9 The curriculum and learning activities

Chapter outline

This chapter presents findings from TIMSS 2015 relating to teaching practices and the curriculum in mathematics and science in Year 6 (Y6, ages 9-10), as reported by teachers, principals and National Research Co-ordinators (or their designated national contact). Within each subsection, findings for mathematics are presented first, followed by findings for science. Where relevant, outcomes for Northern Ireland are compared with international averages and comparator countries.

Key findings

- In Northern Ireland, teaching time for mathematics was higher than the international average, but, for science, teaching time was lower than the international average.
- A very small proportion of Y6 pupils in Northern Ireland were taught science by teachers who reported emphasising science investigation in at least half their science lessons. This proportion is considerably below the international average and is lower than in 2011. In a number of the highest performing countries, teachers tended to report emphasising science investigation to a greater extent than in Northern Ireland.
- Computers were available for the majority of Y6 pupils in their mathematics and science lessons. This was consistent with the findings from 2011.
- According to teachers' reports of topics taught in lessons, a higher proportion of Y6 pupils were taught the TIMSS mathematics topics than the TIMSS science topics. This was also the case on average internationally.

Interpreting the data: percentages in tables

Some of the data in this chapter is derived from teacher reports. Reported percentages refer to pupils and can usually be interpreted as the percentage of pupils whose teachers reported a particular practice or circumstance.

Year 6 (Y6) pupils were sampled by class. As a result, the Y6 teacher questionnaire would, in most cases, have been completed by the class teacher of the sampled class. However, in some cases, it might have been completed by different teachers who teach these pupils mathematics and / or science separately.

This means that the teacher-derived data for mathematics and science may differ slightly, as the sample of teachers in each group is not necessarily the same, or because the distribution of pupils within the sample of teachers may differ by subject.

9.1 Teaching time

Total teaching time[41] for both mathematics and science, as reported by principals and teachers, was calculated using the formula in Figure 9.1. These calculations enabled direct comparison of teaching time between countries participating in TIMSS 2015.

Figure 9.1 Formula for calculation of teaching time

$$\text{Total Instructional Hours per Year} = \text{Principal Reports of School Days per Year} \times \text{Principal Reports of Instructional Hours per Day}$$

$$\text{Hours per Year for Instruction in Mathematics/ Science} = \frac{\text{Teachers Reports of Weekly Mathematics/ Science Instructional Hours}}{\text{Principal Reports of School Days per Year}} \times \text{Principal Reports of School Days per Year}$$

Source: adapted from Exhibit 9.1 TIMSS international mathematics report (Mullis *et al.*, 2016a) and Exhibit 9.1 TIMSS international science report (Martin *et al.*, 2016a).

Data was collected on total teaching time for both mathematics and science. Overall teaching time was higher in Northern Ireland than the international average. Among the comparator countries, teaching time was higher than the international average in Australia, England, Hong Kong and Singapore, and below the average in Finland, Poland and the Republic of Ireland.

9.1.1 Teaching time for mathematics

Table 9.1 shows that the amount of time spent teaching mathematics to Y6 pupils in Northern Ireland was 215 hours per year, out of a possible 962 (total hours of teaching per year). This was higher than the international average (157 hours). Among comparator

[41] Teaching time is referred to as 'instructional time' in the international data and report.

countries, Northern Ireland had the highest number of hours per year dedicated to mathematics teaching. Since 2011, there has been a slight decrease (of 17 hours) in the number of hours spent teaching mathematics. Like the majority of countries participating in TIMSS 2015, in Northern Ireland, teaching time was higher for mathematics than for science in Y6.

9.1.2 Teaching time for science

Table 9.1 shows that, in Northern Ireland, the amount of time spent teaching science to Y6 pupils was 38 hours out of 962 (total hours of teaching per year). This was half the international average (76 hours). The standard errors suggest that it is likely that the amount of time dedicated to teaching science in Northern Ireland is statistically significantly below the international average. This is perhaps not surprising given the design of the Northern Ireland Curriculum where science is included within the 'World Around Us'.

