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EXPLORING THE CHARACTERISTICS OF EDUCATION SYSTEMS WHICH ARE SUCCESSFUL IN SCIENCE

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Report

Exploring the Characteristics of Education Systems which are Successful in Science

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Exploring the Characteristics of Education Systems which are Successful in Science

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Contents

1 Overview

This report focuses on secondary analysis of the TIMSS 2011 data and encyclopaedia to explore the characteristics of seven education systems (Czech Republic, England, Finland, Hungary, the Netherlands, Sweden and the Slovak Republic) which outperformed Northern Ireland in the TIMSS 2011 assessment of nine and ten year olds. It specifically looks at the profile of science (curriculum), teaching, pupils' views and the assessment of science within these education systems. The findings for these successful education systems are compared with science education in Northern Ireland, highlighting important differences that could be used to inform policy for primary science education in Northern Ireland.

2 Recommendations

The main area of difference between science teaching in Northern Ireland and the comparator countries that clearly stands out is that these countries tend to teach science as a separate subject in primary education. This is an area that policy makers in Northern Ireland might wish to explore in order to improve primary science attainment. Two options could be explored linked to the findings.

The first, and potentially least disruptive, would be to raise the profile of science by separating it out more within the subject area 'the world around us', possibly looking at how the Dutch approach science within the 'personal and world orientation' subject area. The second would be to increase the amount of formal monitoring of science learning by increasing the amount of classroom or external assessment.

Policy makers would need to review the extent of curriculum changes, and the impact on teachers and any teacher specialisation required, before deciding whether separating out science more within the curriculum would be feasible. It might also be that without accompanying monitoring or accountability changes the way science is taught will not change and the situation will not measurably improve.

Introduction of national science monitoring testing is an area that could be explored but is not likely to be simple to introduce nor inexpensive. This analysis shows that in a number of the comparator countries there is a greater emphasis on the use of national tests to monitor pupil progress. However, given the potential resource implications it would be harder to justify this as a policy recommendation without conducting further evidence gathering and exploring in more detail how other countries use national monitoring tests in science and whether there are links between the use of such tests and improved attainment in science.

This does not mean that increasing the monitoring of science is not worthy of policy consideration. In Northern Ireland there appears to be less emphasis on the monitoring of pupil progress through classroom assessment. Therefore policy makers could consider mechanisms to increase the amount of monitoring of pupil science achievement by promoting classroom testing. This could be done by production of simple assessment materials for use by teachers or by linking science progress measurement to school inspections or other mechanisms of accountability. Again it might be worth looking in more detail at how classroom tests are used in the comparator countries to see if any of the models provide a potential solution for Northern Ireland.

The data does not readily suggest that there are any other specific training or curriculum areas that policy makers may wish to explore in order to improve primary science attainment.

3 At a Glance Guide to key characteristics of education systems which are successful in primary science

The key information about primary science in the seven comparator countries, Northern Ireland (NI) and the international average (Int. Average) is shown in the tables below to provide an 'At a Glance Guide' for policy makers.

Key to countries: CZ (The Czech Republic); EN (England); FI (Finland); HU (Hungary); NL (the Netherlands); SV (The Slovak Republic); SW (Sweden).

3.1 Science as a separate subject

	NI	CZ	EN	FI	HU	NL	SV	SW
Separate sciences at primary level	✗	✓*	✗	✓*	✓*	Schools choose	✓*	Schools choose

* Yes, at the later primary grades

	NI	CZ	EN	FI	HU	NL	SV	SW	Int. Average
% of pupils not taught science as a separate subject at primary level									
	72.3	9.2	13.3	3.7	7.4	18.7	2.7	21.9	23

	NI	CZ	EN	FI	HU	NL	SV	SW	Int. Average
Teaching hours per year devoted to science teaching	**72** *970	**60** *782	**76** *970	**98** *779	**72** *760	**42** *1074	**101** *780	**75** *849	**85** *897

*Total number of teaching hours per year

3.2 Specialisation in science

% specialist teachers where main area of study is science and where main area of study is education (with science as a specialisation)

	NI	CZ	EN	FI	HU	NL	SV	SW	Int. Average
% of pupils where teaching in the school is not limited by a lack of teachers with specialisation in science*									
	24.6	**72.6**	**34**	**34.8**	**70.7**	**17.7**	**66.7**	**33.9**	**37.3**

* reported by the school principal

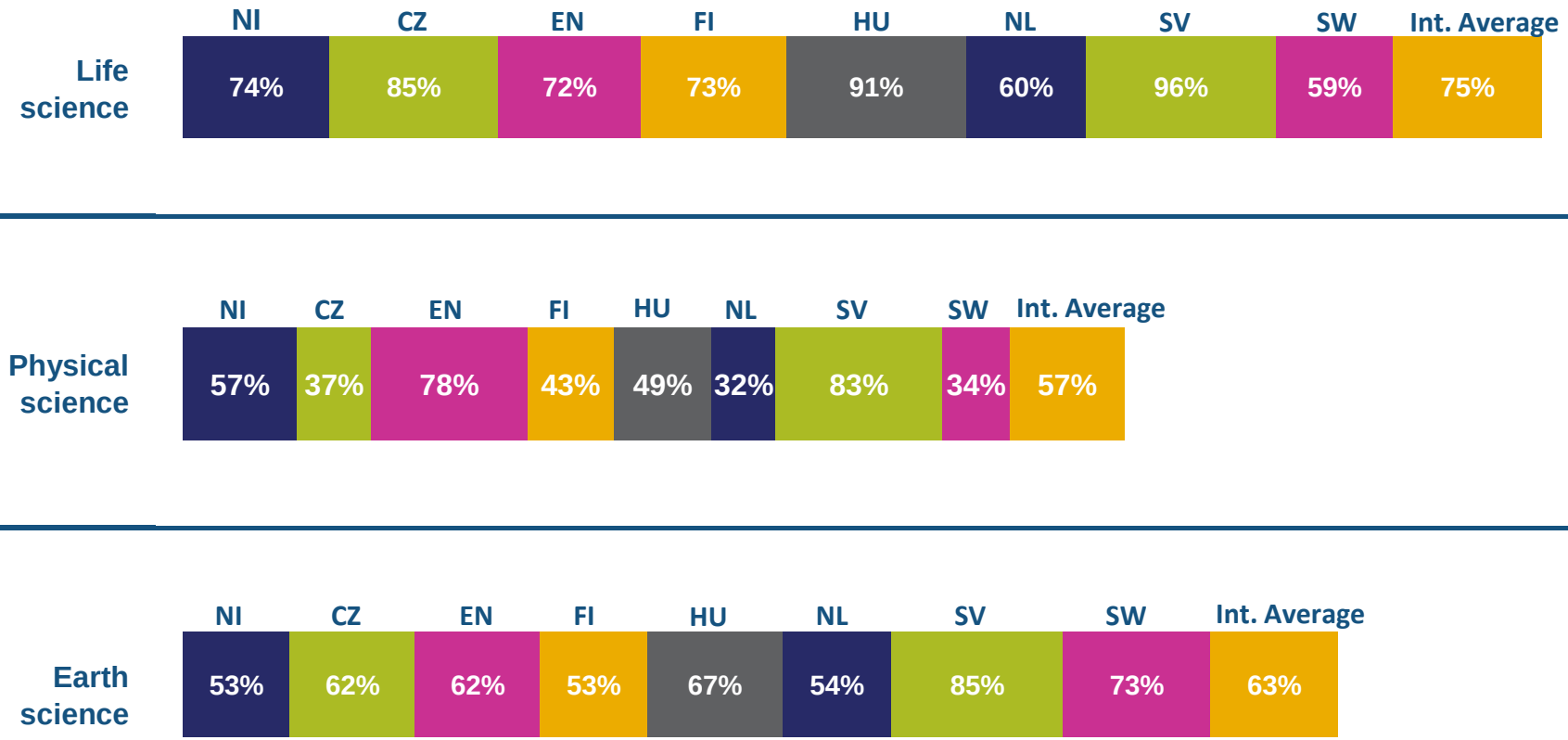
3.3 Classroom practice (only areas that show Northern Ireland as an outlier are shown)

