	52	31	41	27	34	27
Slovenia	32	23	29	19	25	25
United States	51	40	49	41	40	41
TIMSS	42	30	37	28	29	29

Confidence teaching science

Teachers' levels of confidence in handling specific pedagogical challenges is displayed in Table 6.6. Generally, Second Year science teachers' confidence was very high, and was similar to, or slightly higher than, the TIMSS average. Almost all students in Ireland had a science teacher who reported a *high* or *very high* level of confidence in their ability to make science relevant to their students (98%), adapt their teaching to engage students' interest (94%), and inspire students to learn science (92%). Most Second Year students were also taught by a science teacher who was highly confident in assessing students' comprehension (96%) and explaining concepts through experiments (94%). Teachers reported relatively lower (albeit still high) confidence in their ability to develop students' higher-order thinking skills (82%), improve the understanding of struggling students (81%), provide challenging tasks to high-achieving students (75%), and use inquiry methods to teach science (70%).

Science teachers in Ireland reported some of the highest levels of confidence in handling specific pedagogical tasks among our comparison countries. Only science teachers in high-performing Slovenia reported greater confidence in inspiring students to learn science (95% in Slovenia compared to 92% in Ireland), providing challenging tasks for the highest-achieving students (88% compared to 75%), helping students appreciate the value of learning science (89% compared to 88%), developing students' higher order thinking skills (86% compared to 82%) and teaching science using inquiry methods (75% compared to 70%).

Table 6.6: Percentage of students, by teachers' confidence with various aspects of science teaching

		Very high	High	Medium	Low
Inspiring students to learn science	IRL	42	51	8	0
	TIMSS	41	46	12	1
Providing challenging tasks for the highest-achieving students	IRL	23	53	23	2
	TIMSS	22	46	28	3
Adapting my teaching to engage students' interest	IRL	31	63	6	0
	TIMSS	31	53	15	1
Helping students appreciate the value of learning science	IRL	36	52	12	0
	TIMSS	37	49	13	1
Assessing student comprehension of science	IRL	40	56	4	0
	TIMSS	28	55	16	1
Improving understanding of struggling students	IRL	24	57	19	<1
	TIMSS	21	52	25	2
Making science relevant to students	IRL	51	48	2	0
	TIMSS	36	51	13	<1
Developing students' higher-order thinking skills	IRL	28	55	17	1
	TIMSS	24	49	25	2
Explaining concepts or principles by doing science experiments	IRL	58	36	6	0
	TIMSS	35	45	18	2
Teaching science using inquiry methods	IRL	25	45	26	4
	TIMSS	23	45	28	4

In terms of specific science topics (e.g., 'Mixtures and solutions' as part of Chemistry), the vast majority of Second Year students had science teachers who reported feeling *very well* or *somewhat* prepared to teach each topic. In almost all cases, the percentage of students whose science teacher felt *not well prepared* to teach the topic was less than 1%. The teachers of about 5% of students expressed a lack of confidence with several Earth Science topics (which are mostly covered in Geography classes in Ireland). On average across TIMSS countries, fewer than 3% of science teachers indicated that they did not feel well prepared to teach each science topic.[12]

Participation in Continuing Professional Development

Second Year students were less likely to be taught by a science teacher who had taken part in science-related CPD in the two years prior to TIMSS 2015 than students in other countries (Table 6.7). The majority of students in Ireland (57%) had a science teacher with less than 6 hours of recent science CPD (or none at all), compared to 34% of students internationally. At the other extreme, very few (5%) students in Ireland had a science teacher with more than 35 hours of recent science CPD, compared to more than one-fifth (22%) of students internationally. Teachers in several high-performing countries reported substantial amounts of recent subject-specific CPD (for example, 69% of students in the Russian Federation, 42% in the Republic of Korea, and 37% of students in Singapore had a teacher with more than 35 hours' recent CPD in science).

12 The associated tables are included in the accompanying e-appendix (www.erc.ie/timss).

Table 6.7: Percentage of students, by teachers' participation in recent science-related CPD					
	None	Less than 6 hours	6-15 hours	16-35 hours	More than 35 hours
IRL	31	26	27	12	5
TIMSS	17	17	25	18	22

Although not as low as at primary level (see Clerkin et al., 2017, for comparison), fewer Second Year students in Ireland than internationally had a science teacher with recent CPD for each of the specified areas of professional development (Table 6.8). CPD related to the science curriculum (28% of students), science assessment (26%), or addressing the needs of individual students (24%) were the least common in Ireland. Participation was slightly higher for CPD that addressed science content (42%) and pedagogy (38%). However, even here, the corresponding international averages were substantially higher (55% and 57%).