Among comparator countries, teaching time for science was considerably higher in Singapore, Poland, Finland, England and Australia[42] (85, 84, 82, 61 and 57 hours respectively), as well as in most other high performing countries. The Republic of Ireland was the only comparator country where the amount of time dedicated to teaching science was lower than in Northern Ireland.

In Northern Ireland, the amount of time dedicated to teaching science annually in Y6 decreased considerably between 2011 and 2015, from 72 hours in 2011 to almost half of this in 2015. This is notable given that the curriculum in Northern Ireland has not changed between the two cycles of TIMSS.

Table 9.1 Teaching time in Y6

Mathematics

Country	Total Instructional Hours per Year	Hours per Year for Mathematics Instruction
Northern Ireland	r 962 (10.2)	s 215 (6.5)
International Avg.	894 (1.9)	157 (0.5)

( ) Standard errors appear in parentheses. Because of rounding some results may appear inconsistent.
An "r" indicates data are available for at least 70% but less than 85% of the pupils.

Science

Country	Total Instructional Hours per Year	Hours per Year for Science Instruction
Northern Ireland	r 962 (10.2)	s 38 (2.1)
International Avg.	887 (1.9)	76 (0.3)

( ) Standard errors appear in parentheses. Because of rounding some results may appear inconsistent.
An "r" indicates data are available for at least 70% but less than 85% of the pupils.

Source: Exhibit 9.1 International mathematics report (Mullis *et al.*, 2016a), Exhibit 9.1 International science report (Martin *et al.*, 2016a).

[42] Comparisons cannot be made with Hong Kong as data are available for less that 50 per cent of pupils.

9.2 Teachers' emphasis on science investigation in Y6

Interpreting the data: indices and scales

In order to summarise data from a questionnaire, responses to several related items are sometimes combined to form an index or scale. The respondents to the questionnaire items are grouped according to their responses and the way in which responses have been categorised is shown for each index or scale. The data in an index or scale is often considered to be more reliable and valid than the responses to individual items.

Teachers' emphasis on science investigation is measured by their responses to eight statements about teaching science (these statements can be seen below in Figure 9.2). The international analysis used responses to these statements to create the 'Emphasize Science Investigation' scale[43]. Pupils were categorised into two bands: those whose teachers emphasise science investigation in 'About Half the Lessons or More' and those whose teachers emphasise science investigation in 'Less than Half the Lessons'. (Details of how pupils were assigned to each band are provided above Table 9.2).

Table 9.2 shows that 3 per cent of Y6 pupils in Northern Ireland were taught by teachers who emphasised science investigation in 'About Half the Lessons or More'. This was considerably below the international average (27 per cent) and was the joint lowest percentage among all participating countries in TIMSS 2015, along with the Netherlands. All seven comparator countries had a higher proportion of pupils in classes where teachers emphasised science investigation in 'About Half the Lessons or More'. Among these countries, emphasis on scientific investigation was most prevalent in the high performer Singapore, where 34 per cent of pupils were in classes taught by teachers where emphasis was placed on science investigation in 'About Half the Lessons or More'. In contrast, another high performing country, Hong Kong, had only 10 per cent of pupils in classes taught by teachers which had this level of emphasis on science investigation.

There was a 10 per cent reduction between 2011[44] and 2015 in the percentage of pupils in Northern Ireland taught by teachers who emphasise science investigation in 'About Half the Lessons or More'. This was consistent with the international trend. The international average for the percentage of pupils taught by teachers who emphasised science investigation in 'About Half the Lessons or More' decreased by 13 per cent between 2011 and 2015, from 40 per cent in 2011 to 27 per cent in 2015. However, caution needs to be exercised in making direct comparisons between the 2011 and 2015 results as the scales used are not exactly the same.

[43] The scale is labelled as such in the international report; hence American spelling may be used in such scale labels in this report.