	NI	CZ	EN	FI	HU	NL	SV	SW	Int. Average
% of pupils whose teachers never assign science homework*									
	62.1	**5.5**	**39**	**0.7**	**2.8**	**68.9**	**15.4**	**45.8**	**18.3**

	NI	CZ	EN	FI	HU	NL	SV	SW	Int. Average
% of pupils whose teachers never administer written tests or quizzes in science*									
	39.4	**0**	**19.2**	**1.8**	**0**	**25.4**	**0.6**	**30.9**	**6.2**

*at Primary level

TIMSS Grade 4 science topics: % of pupils mostly taught the topic before or in the assessment year

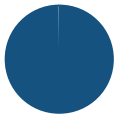
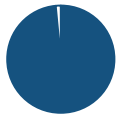
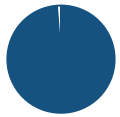


All	NI 61%	CZ 59%	EN 71%	FI 55%	HU 67%	NL 47%	SV 87%	SW 53%	Int. Average 64%

* Grade 4 pupils are ages 9 to 10

3.4 Monitoring pupil progress in primary science

% of pupils whose teachers use the following methods to monitor pupil progress in primary science

	NI	CZ	EN	FI	HU	NL	SV	SW	Int. Average
Evaluation of pupils' ongoing work									
	96.1	100	100	99.6	100	92.1	100	96.2	98.5
Classroom tests									
	54.7	99.6	77.1	98.5	97.9	78.9	98.8	76.0	93.0
National or regional achievement tests									
	27.2	37.7	52.3	21.7	78.5	41.7	71.5	61.2	67.7

A certain amount of caution needs to be exercised in interpreting these tables; they show what the situation is but don't link that information to policy and practice in the various countries. In addition, several of the indicators are linked. For example, the reason fewer principals in Northern Ireland report a lack of specialist teachers limiting science teaching might be because, in the majority of cases, science is not taught as a separate subject so there is no perceived need for specialist teaching. Caution must also be exercised in interpreting these results in light of educational reform taking place in these countries; for ease of interpretation and to ensure that the data in the profiles is directly linked to the educational experience of the pupils whose performance is reported in TIMSS 2011, the information is based on the system in operation in each country at that time. Where it has changed since then we have highlighted this in the country profiles.

In most instances, including the amount of teaching time devoted to science teaching, teacher specialisation, pupil engagement, teacher confidence, and content coverage, Northern Ireland does not stand out as particularly different from the comparator countries.

However in some key areas Northern Ireland does appear to be an outlier. The most obvious area is that, compared to the other countries studied, a far greater proportion of pupils in Northern Ireland are not taught science as a separate subject (as reported by their teachers). Even in a country such as the Netherlands, where science is taught as part of 'personal and world orientation', many teachers seem to separate out science when it comes to teaching those topic areas. In some of the comparator countries (the Czech Republic, Finland, Hungary and the Slovak Republic) science is not only separated out as a subject but separate sciences are taught at the higher primary grades.

This lack of separate science teaching may also be linked to the other areas where Northern Ireland seems to be an outlier. Teachers in Northern Ireland report setting less science homework than most other countries, with only the Netherlands have a greater percentage of pupils being taught by teachers who say they set no homework. Policy context is import here and, in the Netherlands, homework is not expected to be set at primary level, although it is sometimes assigned by schools to start to prepare pupils for secondary school.

Teachers in Northern Ireland are also most likely to report never setting tests or quizzes and to place much less emphasis on monitoring pupil progress in science through either classroom or external achievement tests.

More research would be needed to explain why teachers in Northern Ireland are less likely to set science homework, or to monitor pupil progress through tests, but this might indicate less of a focus on science in primary education and an indication that science occupies a less important place within the priorities of the school.

4 Methodology

This report looks at the countries which outperformed Northern Ireland in TIMSS 2011 in science at Grade 4[1], that is the countries that had scale scores for science that were significantly higher than Northern Ireland's mean scale score. Seventeen countries outperformed Northern Ireland and, of these countries, 12 outperformed Northern Ireland only in science.

TIMSS participants out performing Northern Ireland only in science

12 countries with their TIMSS scores	
Finland	**(570)**
Russian Federation	(552)
United States	(544)
Czech Republic	**(536)**
Hungary	**(534)**
Sweden	**(533)**
Slovak Republic	**(532)**
Austria	(532)
Netherlands	**(531)**
England	**(529)**
Denmark	(528)
Germany	(528)

The seven countries in bold are the countries selected for in-depth comparison. This report features a profile of each country (see Section 5), which includes curriculum and system-level information taken from the TIMSS Encyclopaedia, as well as information about teaching practices, assessment practices and pupil views extracted from the TIMSS international data sets. As the TIMSS data was collected in 2011, a quick review was undertaken to ensure that any changes since 2011 that impact on the science curriculum and teaching are referenced in the relevant country

[1] This is Year 6 in Northern Ireland (pupils aged nine and ten)

profile. Each country profile includes the following information from the TIMSS Encyclopaedia:

- a description of the science curriculum at primary level
- a description of the use of teaching materials, including technology, equipment and laboratories for primary science
- information about teacher education for primary science teachers and requirements for continued professional development
- information about national assessment of science at primary level
- information about whether any special programmes exist to support science education in the country.

To further elaborate what happens in the classroom, the country profiles also examine responses to the following questions from the TIMSS teacher questionnaire:

- whether science is taught as an integrated subject
- teacher confidence in teaching specific areas of science and how well prepared they feel to teach science
- how much time is spent on practical aspects of science
- what resources are used to teach science
- what topics are covered and what content is taught in science lessons
- how often pupils are given science homework
- monitoring pupil progress in science.