Table 6.8: Percentages of students, by teachers' participation in CPD related to specified aspects of science teaching							
	Content	Instruction	Curriculum	Integrating IT into science lessons	Assessment	Improving critical thinking	Addressing individuals' needs
IRL	42	38	28	36	26	34	24
TIMSS	55	57	49	50	44	45	42

Collaborative practices

Table 6.9 illustrates the extent to which informal collaborative practices featured as part of science teachers' regular professional activities. More than half of Second Year students had a science teacher who reported that they *often* or *very often* worked alongside other teachers in implementing the curriculum (61%), discussed how to teach particular topics with their colleagues (56%), or shared their teaching experiences with colleagues (55%). Students were somewhat less likely to have a science teacher who collaborated in planning or preparing instructional materials (48%). For each of these activities, levels of collaboration in Ireland were broadly similar to the international average.

In contrast, some collaborative practices were extremely rare in Ireland, both compared to other practices and compared to the international norms. Most notably, most Second Year students (71%) had a science teacher who *never or almost never* visited another classroom to observe a colleague teaching – much higher than the TIMSS average (27%). Thirty-four percent of students in Ireland were taught by a teacher who *never or almost never* worked with teachers from other grades to ensure continuity, while the corresponding TIMSS average was 17%. Almost one-fifth (18%) of Irish students' teachers *never or almost never* worked to try new ideas with their colleagues, while almost one-tenth (9%) had a teacher who *never or almost never* discussed the teaching of a given topic with another teacher. In both cases, the percentages reported in Ireland were approximately twice the corresponding TIMSS averages (9% and 4%, respectively).

Table 6.9: Percentage of students, by teachers' engagement in various collaborative practices

		Very often	Often	Sometimes	Never or almost never
Discuss how to teach a particular topic	IRL	23	33	35	9
	TIMSS	25	40	32	4
Collaborate in planning or preparing instructional materials	IRL	20	28	44	7
	TIMSS	22	38	34	7
Share what I have learned about my teaching experiences	IRL	21	34	34	11
	TIMSS	23	43	30	4
Visit another classroom to learn more about teaching	IRL	4	4	21	71
	TIMSS	9	21	44	27
Work together to try out new ideas	IRL	9	23	51	18
	TIMSS	16	34	41	9
Work as a group to implement the curriculum	IRL	24	37	30	9
	TIMSS	21	36	34	10
Work with teachers from other grades to ensure continuity in learning	IRL	11	19	37	34
	TIMSS	15	31	37	17

As with mathematics, there is much variation among our comparison countries in terms of the frequency of engagement in collaborative practices. For example, collaboration in planning and preparing instructional materials was a regular practice among science teachers in the Republic of Korea (74% of students had teachers that did so *often* or *very often*) and Australia (71%), but considerably less so in Slovenia (42%) and Hong Kong (44%). Just 11% of students in Slovenia had science teachers that visited another classroom to learn more about teaching *often* or *very often*, which is a similar percentage to that found in Ireland (8%) but substantially lower than in the Russian Federation (45%).

Chapter 7: Teachers' views of the working environment

In this chapter, some more general (not subject-specific) facets of teachers' experiences teaching Second Year students are described, including the challenges of teaching, the broader school environment, and teachers' career satisfaction. Because the responses of Second Year mathematics and science teachers to these questions were generally similar, the responses of mathematics teachers are provided as a default and any notable differences arising from science teachers' responses are discussed in text. A full tabulation of science teachers' responses is provided in the accompanying e-appendix (see www.erc.ie/timss).

Challenges

Teachers were presented with a list of potential challenges that they might face in the classroom (e.g., disruptive students) and were asked to indicate the extent to which each limited their ability to teach their classes. In Ireland, 91% of students were in mathematics classes where teachers felt limited *to some extent* or *a lot* by students' lacking prerequisite knowledge or skills, which is similar to the average across TIMSS countries (Table 7.1). This was, by some margin, the biggest limiting factor out of the options given (as judged by the percentage endorsing *a lot* as the most extreme limitation).[13] High proportions of students had teachers who also reported difficulties with teaching due to a lack of interest (Ireland: 78% vs TIMSS average: 85%) or resulting from students coming to class without having had enough sleep (Ireland: 66% vs TIMSS average: 69%).