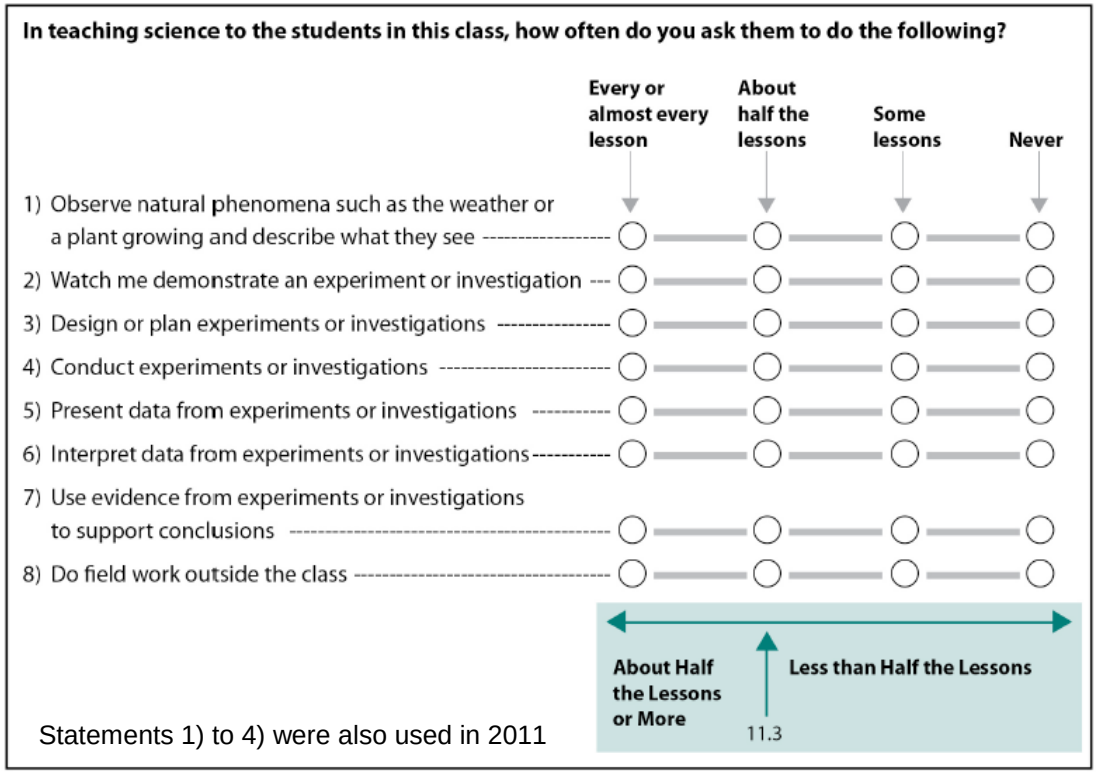
[44] The scale has changed between the 2011 and 2015 survey. In 2011, six statements contributed to the scale. In 2015, eight statements contributed. Four of the statements on the scale were common to both 2011 and 2015.

There are no clear associations between teachers' emphasis on science investigation and pupils' average achievement in Northern Ireland or in most of the main comparator countries. In 29 of the countries participating in TIMSS 2015, average achievement was higher for pupils where science investigation was emphasised in 'About Half the Lessons or More', whereas in 17 countries the opposite was true, with average achievement being higher for pupils where science investigation was emphasised in 'Less than Half the Lessons'.

The standard errors on the international averages suggest that the differences in achievement between pupils in classes where the teacher emphasised science investigation in 'About Half the Lessons or More' are likely to be significantly higher than those where the teacher emphasised science investigation in 'Less than Half of Lessons'.

Among pupils in Northern Ireland whose teachers emphasised science investigation in 'About Half the Lessons or More', average achievement appears to have been lower than among those for whom it was emphasised in 'Less Than Half the Lessons'. However, this difference is unlikely to be significant.[45] This mirrors the findings from 2011. With the exception of the Republic of Ireland, differences in average achievement between the equivalent categories of pupils in comparator countries are also unlikely to be significant.

Figure 9.2 Schools' emphasis on scientific investigation – questions for teachers



Source: Adapted from Exhibit 9.5 International science report (Martin *et al.*, 2016a).

[45] Differences in achievement between groups have not been tested formally for statistical significance in the international analysis, but the sizes of the standard errors in the national data suggest that this apparent difference between groups would not be statistically significant.

Table 9.2 Teachers' emphasis on science investigation in Y6

Students were scored according to their teachers' responses to how often they used each of eight instructional activities on the *Emphasize Science Investigation* scale. Students with teachers who emphasized science investigation in **About Half the Lessons or More** had a score on the scale of at least 11.3, which corresponds to their teachers using all eight activities in "about half the lessons," on average. All other students had teachers who emphasized science investigation in **Less than Half the Lessons**.