Information from responses to the following question from the school questionnaire:

- how is the school's capacity to provide instruction affected by a shortage or inadequacy of a number of different resources.

The profiles also include information from responses to the following questions from the pupil questionnaire:

- views about learning science
- views about their science lessons.

5 Country Profiles

5.1 Northern Ireland[2]

5.1.1 Overview of the primary education system

Legislative responsibility for education lies with the Northern Ireland Assembly and the Minister for Education, who sets policy direction, allocates resources, sets targets for the education system, and is accountable for outcomes. The Department of Education (DE) provides central governance and management. Since 1 April 2015, a single new Education Authority has replaced the five former Education and Library Boards, taking over their role in ensuring effective provision of education.[3] The Education and Training Inspectorate reports on quality. Most schools are grant-aided and spending decisions are largely delegated to them. Grant-aided schools follow a national curriculum setting out the minimum teaching content.

Structure of the primary education system in Northern Ireland

Age	4 -11
Stage	Foundation Stage: ages 4-6 Key Stage 1 (KS1): ages 6-8 Key Stage 2 (KS2): ages 8-11
ISCED level	Age 4-11 ISCED 1
Curriculum	The arts; language and literacy; mathematics and numeracy; personal development and mutual understanding; physical development and movement; the world around us

Young children can access funded preschool education for at least one year, at parental discretion. Compulsory education covers 12 years (ages 4-16) with the option of further study at 16-18. The post-primary phase encompasses Key Stage 3 ((KS3), ages 11-14, Key Stage 4 (KS4), ages 14-16, and post-16 provision, ages 16-18. Post-primary transfer should be based on non-academic criteria, although the law still allows schools to select academically. Each school sets its own selection criteria. Parents can apply to any school for their child. As a result, most pupils are educated with others of the same religious background. The DE facilitates integrated education, aiming for a minimum percentage of Catholic and Protestant pupils in each school. English is the official language and the language of instruction in most schools, although a small number provide Irish-medium education.

[2] Main source of information: TIMSS 2011 Encyclopaedia, with updated information indicated and updated sources (and other data sources) given as applicable. http://timssandpirls.bc.edu/timss2011/encyclopedia-timss.html

[3] http://www.nidirect.gov.uk/education-authority

5.1.2 Science curriculum in primary education

In the primary curriculum (DE, 2007), science and technology are part of the curriculum area 'the world around us'. (Post-primary pupils study science and technology as a distinct subject.) The world around us aims to support primary pupils in exploring and finding answers to questions arising from science, technology, history, and geography, while forming an appreciation of the wonders of the world and their place within it. Pupils develop their powers of observation, their use of information and communication technology (ICT) and their thinking skills. They look, sort, classify, explore, experiment, predict, compare and plan. They develop their knowledge, understanding, and skills in relation to four curricular themes: interdependence, place, movement and energy, and change over time.[4]

5.1.3 Teaching science in primary education

Teaching materials, equipment and laboratories

There are no specified programmes or texts for primary science. Teachers use a variety of texts, worksheets and other materials. Much is taught through activities and practical work. Classrooms are generally well equipped although primary schools tend not to have specialised facilities, such as laboratories. Over 80 per cent of primary pupils in 2011 were in schools where the principal considered that capacity to teach was affected by shortages of library materials for science and science equipment and materials. This was higher than the international average[5] for library materials, but similar to the average for equipment and materials (see Table 1).

Use of technology

Cross-curricular ICT is statutory across all key stages. C2k provides grant-aided schools with a core, managed service, including hardware, local area network services, wide-area services and management information systems.[6] Schools can purchase additional equipment. Despite this infrastructure, over three-quarters of pupils in 2011 were in schools where the principal felt that the school's capacity to teach was affected by a shortage of computer software and audio-visual resources for science instruction (see Table 1). The perceived shortage of computer software was slightly higher than the international average.

Introduction of specialist teachers for science

Primary science teaching is generally undertaken by the classroom teacher and science topics are taught discretely or within project work. Specialist teachers of science are introduced in post-primary education. In 2011, about three-quarters of primary pupils were in schools where a shortage of teachers with a specialisation in science was considered to affect the school's capacity to teach. This was higher than the international average (see Table 1).

[4] http://www.nicurriculum.org.uk/key_stages_1_and_2/areas_of_learning/the_world_around_us/

[5] This is the average across all countries participating in TIMSS 2011.

[6] http://www.c2kni.org.uk/

Table 1: Capacity to provide instruction

How much is your school's capacity to provide instruction affected by a shortage or inadequacy of…	% of pupils whose school principal answered 'not at all' (international average)	% of pupils whose school principal answered 'a little/some/a lot' (international average)
Teaching materials, equipment and laboratories		
…library materials relevant to science instruction?	18.0% (27.5%)	81.9% (72.5%)
…science equipment and materials?	19.8% (19.6%)	80.2% (80.5%)
Use of technology		
…computer software for science instruction?	18.0% (22.7%)	81.9% (77.3%)
…audio-visual resources for science instruction?	21.1% (22.7%)	78.8% (77.3%)
Introduction of specialist teachers for science		
…teachers with a specialisation in science?	24.6% (37.3%)	75.4% (62.6%)

Data is from the TIMSS 2011 school questionnaire, reported as *the percentage of students* taught in schools where the principal (or delegated person) gave the indicated response. This is not necessarily the same as the percentage of schools which gave the response (e.g. schools vary in size, so perceived shortages in a small school may impact on fewer pupils than in a large school).

Data met the response target in Northern Ireland (see Martin *et al.*, 2012, Exhibit 5.7).

Percentages may not total 100 due to rounding.

Primary pupil attitudes to science and science lessons

Pupil attitudes in Northern Ireland are broadly similar to the international average (see Table 2), with over 84 per cent of pupils responding that they 'liked science'. Slightly fewer pupils than the international average consider it important to do well in science, and slightly more than average agree that their teacher gives them interesting things to do in science lessons. However, these differences are unlikely to be statistically significant.

Table 2: Pupil attitudes to science and science lessons

How much do you agree that…	% of pupils who 'agree a lot/agree a little' (international average)	% of pupils who 'disagree a lot/ disagree a little' (international average)
… you enjoy learning science?	87.1% (88.0%)	13.0% (11.9%)
… you learn many interesting things in science?	88.1% (90.2%)	11.9% (9.8%)
… you like science?	84.1% (85.7%)	15.9% (14.4%)
… it is important to do well in science?	87.9% (91.0%)	12.1% (9.0%)
… your teacher gives you interesting things to do in your science lessons?	89.5% (85.6%)	10.6% (14.3%)

Data from the TIMSS 2011 student questionnaire.
Data met the response target in Northern Ireland (see Martin *et al.*, 2012, Exhibit 8.1)
Percentages may not total 100 due to rounding.