Close to half of students (46%) in Ireland were in a class where the teachers reported challenges in relation to students' disruptive behaviour, compared to 72% internationally. Relatively fewer students had a teacher who reported that students suffered from a lack of (or poor) nutrition (Ireland: 21% vs TIMSS average: 43%).

These responses were used to calculate an overall measure of the extent to which teachers felt that their ability to teach was limited by the challenges listed in Table 7.1. The teachers of 41% of Second Year students felt *not limited* by these issues as a whole, compared to 27% of students at the TIMSS average. Just over half of Second Year students (53%) had teachers who reported being *somewhat limited* in their teaching, somewhat lower than the corresponding 62% of students internationally. Finally, 6% of Second Year students were taught by teachers who reported that their teaching was *very limited* by students being disruptive, uninterested, etc. This was about half of the corresponding TIMSS average (11%).

13 On the other hand, 'uninterested students' was the most common limiting factor reported by science teachers in Ireland, with 83% indicating that this issue limited their ability to teach a lot or to some extent.

Table 7.1: Percentage of students, by mathematics teachers' reports of issues limiting their ability to teach their class

		A lot	To some extent	Not at all
Disruptive students	IRL	12	34	54
	TIMSS	20	52	28
Uninterested students	IRL	14	64	22
	TIMSS	25	60	15
Students lacking prerequisite knowledge or skills	IRL	29	62	9
	TIMSS	33	57	11
Students with mental, emotional, or psychological impairments	IRL	4	43	53
	TIMSS	7	43	49
Students with physical disabilities	IRL	<1	7	93
	TIMSS	2	14	85
Students suffering from not enough sleep	IRL	7	59	34
	TIMSS	13	56	31
Students suffering from lack of basic nutrition	IRL	4	17	79
	TIMSS	8	35	57

Teachers also provided reports on a number of broader issues that could affect their ability to teach (e.g., overcrowded classrooms, having too much material to cover) (Table 7.2). Most students had mathematics teachers who *agreed a little* or *a lot* that they had too many students in their class (Ireland: 64% vs TIMSS: 65%), too much material to cover (85% vs 71%),[14] too many administrative tasks (61% vs 49%), and insufficient time for preparation (77% vs 65%). Nearly all students had mathematics teachers who felt that they did not have enough time to help individuals within the class (96% in Ireland and 90% on average across TIMSS countries).

Within Ireland, lesser challenges reported by teachers included feeling pressure from parents (34% of Second Year students vs 26% of students at the TIMSS average), having too many teaching hours (45% vs 46%), or keeping up with changes in the curriculum (50% vs 30%).[15]

14 For science, this was substantially lower in Ireland (66%, vs 71% internationally).
15 For science, this was also substantially lower (37%, vs 31% internationally).

Table 7.2: Percentage of students, by teachers' reports of work-related challenges					
		Agree a lot	Agree a little	Disagree a little	Disagree a lot
There are too many students in the classes	IRL	22	42	22	14
	TIMSS	30	35	21	14
I have too much material to cover in class	IRL	36	49	11	4
	TIMSS	28	43	23	6
I have too many teaching hours	IRL	13	32	35	20
	TIMSS	16	30	34	21
I need more time prepare for class	IRL	34	43	16	8
	TIMSS	23	42	24	10
I need more time to assist individual students	IRL	57	39	4	<1
	TIMSS	49	41	7	2
I feel too much pressure from parents	IRL	6	28	46	20
	TIMSS	5	21	45	29
I have difficulty keeping up with all the changes to the curriculum	IRL	8	42	33	18
	TIMSS	5	25	39	31
I have too many administrative tasks	IRL	23	38	25	13
	TIMSS	19	30	28	23

Teachers' views on these issues (having too many students, keeping up with curricular changes, etc.) were combined to create a broad indicator of the challenges that they face in their daily practice. On this composite measure, 36% of Second Year students were in a mathematics class where the teacher reported *few challenges* in their teaching. This was lower than the TIMSS average of 45%. Both in Ireland (53%) and internationally (49%), close to half of students had teachers who reported *some challenges* in teaching their classes. Finally, Second Year students were twice as likely as their international peers to have a mathematics teacher who reported having *many challenges* in their daily teaching (Ireland: 11% vs TIMSS: 5%).[16] Among our comparison countries, the latter figure ranged from 0% in the Russian Federation to 12% in England and 15% in the Republic of Korea.