Country	About Half the Lessons or More		Less than Half the Lessons		Average Scale Score
	Percent of Students	Average Achievement	Percent of Students	Average Achievement	
Northern Ireland r	3 (0.7)	504 (12.0)	97 (0.7)	521 (2.2)	8.5 (0.13)
International Avg.	27 (0.4)	508 (1.1)	73 (0.4)	505 (0.7)	

This TIMSS questionnaire scale was established in 2015 based on the combined response distribution of all countries that participated in TIMSS 2015. To provide a point of reference for country comparisons, the scale centerpoint of 10 was located at the mean of the combined distribution. The units of the scale were chosen so that 2 scale points corresponded to the standard deviation of the distribution.

( ) Standard errors appear in parentheses. Because of rounding some results may appear inconsistent.

An "r" indicates data are available for at least 70% but less than 85% of the pupils.

Source: Exhibit 9.5 International science report (Martin *et al.*, 2016a) and adapted from the international version of the TIMSS Teacher Questionnaire.[46]

9.3 Use of computers

Teachers were asked whether computers were available during mathematics and science lessons. They were also asked about the frequency of their use for different subject-specific, computer-based activities. Table 9.3 summarises this information, giving the results for Northern Ireland and the international average.

9.3.1 Use of computers in Y6 mathematics lessons

Table 9.3 shows that, in Northern Ireland, 71 per cent of pupils participating in TIMSS 2015 were taught by teachers who reported that computers were available for use in mathematics lessons; this is almost double the international average (37 per cent). Only three countries participating in TIMSS in 2015 (New Zealand, Denmark and the Netherlands) had higher computer availability in mathematics lessons. The high availability of computers in mathematics lessons in Northern Ireland was consistent with the 2011 results, where 76 per cent of Y6 pupils had access to computers.

Internationally, there was no clear link between higher computer availability and higher mathematics performance. For example in Singapore, the highest performing country in mathematics, computer availability was the same as the international average (37 per cent). In Northern Ireland, there is no statistically significant difference between the average achievement of those pupils who have access to a computer in mathematics lessons (573 scale points) and those which do not (572 scale points). The relationship between computer availability and average attainment is complex; as a result, achievement data in this area should be interpreted with caution. For example, in some cases, computers might be made available to high-achieving pupils in order to challenge them and stretch their skills. In other cases, they might be made available to lower-achieving pupils for drill and practice.

[46] http://timssandpirls.bc.edu

In Northern Ireland, as was the case in 2011, in instances where pupils did have access to computers for their mathematics lessons, they were most commonly used to practice skills and procedures. This was also the case in all seven comparator countries. In Northern Ireland, computers were used in mathematics lessons to a similar extent to explore mathematical principles and concepts, and to look up Ideas and information. This mirrors the 2011 findings.

9.3.2 Use of computers in Y6 science lessons

Table 9.3 shows that, in Northern Ireland, 76 per cent of Y6 pupils were taught by teachers who reported that computers were available for use in science lessons, 30 percentage points above the international average. As was the case for mathematics, computer availability for science in Northern Ireland was higher than in all other comparator countries, where there was considerable variation, ranging from 42 per cent in the Republic of Ireland to 71 per cent in England.

In many countries participating in TIMSS 2015, computer availability was higher for science lessons than for mathematics lessons; the international average was 9 per cent higher for science than for mathematics. In Northern Ireland and internationally, there was no clear association between science achievement and computer availability in science lessons. For example, computer availability was particularly low in Korea, the second highest performing country in science, with only 22 per cent of pupils taught by teachers who reported that computers were available for science lessons (below the international average).

In Northern Ireland, where pupils did have access to computers for science lessons, they were mainly used to look up ideas and information. This was the case across the majority of participating countries and mirrors the findings from 2011.

The use of computers in Y6 science lessons has remained stable between 2011 and 2015, with the percentage of pupils that have computers available to use in science lessons decreasing by only 2 per cent between 2011 and 2015. This slight reduction in computer availability in science lessons in Northern Ireland between 2011 and 2015 was also reflected internationally.