5.1.4 Teaching science to the TIMSS class[7]

Despite science being embedded in the curriculum area 'the world around us', more than a quarter of pupils in 2011 were taught science as a separate subject, compared with just over three-quarters internationally (see Table 3). Average teaching time for science in primary education in Northern Ireland was 72 hours a year, which is less than the international average (see Table 4).

[7] This refers to the primary class(es) in the schools who took part in the TIMSS 2011 assessment in the Northern Ireland.

Table 3: Science in the primary curriculum

Is science taught mainly as a separate subject?	% of pupils whose teachers answered 'no' (international average)
	72.3% (23.0%)

Data from the TIMSS 2011 teacher questionnaire.
No Grade 4 report in Martin *et al.* (2012), hence no data is available regarding the percentage of pupils whose teachers responded.

Table 4: Teaching hours in primary science

Teaching hours per year	Total teaching hours (international average)	Science teaching hours (international average)
	970 (897)	72 (85)

Data from Martin *et al.* (2012), Exhibit 8.6. Data available for fewer than 85 per cent of pupils in Northern Ireland.

Table 5: Teacher confidence

In teaching science to this class, how confident do you feel…	% of pupils whose teachers answered 'very confident' (international average)
… answering students' questions about science?	41.6% (62.1%)
… explaining science concepts or principles by doing science experiments?	36.3% (51.1%)
… helping students appreciate the value of learning science?	43.9% (68.0%)

Data is from the TIMSS 2011 teacher questionnaire, and reported as the *percentage of students* taught by teachers who gave each response. This is not necessarily the same as the percentage of teachers who gave the response. For example, one teacher might teach science to a single class while another might teach it to several classes. Similarly, numbers of pupils in classes may vary. Thus, each teacher's science teaching practice will impact differently on the overall pupil population.
Data available for fewer than 85 per cent of pupils in Northern Ireland (see Martin *et al.*, 2012, Exhibit 7.11)

Fewer than average pupils (see Table 5) had teachers who were very confident about explaining concepts by doing experiments (36.3 per cent), answering pupils' questions (41.6 per cent), or helping pupils appreciate the value of learning science (43.9 per cent).

Teachers' emphasis on specific science activities was measured by responses to statements about how often they asked their pupils to undertake a variety of learning activities in their science lessons. In Northern Ireland, fewer than average pupils had teachers who carried out the specified science activities in half or more of their science lessons (see Table 6), with notably more than the average never being asked to watch their teachers demonstrate an experiment (11.3 per cent), read their textbooks or other materials (11.2 per cent), memorise facts (31.7 per cent), do field work outside the class (19.8 per cent), or take a written test or quiz (39.4 per cent).

Fewer than average pupils in Northern Ireland had been taught the TIMSS earth science topics in or before the year of the assessment (53 per cent), although coverage for the other topic areas (57 to 74 per cent) was close to the international average (see Table 7). Notably, fossils (24.8 per cent), the solar system (48.7 per cent) and the earth's rotation (50.0 per cent) had been taught to fewer pupils than average.

Table 6: Learning activities

In teaching science to this class, how often do you usually ask students to…	% of pupils whose teachers answered 'half the lessons' or more (international average)	% of pupils whose teachers answered 'never' (international average)
… observe natural phenomena such as the weather or a plant growing and describe what they see?	18.7% (44.3%)	3.4% (1.7%)
… watch you demonstrate an experiment or investigation?	8.9% (38.7%)	11.3% (4.3%)
… design or plan experiments or investigations?	18.6% (33.7%)	4.0% (9.1%)
… conduct experiments or investigations?	22.1% (38.6%)	4.2% (3.9%)
… read their textbooks or other resource materials?	22.3% (69.9%)	11.2% (3.0%)
… memorise facts and principles?	8.0% (51.5%)	31.7% (11.2%)
… give explanations about something they are studying?	52.7% (81.7%)	0.8% (0.5%)
… relate what they are learning in science to their daily lives?	60.4% (84.9%)	0.7% (0.4%)
… do field work outside the class?	7.1% (19.1%)	19.8% (10.7%)
… take a written test or quiz?	2.6% (33.3%)	39.4% (6.2%)

Data is taken from the TIMSS 2011 teacher questionnaire.
Data available for fewer than 85 per cent of pupils in Northern Ireland (see Martin *et al.,* 2012, Exhibit 8.27).
Percentages do not total 100 as not all response categories are reported.

Table 7: Primary pupils taught the TIMSS science topics

TIMSS Grade 4 science topics	% of pupils mostly taught the topic before or in the assessment year (international average)
All (20 topics)	61% (64%)
Life science (6 topics)	74% (75%)
Physical science (8 topics)	57% (57%)
Earth science (6 topics)	53% (63%)

Data from Martin et al. (2012), Exhibit 8.8. Data available for fewer than 85 per cent of pupils in Northern Ireland.

Fewer than average pupils had teachers who felt very well prepared to teach the TIMSS science topics, with earth science having the lowest average (44 per cent). The range within each topic area was wide, with some earth science and physical science topics (fossils, forming and separating mixtures) having as few as a quarter to about a third of pupils taught by very well-prepared teachers (see Table 8), while other topics in these areas (energy sources, weather) had nearly two-thirds with very well-prepared teachers. The international average ranges were similarly wide.

Table 8: Teacher preparedness

TIMSS Grade 4 science topics	% of pupils whose teachers feel 'very well prepared' to teach the topics (international average)	Highest and lowest percentages within each topic area (international range)
All (20 topics)	54% (62%)	27.6% - 62.8% (30.6% - 66.6%)
Life science (6 topics)	62% (70%)	43.1% - 62.2% (54.2% - 66.6%)
Physical science (8 topics)	56% (62%)	34.2% - 62.8% (35.2% - 62.4%)
Earth science (6 topics)	44% (53%)	27.6% - 59.9% (30.6% - 61.6%)

Data from Martin *et al.* (2012), Exhibit 7.9 and TIMSS 2011 teacher questionnaire.
Data available for fewer than 85 per cent of pupils in Northern Ireland.

Schools manage their own homework policies, with guidance from DE. In 2011, 62.1 per cent of pupils were assigned no science homework, far higher than the international average of 18.3 per cent. None were assigned science homework three times a week or more (see Table 9).

Table 9: Science homework

How often do you usually assign science homework to the students in this class?	% of pupils whose teachers assign no science homework (international average)	% of pupils whose teachers assign homework 3 times a week or more (international average)
	62.1% (18.3%)	0.0% (12.4%)

Data from TIMSS 2011 teacher questionnaire.
No Grade 4 report in Martin *et al.* (2012), hence no data is available regarding the percentage of pupils whose teachers responded.