Safe and orderly school environment

In addition to their own classroom experience, participating teachers were asked about the broader school environment in which they operate (and in which their students learn and experience school life). Their responses to eight questions were used to create an overall scale representing 'safe and orderly' schools. A positive point of note is that post-primary schools in Ireland were rated by teachers as providing the safest learning environment, on average, of any country that participated in TIMSS 2015.[17]

The majority (70%) of Second Year students attended schools that their teachers describe as *very safe and orderly*, with most of the remainder (26%) attending *safe and orderly* schools (Table 7.3). The corresponding international averages were both 46%. Nonetheless, about 4% of Irish students were in schools that were regarded as being *less than safe and orderly*. For comparison,

16 The equivalent figures for science teachers in Ireland were: 42% of students in classes where the teacher had *few challenges*, 50% in classes with *some challenges*, and 8% in classes with *many challenges* (TIMSS: 45%, 49%, 6%).
17 The scale was set to a mean of 10 (with a standard deviation of 2). The country with the lowest rating of safety was Botswana (8.3), while the highest was Ireland (11.6).

the equivalent figure was lower in Hong Kong (<1%) and Singapore (3%) but was somewhat higher in Australia (7%), New Zealand (8%), and the Republic of Korea (8%), and substantially higher in the United States (13%) and in Japan (14%). Almost one-quarter of students in South Africa, Morocco and Turkey, and one-third in Botswana, were in *less than safe and orderly* schools. In Ireland, the biggest issue for teachers was a perceived lack of respect from students for school property (seen as a problem to some degree by the teachers of 20% of students).

Both in Ireland and internationally, teachers' ratings of the school environment were strongly positively associated with student achievement (Table 7.3). For example, Second Year students attending *very safe and orderly* schools achieved a mean mathematics score of 534 (TIMSS: 493) and those attending *safe and orderly* schools scored 505 (TIMSS: 474), while the small number of students attending schools that were *less than safe and orderly* achieved a mean score of 452 (TIMSS: 453) on the mathematics assessment.[18]

Table 7.3: Percentage of students and mean mathematics achievement, by teachers' reports of the safety of the school environment

	Very safe and orderly		Safe and orderly		Less than safe and orderly	
	%	Maths	%	Maths	%	Maths
Australia	60	523	33	492	7	445
England	50	527	44	514	6	461
Hong Kong SAR	56	606	43	580	<1	--
Ireland	70	534	26	505	4	452
New Zealand	50	507	42	479	8	482
Rep. of Korea	27	613	64	604	8	598
Russian Fed.	57	545	42	528	2	--
Singapore	59	629	38	609	3	586
Slovenia	19	527	71	515	10	512
United States	46	538	41	507	13	482
TIMSS	46	493	46	474	8	453

-- indicates that the percentage of students in this category is too small to give a reliable estimate of achievement.

Emphasis on academic success

Schools in Ireland were also found to place a high emphasis on the academic success of their students by comparison to many other countries (Table 7.4).[19] According to mathematics teachers' reports, 12% of Second Year students attended schools with a *very high* emphasis on academic success (compared to 5% internationally), while 61% attended a school with a *high* emphasis (46% internationally). About one-quarter of students in Ireland (27%) were in a school that was categorised as having only a *medium* emphasis on academic success, compared to one-half of students (49%) across all TIMSS countries. Fewer than 1% of students in the Russian Federation and Slovenia had teachers who reported a very high emphasis on academic success.

18 For science, the corresponding figures in Ireland were: 64% of students in *very safe and orderly* schools (mean science achievement: 544), 32% in *safe and orderly* schools (514), and 4% in *less than safe and orderly schools* (475).

19 'Emphasis on academic success' was considered to encompass wide-ranging features of the school such as teachers' understanding of the school's curricular goals; teachers' expectations for student achievement; teachers' ability to inspire students; parents' support for student achievement; parental pressure for the school to maintain high academic standards; and students' respect for classmates who excel in school.

Although this measure was significantly related to student achievement at the international average, there was little difference in the mean scores of students in Ireland who attended schools with *very high* (538 for mathematics) or *high* (535) emphasis on academic success. However, the mean score among Second Year students in schools with a *medium* emphasis on academic success was lower (490).[20]

Table 7.4: Percentage of students and mean mathematics achievement, by teachers' reports of their schools' emphasis on academic success

	Very high emphasis		High emphasis		Medium emphasis	
	%	Maths	%	Maths	%	Maths
Australia	8	543	48	523	44	484
England	9	568	54	528	37	487
Hong Kong SAR	1	--	40	626	59	572
Ireland	12	538	61	535	27	490
New Zealand	4	531	59	500	37	478
Rep. of Korea	16	620	57	611	27	587
Russian Fed.	<1	--	35	552	64	529
Singapore	4	643	49	639	47	598
Slovenia	<1	--	42	519	58	514
United States	6	558	39	537	55	501
TIMSS	5	515	46	495	49	464

-- indicates that the percentage of students in this category is too small to give a reliable estimate of achievement.