Table 9.3 Use of computers in Y6 lessons

Mathematics

Country	Computers Available for Students to Use in Mathematics Lessons			Percent of Students Whose Teachers Have Them Use Computers at Least Monthly		
	Percent of Students	Average Achievement				
	Yes	Yes	No	To Explore Mathematics Principles and Concepts	To Practice Skills and Procedures	To Look Up Ideas and Information
Northern Ireland	r 71 (3.8)	573 (4.1)	572 (5.1)	r 58 (3.9)	r 68 (3.8)	r 58 (5.0)
International Avg.	37 (0.5)	510 (1.0)	504 (0.6)	26 (0.4)	33 (0.4)	27 (0.4)

( ) Standard errors appear in parentheses. Because of rounding some results may appear inconsistent.
An "r" indicates data are available for at least 70% but less than 85% of the pupils.

Science

Country	Computers Available for Students to Use in Science Lessons			Percent of Students Whose Teachers Have Them Use Computers at Least Monthly			
	Percent of Students	Average Achievement					
	Yes	Yes	No	To Practice Skills and Procedures	To Look Up Ideas and Information	To Do Scientific Procedures or Experiments	To Study Natural Phenomena Through Simulations
Northern Ireland	r 76 (3.9)	523 (2.8)	516 (5.7)	r 37 (4.5)	r 69 (4.2)	r 23 (4.5)	r 39 (4.8)
International Avg.	46 (0.5)	509 (0.9)	504 (0.7)	31 (0.5)	41 (0.5)	26 (0.5)	28 (0.5)

( ) Standard errors appear in parentheses. Because of rounding some results may appear inconsistent.
An "r" indicates data are available for at least 70% but less than 85% of the pupils.

Source: Exhibit 9.5 international TIMSS mathematics report (Mullis *et al.*, 2016a), Exhibit 9.9, international TIMSS science report (Martin *et al.*, 2016a).

9.4 The Y6 mathematics and science curriculum

The TIMSS mathematics and science Assessment Frameworks (Mullis and Martin, 2013) are not designed to exactly match the curriculum of any one participating country.

In the Teacher Questionnaire, teachers were asked to indicate whether each of the TIMSS 2015 topics was 'mostly taught before this year', 'mostly taught this year', or 'not yet taught or just introduced' (see Figures 9.3 and 9.4 for further details). Table 9.4 shows the percentage of pupils whose teachers reported that they had been taught the topics either prior to or during the year of the assessment, averaged across topics, and presented both as an overall percentage and according to content domain.