5.1.5 Teacher education specific to science

Teaching is all-graduate: teachers usually hold either a Bachelor of Education (BEd) qualification (catering mainly to the primary sector) or a Postgraduate Certificate in Education (PGCE) qualification (mainly post-primary, and with a BA or BSc as a pre-requisite). A BEd takes four years, involving professional tuition, academic study in one or more specialist subjects, and classroom-based teaching practice. Students on PGCE courses undertake professional tuition and teaching practice. Newly qualified teachers follow an induction programme (normally one year), followed by a two-year Early Professional Development programme.

Fewer than 12 per cent of Northern Ireland's primary TIMSS pupils were taught by teachers who studied post-secondary science, and fewer than ten per cent by teachers who had science as a specialism in their teacher education degree (see Table 10). Both figures are notably lower than the international average.

Table 10: Teacher specialisation

During your post-secondary education…	% of pupils whose teachers answered 'yes' (international average)
… was science your major or main area of study?	11.7% (28.0%)
If your major or main area of study was education, was science your specialisation?	9.7% (31.3%)

Data from the TIMSS 2011 teacher questionnaire.
Data available for fewer than 85 per cent of pupils in Northern Ireland (see Martin *et al.*, 2012, Exhibit 7.3).

Professional development

All teachers have access to ongoing professional development, which may be centre-based or school-based. Arrangements for initial and continuing professional development have recently been reviewed and possible future changes are being considered.[8]

Relative to the international average, few pupils were taught science by teachers who had participated in science-related professional development in the previous two years (see Table 11). This ranged from 5.1 per cent for those teachers who had learned about science assessment, up to 28.6 per cent for those teachers who had received science curriculum training.

[8] https://webgate.ec.europa.eu/fpfis/mwikis/eurydice/index.php/United-Kingdom-Northern-Ireland:Initial_Education_for_Teachers_Working_in_Early_Childhood_and_School_Education#Institutions.2C_Level_and_Models_of_Training

Table 11: Professional development

In the past two years, have you participated in professional development in…	% of pupils whose teachers answered 'yes' (international average)
… science content?	26.0% (34.9%)
… science pedagogy/instruction?	27.9% (33.7%)
… science curriculum?	28.6% (33.7%)
… integrating information technology into science?	22.3% (27.9%)
… science assessment?	5.1% (26.8%)
… addressing individual students' needs?	12.5% (32.2%)

Data from the TIMSS 2011 teacher questionnaire.
Data available for fewer than 85 per cent of pupils in Northern Ireland (see Martin *et al.*, 2012, Exhibit 7.7).

5.1.6 Monitoring pupil progress in science

Assessment of pupil progress in all learning areas in Northern Ireland is delegated to schools, and information on pupil progress is not collected centrally. The Council for the Curriculum, Evaluation and Assessment (CCEA) provides advice and exemplars of good practice, supporting schools and teachers in exercising their professional judgement.

Pupil progress in the cross-curricular skills of using mathematics, communication, and ICT is assessed annually by teachers. The information is used to inform teaching and learning in school and is reported to parents. Teacher assessments of pupil outcomes in the cross-curricular skills at the end of each key stage are collected centrally and used as a system measure and for accountability purposes. There is no comparable collection of data for science.

TIMSS 2011 data underlines these approaches: almost all pupils (96.1 per cent) are taught by teachers who monitor their progress based on ongoing evaluation of their work (similar to the international average), but far fewer than average are assessed through classroom tests (54.7 per cent) or national/regional tests (27.2 per cent). These figures are much lower than the international average (see Table 12).

Table 12: Monitoring progress

How much emphasis do you place on … to monitor students' progress in science?	% of pupils whose teachers answered 'major/some' emphasis (international average)
the evaluation of students' ongoing work	96.1% (98.5%)
classroom tests	54.7% (93.0%)
national or regional achievement tests	27.2% (67.7%)

Data from the TIMSS 2011 teacher questionnaire.

No Grade 4 report in Martin *et al.* (2012), hence no data is available regarding the percentage of pupils whose teachers responded.

5.2 Czech Republic[9]

5.2.1 Overview of the primary education system

Responsibility for schools in the Czech Republic is distributed between the Ministry of Education, Youth and Sports, regional education authorities, and municipalities. Between 2001 and 2003, regional education authorities were established, fundamentally decentralising the education system. The Ministry of Education, Youth and Sports retained its policymaking responsibilities but transferred administrative responsibilities to the regions. Municipalities are now responsible for nursery schools and for basic schools, which provide compulsory primary and lower secondary education.

Structure of the primary education system in the Czech Republic

Age	6 –11 years (Grade 1-5)
Stage	1st stage (Grade 1-5); 2nd stage (Grade 6-9)
ISCED level	Grade 1-5 – ISCED level 1 Grade 6-9 – ISCED level 2
Curriculum	Stage 1: Czech, first foreign language (English,), mathematics, information and communication technology, people and their world (basics of history and geography, basics of sciences), art and culture, music and physical education. Stage 2: Includes all the Stage 1 curriculum (apart from people and their world) and second foreign language (obligatory from Grade 8 (age 12+); mainly German, but French, Spanish or Russian are also common), people and society, and people and nature (history, civics, physics (from Grade 6 or 7), chemistry (from Grade 7 or 8), biology).

Basic schools provide nine years of education for the primary and lower secondary levels and attendance is compulsory. The primary level lasts five years for pupils aged six to 11, and the lower secondary level lasts four years for pupils ages 11–15.

Public schools do not charge for tuition, but parents may be asked to pay up to 50 per cent of operating costs. Private schools were first established in 1990 (private universities in 1999). These schools are mostly secular and are usually established by for-profit or non-profit grant-aided organisations. According to TIMSS 2011 data, non-governmental basic schools (private and parochial schools) represent only 2.9 per cent of the total number of basic schools and educate 1.5 per cent of pupils at that level.

[9] Main source of information: TIMSS 2011 Encyclopaedia, with updated information indicated and updated sources (and other data sources) given as applicable. http://timssandpirls.bc.edu/timss2011/encyclopedia-timss.html

In the Czech Republic the official language and language of instruction is Czech. However, ethnic minority pupils are guaranteed the right to education in their mother tongue to the extent appropriate for the development of their ethnic community; the only minority language schools in the country are Polish.

5.2.2 Science curriculum in primary education

Since September 2007, instruction has followed the Framework Educational Program for Elementary Education (FEP EE) which specifies the concrete objectives, form, length, and basic curricular content of education as well as general conditions for their implementation and defines nine main educational areas (consisting of one or more educational fields), cross-curricular themes, and supplementary educational fields. Each school head devises a school educational programme in accordance with FEP EE and comprising the expected outcomes and topics taught in each subject.

The science curriculum in the primary grades (Grades 1–5) follows FEP EE and is divided into five thematic areas relating to 'man and his world'. These are the 'place where we live', 'people around us', 'man and time', 'diversity of nature', and 'man and his health'. Traditionally, instruction following the framework in Grades 1–3 integrates subject matter from the five individual thematic areas into one subject. In Grades 4–5, instruction following the framework is divided into two separate subject areas: one subject drawing on the thematic areas place where we live, people around us, and man and time as a foundation for geography and history; and one subject drawing on the thematic areas of diversity of nature and man and his health as a foundation for the natural sciences.