20 The equivalent figures reported by Second Year science teachers are: 11% of students in schools with *very high emphasis* on academic success (mean science achievement: 546), 63% in schools with *high emphasis* (541), and 26% in schools with *medium emphasis* (504).

Career satisfaction

Table 7.5 presents mathematics teachers' responses to a series of questions regarding their career satisfaction. In general, most Second Year students had a mathematics teacher who expressed high levels of satisfaction with their profession, both in the abstract and in their own circumstances (i.e., in their school).

Table 7.5: Percentage of students, by teachers' satisfaction with various aspects of being a teacher

		Very often	Often	Sometimes	Never or almost never
I am content with my profession as a teacher	IRL	61	31	8	<1
	TIMSS	49	39	11	1
I am satisfied with being a teacher at this school	IRL	64	26	9	<1
	TIMSS	47	38	13	2
I find my work full of meaning and purpose	IRL	51	37	11	<1
	TIMSS	57	35	8	<1
I am enthusiastic about my job	IRL	64	30	6	<1
	TIMSS	53	38	8	<1
My work inspires me	IRL	48	37	13	2
	TIMSS	46	40	13	1
I am proud of the work I do	IRL	66	29	5	<1
	TIMSS	58	33	9	<1
I am going to continue teaching for as long as I can	IRL	59	26	11	3
	TIMSS	50	32	13	5

These responses were used to calculate an overall measure of job satisfaction, shown in Table 7.6. The results of this composite measure indicate that the vast majority of students in Ireland have mathematics teachers who are *very satisfied* (58%) or *satisfied* (36%) in their jobs. Only 6% of Second Year students have a teacher who is *less than satisfied* at work. Teachers in Ireland reported more positive views of their profession than the TIMSS average, and also more positive views than those found in any of our comparison countries. For example, much fewer students whose teachers who were *very satisfied* in their careers were found in England (29%), Hong Kong (31%), and Singapore (31%).

Although few students in Ireland had *less than satisfied* teachers, this small percentage is nonetheless worthy of attention, for two reasons. First, from a teacher's perspective, ongoing dissatisfaction at work could be regarded as indicating a stressful or demotivating environment that increases the risk of burnout, possibly leading to leaving the teaching profession earlier than might otherwise be intended (as well as having a shorter-term negative impact on general wellbeing). Second, student achievement was generally positively associated with their teachers' job satisfaction, both in Ireland and in many other countries. In Ireland, teachers' satisfaction was more clearly related to mathematics achievement (where a linear relationship was observed) than for science.[21]

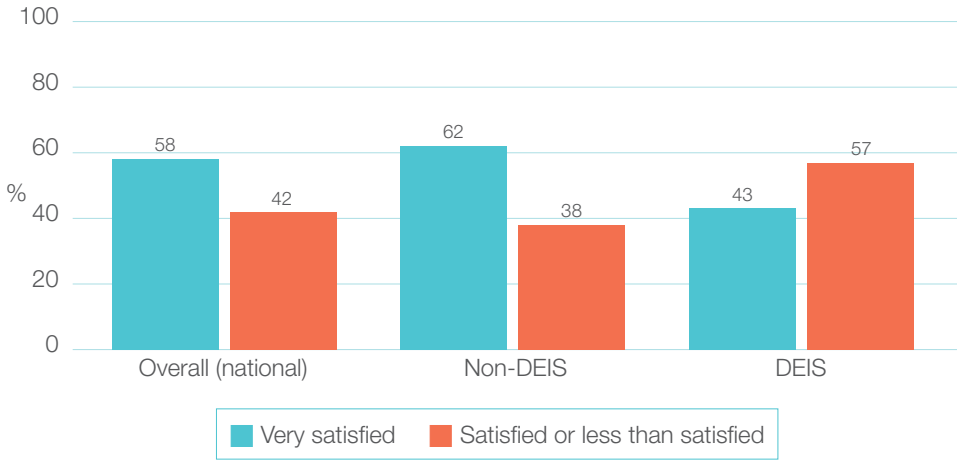
21 For science, 55% of students were taught by *very satisfied* science teachers (mean science achievement: 539), 37% taught by *satisfied* teachers (521), and 8% taught by *less than satisfied* teachers (532). The corresponding international averages were 49% (492), 42% (483), and 9% (478), respectively.