9.4.1 The Y6 mathematics curriculum

Figure 9.3 TIMSS mathematics topics taught – questions for teachers

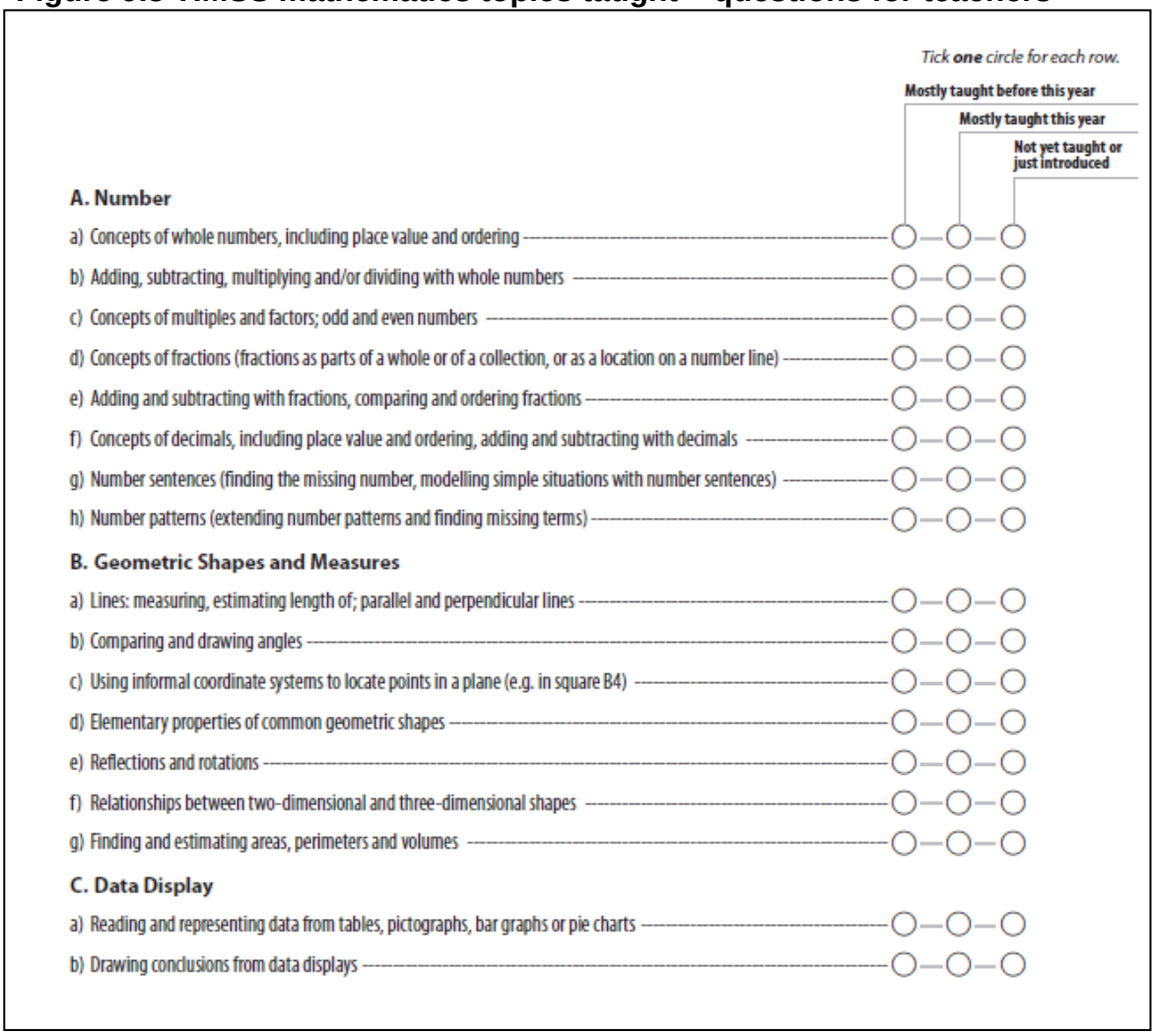


Table 9.4 shows that 92 per cent of pupils in Northern Ireland were taught the TIMSS mathematics topics either before or during the year of the TIMSS assessment. This percentage was second only to Portugal and 16 percentage points above the international average. This has remained stable between 2011 and 2015.

There was a mixed picture internationally in terms of the content domains that were most commonly taught to pupils. The most commonly taught domains in Northern Ireland were Number (97 per cent) and Data Display (94 per cent), as was the case in 2011. On average internationally, topics from these two content domains were most commonly taught (83 per cent taught Number topics and 78 per cent taught Data Display topics), while Geometric Shapes and Measures topics were less commonly taught both internationally and in Northern Ireland.

Looking across the comparator countries, in Singapore, as in Northern Ireland, Number and Data Display topics were the most commonly taught (100 per cent and 95 per cent of pupils respectively), whereas in Australia and the Republic of Ireland, Data Display topics were more commonly taught than the Number topics. It is, however, important to note that there