5.2.3 Teaching science in primary education

Teaching materials, equipment and laboratories

Pupils in primary grades conduct simple science experiments and make measurements using simple tools and devices. The FEPEE contains directives for equipping schools. As a minimum, schools should have specific spaces dedicated to science and information and communication technology (ICT) instruction, and laboratory space should be created and furnished with equipment and tools specific to the subject taught in that space, as well as appropriate audiovisual and ICT equipment.

The Czech Republic has no specific requirements for teaching aids. The Ministry of Education, Youth and Sports publishes a list of approved textbooks and teaching texts in the Bulletin of the Ministry of Education, Youth and Sports and on the Internet. These comply with the educational objectives stipulated in the Education Act, the Framework Education Programs, and legal regulations. Schools may use other textbooks and teaching materials that have been approved by the head of the school.

Use of technology

Instruction in ICT is included as a compulsory part of primary level education; pupils become better at independent and critical work with information sources.

Introduction of specialist teachers for science

Pupils first have specialist teachers for science in Grade 6 (age 10-11). Because from Grade 6 onwards science is taught as separate subjects, science teachers specialise in biology, chemistry, physics, or earth science.

Table 1 shows that just over a quarter of primary pupils were in schools where a shortage of teachers with a specialisation in science was considered to affect the school's capacity to teach (less than half the international average). This is quite a different picture to that seen in Northern Ireland where just over three quarters of pupils are in schools where lack of specialised science teachers affects teaching. However, a shortage of other materials and resources did seem to affect schools' capacity to provide instruction. The majority of pupils were in schools' where a shortage or inadequacy of teaching materials, equipment and laboratories and the use of technology was considered to affect the schools capacity to teach - .in general this was similar to the international average.

Table 1: Capacity to provide instruction

How much is your school's capacity to provide instruction affected by a shortage or inadequacy of…	% of pupils whose headteachers answered 'not at all' (international average)		% of pupils whose headteachers answered 'a little/some/a lot' (international average)	
Teaching materials, equipment and laboratories				
	CZECH R.	**NI**	**CZECH R.**	**NI**
…library materials relevant to science instruction?	30.7%	18.0% (27.5%)	69.3%	81.9% (72.5%)
…science equipment and materials?	19.4%	19.8% (19.6%)	80.6%	80.2% (80.5%)
Use of technology				
…computer software for science instruction?	42.0%	18.0% (22.7%)	58.0%	81.9% (77.3%)
…audio-visual resources for science instruction?	29.5%	21.1% (22.7%)	70.5%	78.8% (77.3%)
Introduction of specialist teachers for science				
…teachers with a specialisation in science?	72.6%	24.6% (37.3%)	27.4%	75.4% (62.6%)

Data is from the TIMSS 2011 school questionnaire, reported as *the percentage of students* taught in schools where the headteacher gave the indicated response. This is not necessarily the same as the percentage of schools which gave the response (e.g. schools vary in size, so perceived shortages in a small school may impact on fewer pupils than in a large school). Percentages may not total 100 due to rounding.

Primary pupil attitudes to science and science lessons

Table 2 shows Grade 4 pupil attitudes to science and science lessons from the pupil questionnaire. The largest majority of pupils in the Czech Republic agree it is important to do well in science (94.1 per cent) and they learn many interesting things in science (92.5 per cent). Over three-quarters of pupils enjoy learning science (77.7 per cent), and agree that their teacher gives them interesting things to do in science lessons (76.1 per cent); lower than the international average.

Table 2: Pupil attitudes to science and science lessons

How much do you agree that…	% of pupils who 'agree a lot/agree a little' (international average)		% of pupils who 'disagree a lot/ disagree a little' (international average)	
	CZECH R.	NI	CZECH R.	NI
…you enjoy learning science?	77.7%	87.1% (88.0%)	22.3%	13.0% (11.9%)
…you learn many interesting things in science?	92.5%	88.1% (90.2%)	7.5%	11.9% (9.8%)
…you like science?	77.1%	84.1% (85.7%)	22.8%	15.9% (14.4%)
…it is important to do well in science?	94.1%	87.9% (91.0%)	5.9%	12.1% (9.0%)
…your teacher gives you interesting things to do in your science lessons?	76.1%	89.5% (85.6%)	24.0%	10.6% (14.3%)

Data from the TIMSS 2011 student questionnaire. Percentages may not total 100 due to rounding.

5.2.4 Teaching science to the TIMSS class[10]

In the Czech Republic, less than ten per cent of pupils in 2011 were taught science as integrated subject, just under half the international average (see Table 3). Average teaching time for science in primary education in the Czech Republic was 60 hours a year; this is less than in Northern Ireland where on average teachers report spending 72 hours a year teaching science (see Table 4).

Table 3: Science in the primary curriculum

Is science taught mainly as a separate subject?	% of pupils whose teachers answered 'no' (international average)	
	CZECH R.	NI
	9.2% (23.0%)	72.3%

Data from the TIMSS 2011 teacher questionnaire.

[10] This refers to the primary class(es) in the schools who took part in the TIMSS 2011 assessment in the Czech Republic.

Table 4: Teaching hours in primary science

Teaching hours per year	Total teaching hours (international average)		Science teaching hours (international average)	
	CZECH R.	NI	CZECH R.	NI
	782 (897)	970	60 (85)	72

Data from Martin *et al. (2012),* Exhibit 8.6.

To investigate teachers' confidence in teaching primary science, teachers were asked to indicate how confident they feel about: answering pupils' questions about science; explaining science principles or concepts by doing science experiments; providing challenging tasks for capable pupils; adapting their teaching to engage pupils' interest; and helping pupils appreciate the value of learning science.

Fewer than average pupils (see Table 5) had teachers who were very confident about explaining science concepts by doing experiments (25 per cent), answering questions (29.3 per cent), or helping pupils appreciate the value of learning science (58.1 per cent). Compared with Northern Ireland, a much smaller proportion of pupils in the Czech Republic had teachers who felt very confident explaining science concepts by doing experiments and answering questions about science.

Table 5: Teacher confidence

In teaching science to this class, how confident do you feel…	% of pupils whose teachers answered 'very confident' (international average)	
	CZECH R.	**NI**
…answering students' questions about science?	29.3%	41.6% (62.1%)
…explaining science concepts or principles by doing science experiments?	25.0%	36.3% (51.1%)
…helping students appreciate the value of learning science?	58.1%	43.9% (68.0%)

Data is from the TIMSS 2011 teacher questionnaire, and reported as the *percentage of students* taught by teachers who gave each response. This is not necessarily the same as the percentage of teachers who gave the response. For example, one teacher might teach science to a single class while another might teach it to several classes. Similarly, numbers of pupils in classes may vary. Thus, each teacher's science teaching practice will impact differently on the overall pupil population.