Table 7.6: Percentage of students and mean mathematics achievement, by teachers' overall career satisfaction

	Very satisfied		Satisfied		Less than satisfied	
	%	Maths	%	Maths	%	Maths
Australia	50	514	39	504	11	496
England	29	523	57	517	14	505
Hong Kong SAR	31	612	60	587	10	562
Ireland	58	532	36	514	6	498
New Zealand	43	494	47	497	10	472
Rep. of Korea	38	604	53	606	10	609
Russian Fed.	39	548	55	535	6	502
Singapore	31	631	56	616	14	612
Slovenia	40	517	55	516	5	521
United States	44	520	42	516	14	518
TIMSS	50	486	43	478	7	480

There was some variation in teachers' career satisfaction in more disadvantaged schools (Figure 7.1). Although the overall national figures show that the majority of Second Year students have a mathematics teacher who reported being *very satisfied* with their career, such high levels of satisfaction were more common in non-DEIS schools (62%) than in DEIS schools (43%).

Figure 7.1: Percentage of students, by mathematics teachers' career satisfaction, by DEIS status



Chapter 8: Discussion

This chapter draws together the main findings relating to the teaching of mathematics and science in Second Year classrooms. Six broad themes are identified: the qualifications of mathematics and science teachers; instructional time in mathematics and science; the use of ICT in lessons; continuing professional development and collaborative practices of teachers in Ireland; and some general findings on the teaching of mathematics, and science, in Ireland.

The achievement results from TIMSS 2015 indicate that the performance of students in Ireland in mathematics and science is relatively high by international standards. Only six of 39 countries obtained significantly higher mean scores than Ireland in mathematics, while seven countries significantly outperformed Ireland in science. Significant improvements since 1995, the last time Ireland participated in TIMSS at Second Year, were observed for science, although not for mathematics.

Qualifications

In recent years, out-of-field teaching has been a cause for concern in the areas of mathematics and science. Findings from TIMSS 2015 indicate that, relative to the TIMSS average, a large percentage of students in Ireland were taught mathematics and science by teachers with a postgraduate qualification. However, about one-fifth of students in Ireland were taught mathematics by a teacher whose main area of study was something other than mathematics or mathematics education, compared to 13% on average across TIMSS countries. This is considerably larger than the corresponding proportions in some of the highest-achieving countries, such as Singapore, the Republic of Korea and the Russian Federation (although not Hong Kong, a country that also had significantly higher mean mathematics performance than Ireland).

A definition of *main or major areas of study* was not given as part of the questionnaires in TIMSS (an issue that will apply in all countries) and therefore a direct comparison with the Teaching Council's requirement for teaching mathematics is not possible. However, it is likely that a teacher who had not studied mathematics or mathematics education as a major part of their third level education would not meet the Teaching Council's requirements (with the caveat that the extent to which respondents considered participation in the Professional Diploma in Mathematics for Teaching when completing the questionnaire is not clear). Nevertheless, the proportion of 'out-of-field' mathematics teachers in Ireland is considerable, although it appears to have decreased since Ní Ríordáin and Hannigan's (2009) study.

For science, many more students in Ireland had teachers who studied biology or chemistry as a main area than on average across TIMSS countries, while fewer had teachers who reported physics or Earth science as a main area of study. Only one-quarter of Second Year students had a science teacher who had studied physics as a main area of study. These findings are in line with the conclusions from Childs (2014) and the STEM Education Review Group (2016), who have argued that this imbalance in the proportions of teachers qualified in different areas of science is an issue that should be addressed urgently.

Instructional time

The Department of Education and Skills' *National Strategy to Improve Literacy and Numeracy* specified that the time devoted to mathematics teaching be increased to a minimum of five periods per week (DES, 2011). Despite this, Ireland remains one of the TIMSS countries with the lowest amount of instructional time devoted to mathematics, both in terms of the absolute number of hours and as a proportion of overall instructional time. Second Year students in Ireland received 109 hours of mathematics teaching over the course of the year, representing about 11% of total instructional time, considerably short of the 138 hours (14% of instructional time) on average across TIMSS countries.

There is not a direct relationship between instructional time and achievement, and while many of the highest-performing countries devoted more instructional time to mathematics than in Ireland, not all did. For example, 106 hours (10% of instructional time) is devoted to mathematics in Japan, a country with significantly higher performance than Ireland, while the United States has similar mean mathematics performance to Ireland but students receive 155 hours (14% of instructional time) per year. It should be noted that these figures (reported by teachers in relation to their classroom teaching) do not take account of additional lessons or tutoring that is not provided by the school, which students in Ireland have been found to engage in less frequently than students in many other TIMSS countries (Eivers & Chubb, 2017).