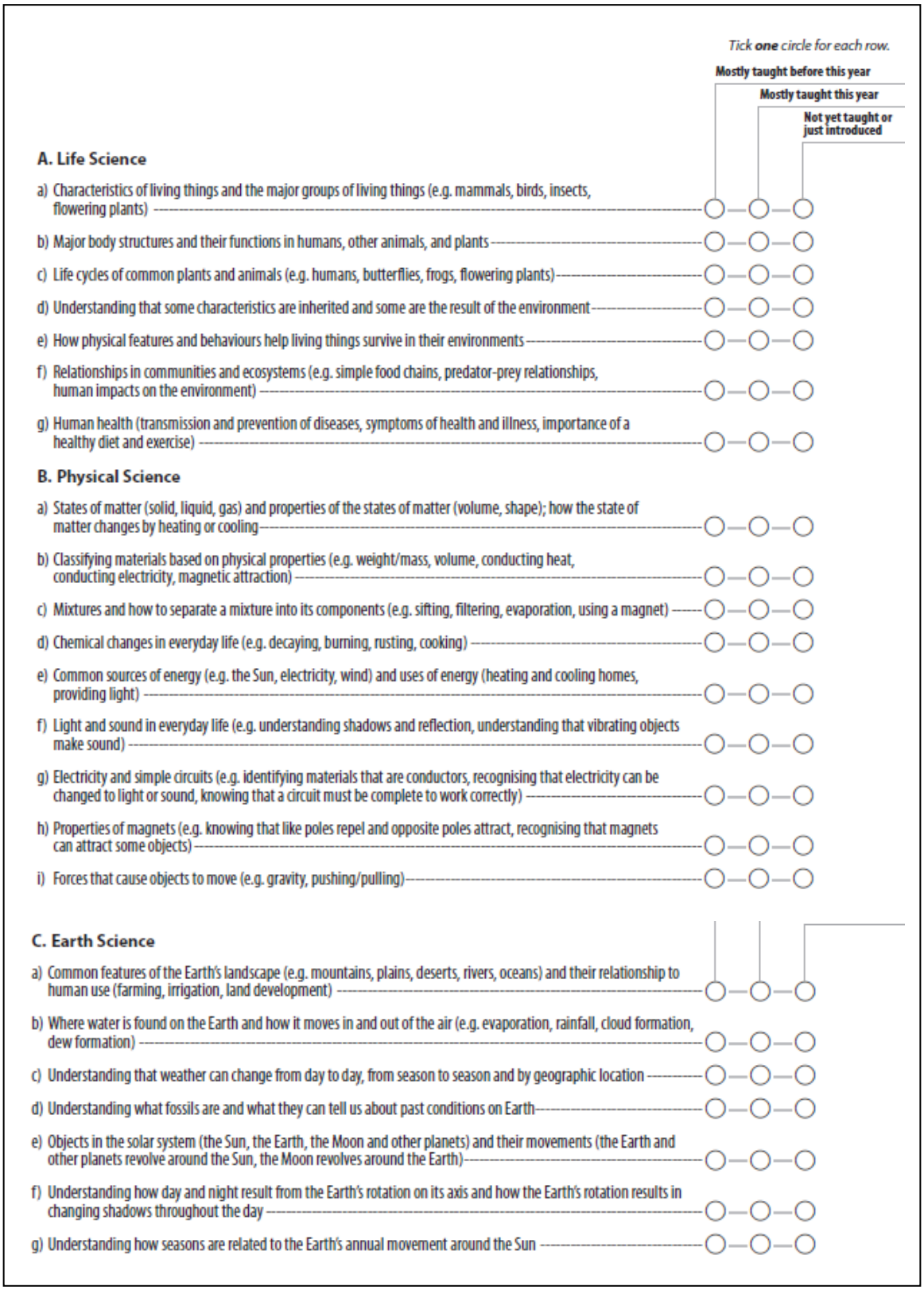
are only two topics in the TIMSS Data Display content domain, compared with eight topics for Number. In Northern Ireland, Australia and England a higher proportion of pupils were taught Geometric Shapes and Measures topics than in Finland, Hong Kong, Poland, the Republic of Ireland and Singapore.

9.4.2 The Y6 science curriculum

Table 9.4 shows that 61 per cent of pupils in Northern Ireland were taught the TIMSS science topics either before or during the year of the TIMSS assessment. This percentage remains unchanged from the 2011 TIMSS survey and was below the international average for 2015 of 65 per cent. Fewer pupils were taught the TIMSS science topics than the TIMSS mathematics topics both in Northern Ireland and on average internationally.

Among the comparator countries, the percentage of pupils taught the TIMSS science topics was lower in Finland, Hong Kong, Singapore and Poland than in Northern Ireland. However, the percentage was higher in England and the Republic of Ireland (73 per cent and 75 per cent respectively). The most commonly taught content domain in Northern Ireland was Life Science (73 per cent); this was the same in all the comparator countries other than England and Singapore, where the most commonly taught domain was Physical Science.