Percentages may not total 100 due to rounding.

Teachers' emphasis on specific science activities was measured by responses to statements about how often they asked their pupils to undertake a variety of learning activities in their science lessons. In most cases, far fewer pupils than average in the Czech Republic carried out the specified activities in half or more of their lessons (see Table 6). Observing natural phenomena, giving explanations and doing field work were closer to the averages (46.8 per cent, 84.2 and 18.8 per cent of pupils respectively). Relatively high proportions of pupils were never asked to design or plan experiments (23.1 per cent) or memorise facts (22.4 per cent). However, compared with pupils in Northern Ireland, far more pupils in the Czech Republic carried out the specified activities in half or more of their lessons.

TIMSS 2011 data in Table 7 shows that, in the Czech Republic, the percentage of pupils taught each of the specified topics, before or in the TIMSS assessment year, was generally above the international average for life science (85 per cent) and earth science (62 per cent), but below the international average for physical science (37 per cent). These are higher percentages than are seen for Northern Ireland.

Table 6: Learning activities

In teaching science to this class, how often do you usually ask students to…	% of pupils whose teachers answered 'half the lessons' or more (international average)		% of pupils whose teachers answered 'never' (international average)	
	CZECH R.	NI	CZECH R.	NI
…observe natural phenomena such as the weather or a plant growing and describe what they see?	46.8%	18.7% (44.3%)	0.7%	3.4% (1.7%)
…watch you demonstrate an experiment or investigation?	14.4%	8.9% (38.7%)	5.6%	11.3% (4.3%)
…design or plan experiments or investigations?	11.5%	18.6% (33.7%)	23.1%	4.0% (9.1%)
…conduct experiments or investigations?	18.0%	22.1% (38.6%)	7.6%	4.2% (3.9%)
…read their textbooks or other resource materials?	82.2%	22.3% (69.9%)	0.0%	11.2% (3.0%)
… memorise facts and principles?	19.4%	8.0% (51.5%)	22.4%	31.7% (11.2%)
…give explanations about something they are studying?	84.2%	52.7% (81.7%)	0.0%	0.8% (0.5%)
…relate what they are learning in science to their daily lives?	93.9%	60.4% (84.9%)	0.0%	0.7% (0.4%)
…do field work outside the class?	18.8%	7.1% (19.1%)	4.9%	19.8% (10.7%)
…take a written test or quiz?	15.1%	2.6% (33.3%)	0.0%	39.4% (6.2%)

Data is taken from the TIMSS 2011 teacher questionnaire.
Percentages do not total 100 as not all response categories are reported.

Table 7: Primary pupils taught the TIMSS science topics

TIMSS Grade 4 science topics	% of pupils mostly taught the topic before or in the assessment year (international average)	
	CZECH R.	NI
All (20 topics)	59%	61% (64%)
Life science (6 topics)	85%	74% (75%)
Physical science (8topics)	37%	57% (57%)
Earth Science (6 topics)	62%	53% (63%)

Data from Martin *et al. (2012),* Exhibit 8.8.

TIMSS 2011 gathered information from the teachers of pupils taking the assessment about how well prepared they felt to teach the science content topics assessed in TIMSS. Across this year group, 62 per cent of pupils were taught by teachers who felt very well prepared to teach the TIMSS science topics. Across the content domains, a larger percentage of pupils had teachers who felt very well prepared to teach the life science topics (79 per cent) followed by physical science topics (56 per cent) and earth science topics (55 per cent).

In the Czech Republic, the range within the physical science and earth science content domains was wider than the international range for these areas. Within the physical science sub-domains, it is highest for ‘states of matter and differences in their physical properties’ (60.5 per cent) and lowest for ‘electrical circuits and properties of magnets’ (10.6 per cent). Within earth science sub-domains it is highest for ‘water on earth’ (70 per cent) and lowest for ‘fossils of animals and plants’ (15.9 per cent).

Table 8: Teacher preparedness

TIMSS Grade 4 science topics	% of pupils whose teachers feel 'very well prepared' to teach the topics (international average)		Highest and lowest percentages within each topic area (international range)	
	CZECH R.	NI	CZECH R.	NI
All (20 topics)	62%	54% (62%)	10.6% - 75.4%	27.6% - 62.8% (30.6% - 66.6%)
Life science (6 topics)	79%	62% (70%)	71% - 75.4%	43.1% - 62.2% (54.2% - 66.6%)
Physical science (8 topics)	56%	56% (62%)	10.6% - 60.5%	34.2% - 62.8% (35.2% - 62.4%)
Earth science (6 topics)	55%	44% (53%)	15.9% - 70%	27.6% - 59.9% (30.6% - 61.6%)

Data from Martin *et al. (2012),* Exhibit 7.9 and TIMSS 2011 teacher questionnaire.

Table 9: Science homework

How often do you usually assign science homework to the students in this class?	% of pupils whose teachers assign no homework (international average)		% of pupils whose teachers assign homework 3 times a week or more (international average)	
	CZECH R.	NI	CZECH R.	NI
	5.5%	62.1% (18.3%)	0.1%	0.0% (12.4%)

Data from TIMSS 2011 teacher questionnaire.

The Czech Republic has no homework regulations. In 2011, only 5.5 per cent of pupils were assigned no science homework, much lower than the percentage in Northern Ireland and lower than the international average, A tiny proportion of pupils (0.1 per cent) assigned science homework three times a week or more (see Table 9)

5.2.5 Teacher education specific to science

Higher education institutions train basic school teachers. Primary level teachers (Grades 1–5) must have master's degrees, which generally take five years to complete at a school of education (usually a three-year bachelor's programme followed by a two-year master's programme). Graduates from these programmes are qualified to teach all subjects at the primary level. Some programmes allow prospective teachers to specialise in a chosen subject. Teacher preparation includes a practical component that lasts from six to 12 weeks, depending on the school. A teacher who is fully qualified at the primary or secondary level may teach outside his or her area of specialisation at the discretion of the head of the school. At the end of their studies, teachers are qualified at the ISCED 5A level and obtain a university diploma, a diploma supplement and the academic degree of *Magistr* (master).

Only 2.2 per cent of the Czech Republic's primary TIMSS pupils were taught by teachers who studied post secondary science, and just over five percent by teachers with a science education in their teacher education degree. This is a smaller proportion than is seen in Northern Ireland and considerably lower than the international average (see Table 10).

Table 10: Teacher specialisation

During your post-secondary education…	% of pupils whose teachers answered 'yes' (international average)	
	CZECH R.	**NI**
…was science your major or main area of study?	2.2%	11.7% (28.0%)
If your major or main area of study was education, was science your specialisation?	6.4%	9.7% (31.3%)

Data from the TIMSS 2011 teacher questionnaire.