At 90 hours per annum, instructional time for science in Ireland was lower than for mathematics, among the lowest of all countries that participated in TIMSS, and considerably lower than the TIMSS average (144 hours). Further, these data were collected prior to the implementation of the new science curriculum, one outcome of which will be that minimum science instruction will be reduced from 240 hours to 200 hours over three years (i.e., from an average annual minimum of 80 hours to 67 hours). It is noteworthy that Fourth Class pupils in Ireland were reported to receive less time on science instruction than pupils in any other country in TIMSS 2015 at primary level (Clerkin et al., 2017). If the new minimum guidelines for junior cycle science influence practice, Second Year students are also likely – based on current comparisons – to receive the least time for science instruction of any country at Eighth grade in future.

Use of ICT in lessons

Access to, and use of, computers or tablets in mathematics and science lessons in Ireland was below the TIMSS average. About one-quarter of students in Ireland had access to a computer or tablet in their mathematics or science lessons, compared to a TIMSS average of about one-third of students for mathematics lessons and over two-fifths for science lessons. In Ireland, access to computers was typically shared across the school, with relatively few students having access to their own computer or tablet or a set of computers shared by the class. On the other hand, many more students in Ireland than internationally were taught by teachers who had attended CPD relating to integrating ICT into mathematics lessons.

Only about one-tenth of students in Ireland, compared to about one-fifth internationally, used a computer or tablet in mathematics classes for various activities, including exploring mathematics principles and concepts, practising skills and procedures, looking up ideas and information, and processing and analysing data. Use of computers for these activities in science lessons was also more common internationally than in Ireland, with approximately 30% of students doing so at least monthly, compared to only about 10% in Ireland. Looking up ideas and information was the most

common activity on a computer in science lessons in Ireland and internationally, while performing scientific procedures and experiments was much less frequent.

These findings are in line with findings from the 2013 ICT census (Cosgrove et al., 2014) and indicate that improvements in terms of both access to and use of ICT in the classroom are required in order for the goals of the *Digital Strategy for Schools* (DES, 2015b) to be fully realised.

Continuing Professional Development and collaborative practices

Mathematics teachers in Ireland reported high levels of continuing professional development (CPD), relative to their counterparts in many other countries, in the two years prior to the 2015 study. On the other hand, participation in CPD was found to be relatively low among science teachers in Ireland, whether by comparison to mathematics teachers in Ireland or to science teachers internationally.

While engagement in formal CPD was relatively high among Second Year mathematics (but not science) teachers, both mathematics and science teachers in Ireland engaged in professional collaborative practices with their colleagues to a lesser degree than their international counterparts. The only practice in which teachers in Ireland engaged to a greater extent than the TIMSS average was working as a group to implement the curriculum. In particular, mathematics and science teachers in Ireland were much less likely to visit another classroom to learn more about teaching or to work together to try out new ideas. The percentage of mathematics teachers who indicated that they work with teachers from other grades to ensure continuity was in line with the international average, but this was much less common among science teachers in Ireland.

It is possible that teachers in Ireland engage in collaborative practices to a lesser degree due to a heavy administrative burden. A greater percentage of students in Ireland than internationally were taught by mathematics and science teachers who indicated that they had too much material to cover (especially in mathematics), too many administrative tasks and insufficient time for preparation. Analysis of data from TALIS 2008 (Gilleece et al., 2009) found that, in Ireland, positive teacher-student relations were associated with the extent to which exchange and co-ordination for teaching takes place, and that greater co-operation between teachers should be encouraged in schools. This study also noted that there was scope to extend the amount and type of professional collaboration taking place in schools in Ireland, a finding that is also supported by TIMSS 2015 data.

The teaching of mathematics

Some findings relating to the teaching of mathematics in Ireland are highlighted for consideration in light of the recent review of mathematics at junior cycle. For example, teachers' self-reports indicate that students in Ireland were less likely to be asked to decide their own problem-solving procedures in mathematics lessons compared to the TIMSS average, but were more likely to be asked to complete challenging exercises that required them to go beyond their direct instruction. (However, note that the self-reported nature of these data means that they should be interpreted somewhat cautiously – for example, one teacher's judgement of a 'challenging exercise' might differ from a colleague's.)