Figure 9.4 TIMSS science topics taught – questions for teachers



Source: Y6 Northern Ireland version of Teacher Questionnaire.

Table 9.4 Percentage of students taught the TIMSS mathematics and science topics

Mathematics

Country	All Mathematics (17 topics)	Number (8 topics)	Geometric Shapes and Measures (7 topics)	Data Display (2 topics)
Australia	87 (1.0)	89 (0.9)	83 (1.4)	93 (1.6)
England	89 (1.2)	95 (0.8)	85 (1.9)	80 (3.0)
Finland	76 (1.0)	89 (0.9)	58 (2.1)	85 (2.2)
Hong Kong SAR	85 (0.9)	94 (0.8)	71 (1.5)	93 (2.1)
Ireland,Rep. of	81 (1.0)	92 (0.8)	66 (1.7)	94 (1.9)
Northern Ireland	r 92 (0.9)	r 97 (0.6)	r 85 (1.7)	r 94 (2.7)
Poland	58 (1.3)	71 (1.4)	46 (1.4)	47 (3.7)
Singapore	85 (0.5)	100 (0.1)	66 (1.1)	95 (1.0)

* Percentage mostly taught before or in the assessment year averaged across topics.
( ) Standard errors appear in parentheses. Because of rounding some results may appear inconsistent.
An "r" indicates data are available for at least 70% but less than 85% of the students.

Science

Country	All Science (23 topics)	Life Science (7 topics)	Physical Science (9 topics)	Earth Science (7 topics)
Australia	61 (1.4)	72 (1.6)	52 (2.0)	62 (2.3)
England	r 73 (2.0)	r 67 (2.5)	r 78 (2.2)	r 72 (2.7)
Finland	60 (1.4)	72 (1.4)	48 (2.2)	64 (1.7)
Hong Kong SAR	52 (1.6)	67 (2.1)	45 (2.2)	47 (2.4)
Ireland, Rep. of	75 (1.3)	78 (1.6)	74 (1.4)	74 (2.3)
Northern Ireland	r 61 (1.9)	r 73 (2.6)	r 50 (2.9)	r 64 (2.5)
Poland	33 (0.9)	53 (1.7)	16 (1.2)	37 (1.4)
Singapore	40 (0.6)	52 (0.9)	58 (0.8)	6 (0.8)

* Percentage mostly taught before or in the assessment year averaged across topics.
( ) Standard errors appear in parentheses. Because of rounding some results may appear inconsistent.
An "r" indicates data are available for at least 70% but less than 85% of the students.

Source: Exhibit 9.3, international Mathematics report (Mullis *et al.*, 2016a), Exhibit 9.3 international science report (Martin *et al.*, 2016a).

9.5 Conclusion

Teachers and principals were asked a range of questions relating to learning activities and the curriculum in Y6 mathematics and science lessons. This included total teaching time and use of computers for both subjects. For science, teachers were asked about the extent to which they emphasised science investigation. For both mathematics and science, to assess the degree of correspondence between participants' curricula and the TIMSS Assessment Frameworks (Mullis and Martin, 2013), teachers reported on whether the TIMSS topics were covered in lessons, according to content domain.

In Northern Ireland, although teaching time for mathematics was higher than the international average, teaching time for science was lower than the international average.

In Northern Ireland, a very small proportion (3 per cent) of Y6 pupils were taught science by teachers who emphasise science investigation in at least half of their science lessons. This proportion was considerably lower than the international average (27 per cent) and the joint lowest internationally. In some (but not all) of the highest performing countries, science investigation was emphasised to a greater extent. However, there was no clear association between emphasis on science investigation and average achievement within countries.

There was a high level of computer availability for both mathematics and science lessons in Y6 in Northern Ireland. A slightly higher proportion of pupils had access to computers in science lessons compared with mathematics lessons. This trend was consistent with the picture internationally. No clear patterns emerged relating computer availability to average achievement in either subject. This was the case on average internationally and in Northern Ireland.

According to teachers' reports of topics taught in lessons, a higher proportion of Y6 pupils were taught the TIMSS mathematics topics than the TIMSS science topics, as was also the case on average internationally.