Working on problems for which there was no immediately obvious solution was also more common internationally than in Ireland. On a related note, while teachers in Ireland reported high levels of confidence in various aspects of the teaching of mathematics, and Irish mathematics teachers' ratings of confidence were similar to the corresponding TIMSS averages across most

areas, it was slightly lower in relation to showing students a variety of problem-solving strategies. This is noteworthy, considering that development of problem-solving strategies is included as one of the Statements of Learning (SOL 17) in the new junior cycle (DES, 2015a). Given the relatively poorer performance of the highest-achieving students in Ireland compared to other countries with similar overall performance, engagement in tasks that support higher-order thinking could be promoted and may be an aspect of teaching that could receive greater attention in CPD for mathematics teachers.

Second Year students were taught by mathematics teachers who reported high levels of involvement in mathematics-related CPD in the two years prior to the survey, most likely due to the implementation of Project Maths. The percentages of students taught by teachers who received CPD in specific aspects of mathematics teaching was considerably higher in Ireland across all areas, with the exception of assessment and addressing individual students' needs. Assessment seems to be a particularly important area to address through CPD, given the broadening of the approach to assessment outlined in the *Framework for Junior Cycle* (DES, 2015a) and the finding from TIMSS 2015 that teachers in Ireland placed comparatively little emphasis on assessing students' work on an ongoing basis as a way of monitoring their progress. In addition, while the proportion of students in Ireland taught by mathematics teachers who reported many challenges in their teaching was low (11%), it was considerably higher than the international average (5%). Students' lacking prerequisite knowledge was identified by mathematics teachers in Ireland as a particular challenge limiting their teaching.

Students in Ireland were more likely than students internationally to have been taught Data and Chance topics by the end of Second Year, and were as likely to have been taught Number and Algebra topics. On the other hand, students in Ireland were considerably less likely to have covered Geometry items by the end of Second Year when compared to the TIMSS average. This is line with Ireland's relative underperformance on the Geometry subscale in TIMSS compared to other content areas (Clerkin et al., 2016), and also corresponds with Ireland's poorer performance on the Space and Shape subscale in PISA (Perkins, Shiel, Merriman, Cosgrove & Moran, 2013).

The teaching of science

As with mathematics, students in Ireland were less likely than average to be asked to decide their own problem-solving procedures, but more likely to be asked to complete challenging exercises that required them to go beyond their instruction. Also, while confidence with various aspects of science teaching was high among teachers in Ireland, it was lowest (although still higher than the corresponding international averages) for providing challenging tasks to high-achieving students and using inquiry methods to teach science. This indicates that engagement in tasks that support higher-order thinking should be promoted in science as well as mathematics, and may be considered as an aspect of teaching that could be addressed in future CPD in science.

Another finding from TIMSS 2015 was that the proportion of students in Ireland taught by science teachers who reported *many challenges* was lower than for mathematics, and was in line with the international average. Students' lack of interest was reported by science teachers as being one of the most common limiting factors they encountered in their teaching, with 83% of students having science teachers who indicated that this limited their teaching a lot or to some extent.

Scientific investigation was emphasised to a lesser degree in classrooms in Ireland than on average across TIMSS countries. However, this was also the case in many of the highest-performing countries such as Singapore, the Republic of Korea, Slovenia and the Russian Federation. While there was a positive association between use of active science investigation and performance on the

TIMSS assessment across most of the comparison countries included in this report, the association tended to be small.

As part of the TIMSS science teacher questionnaire, teachers were presented with a list of science topics from across the TIMSS content areas (Biology, Chemistry, Physics, Earth Science) and asked to indicate which had been mostly taught by the end of Second Year. Coverage of Chemistry topics was slightly higher in Ireland compared to the average across TIMSS countries, while coverage of Biology and Physics topics were slightly lower when compared to the international averages. On the other hand, coverage of Earth science topics was reported to be much lower by science teachers in Ireland than on average across TIMSS countries. Much of the TIMSS Earth science content is taught as part of the Geography syllabus in Ireland, which at least partly accounts for the relatively low coverage in science lessons. A similar situation may also arise in some other countries, although the extent to which this occurs is unclear.

Further reporting from TIMSS 2015

For a broader context on these findings, readers are referred to a sister volume to this report, which presents the corresponding findings for the teaching of mathematics and science at primary level (Clerkin et al., 2017). Eivers and Chubb (2017) provide a comparison of some system-level characteristics in Ireland and other TIMSS countries (e.g., structure of the curricula). Both reports are available to download from www.erc.ie/timss.

Other contextual factors relating to students' learning in mathematics and science, including students' attitudes and engagement in school and aspects of the home environment, will be explored in forthcoming reports.

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