Professional development

The Ministry of Education, Youth and Sports accredits educational institutions and programmes focused on professional development. The head of the school provides professional development for educational staff aligned with a plan developed with the relevant trade union (if there is one at the workplace). There are no requirements for professional development specific to science. A revised career system for teachers is currently being finalised (the full operational mode to be launched at the beginning of July 2018). This will enable the professional growth of teachers and improve the quality of their work life and to a motivating reward system.

Compared with the international average, few primary pupils in the Czech Republic were taught by teachers who had participated in science-related professional

development in the previous two years (see Table 11). This ranged from 4.8 for those teachers who had learned about science assessment to 18.2 per cent whose teachers had received training about science content. The finding for science assessment mirrors what is seen in Northern Ireland with notably fewer pupils, than the international average, being taught by teachers who have received training in this area. More (24.1 per cent, closer to the average) had teachers who had learned about addressing individual needs.

Table 11: Professional development

In the past two years, have you participated in professional development in…	% of pupils whose teachers answered 'yes' (international average)	
	CZECH R.	**NI**
…science content?	18.2%	26.0% (34.9%)
…science pedagogy/instruction?	10.1%	27.9% (33.7%)
…science curriculum?	8.5%	28.6% (33.7%)
…integrating information technology into science?	15.3%	22.3% (27.9%)
…science assessment?	4.8%	5.1% (26.8%)
…addressing individual students' needs?	24.1%	12.5% (32.2%)

Data from the TIMSS 2011 teacher questionnaire.

5.2.6 Monitoring pupil progress in science

In the Czech Republic, primary level pupils did not, until recently, take national or regional examinations. In 2014, sample attainment tests were piloted in Grades 5 (age 10-11) and 9 (age 14-15) of basic education as part of reforms to the education system.

Schools use teacher-written tests to measure achievement and, while the use of nationwide standardised tests is not yet compulsory, most schools use some type of commercial test. Assessment is based on an evaluation of the extent to which a pupil has achieved the expected curricular outcomes in each subject. Teachers assess pupils based on written and oral work, as well as homework.

Teachers also conduct verbal assessments of pupil progress, describing and commenting in writing about pupils' strengths and weaknesses. After 1990, such verbal assessment became commonplace, especially in the primary grades, and was officially authorised in 1993. Since 2005, verbal assessments have been regulated by a Ministry of Education, Youth and Sports decree.

The results of these continuous assessments are summarised in a report at the end of each term. Most schools report pupil progress for written work and percentage scores for oral work. Verbal assessments are included in this report as narrative. Pupils who successfully pass all compulsory subjects are promoted to the next grade, while pupils who do not pass all compulsory subjects repeat the grade. Pupils may only repeat one grade at the primary level.

The TIMSS 2011 data shows the evaluation of pupils' work is paramount, all pupils are taught by teachers who monitor their progress based on ongoing evaluation of their work (slightly higher than the international average). Almost as many pupils are assessed through classroom tests (99.6 per cent), but far fewer than average are assessed through national/regional tests (37.7 per cent). Compared with pupils in Northern Ireland a greater proportion of pupils in the Czech Republic have their progress monitored through classroom tests or national/regional tests.

Table 12: Monitoring progress

How much emphasis do you place on … to monitor students' progress in science?	% of pupils whose teachers answered 'major/some' emphasis (international average)	
	CZECH R.	**NI**
…the evaluation of students' ongoing work…	100%	96.1% (98.5%)
…classroom tests…	99.6%	54.7% (93.0%)
…national or regional achievement tests…	37.7%	27.2% (67.7%)

Data from the TIMSS 2011 teacher questionnaire.

5.3 England[11]

5.3.1 Overview of the primary education system

In January 2010, there were 24,616 schools in England, with 8.1 million pupils enrolled. The Department for Education administers education at the national level. However, although a great deal of education policy is centrally determined, responsibility for day-to-day decision making is held by schools.

Structure of the primary education system in England

Age	5-11
Stage	Key Stage 1: ages 5–7 Key Stage 2: ages 7–11
ISCED level	Level 1: ages 5–11
Curriculum	Core subjects: English, mathematics, science Foundation subjects: design and technology, information and communication technology (ICT), history, geography, art and design, music, and physical education. A modern foreign language (MFL) is compulsory (from age 7, from 2014). Religious education is also taught.

Education becomes compulsory in the primary phase of England's education system when a child reaches age five. Primary education ends at 11. Publicly funded primary education is non-selective.

In England, the Department for Education is responsible for the development and implementation of a national curriculum for all subjects. All publicly funded schools, with the exception of academies, must follow the national curriculum during the years of compulsory education.

The official language and medium of instruction is English. In 2010, 16.0 per cent of pupils in primary schools spoke a language other than English at home. The official policy is to integrate children who are at the earliest stages of learning English into mainstream schools, providing additional language support if necessary.

[11] Main source of information: TIMSS 2011 Encyclopaedia, with updated information indicated and updated sources (and other data sources) given as applicable. http://timssandpirls.bc.edu/timss2011/encyclopedia-timss.html

5.3.2 Science curriculum in primary education

The science curriculum is delivered in key stages. The main content and attainment targets for science at Key Stage 2 (ages seven to 11) are:

- scientific inquiry - ideas and evidence in science and investigative skills, including planning, obtaining, presenting, considering and evaluating evidence
- life processes and living things - life processes; humans and other animals, including nutrition, circulation, movement, and health; green plants, including growth, nutrition, and reproduction; variation and classification; and living things in their environment, including adaptation, feeding relationships and micro-organisms
- materials and their properties - grouping and classifying materials; physical and chemical changes in materials; and separating mixtures of materials
- physical processes - electricity; forces and motion, including types of force; light and sound, including everyday effects of light, seeing, vibration, and sound; and the earth and beyond, including the sun, earth, moon and periodic changes.

The curriculum gives particular emphasis to scientific inquiry by relating the other three attainment targets to it. Each part of the science curriculum at Key Stage 2 has associated expected attainment level descriptors.

5.3.3 Teaching science in primary education

Teaching materials, equipment and laboratories

There are no centrally published or mandated books for teaching science. Materials provided by the 'National Strategies' (a government-supported initiative which ended in 2011) for science may have influenced classroom practice and some remain available for optional use. Very few primary schools in England have science laboratories. Over 50 per cent of primary pupils in 2011 were in schools where the headteacher considered that capacity to teach was affected by shortages of library materials for science and science equipment and materials. This was lower than the international average (see Table 1).

Use of technology

The use of computers is widespread in schools in England. However, while the majority of teachers have access to a computer, the number of computers available for pupil use varies across schools. Primary schools are likely to have pupil access to computers. The majority of computers in primary school have Internet access, though primary schools are less likely to have technical support on site. Calculator use is included at primary level and a large number of primary schools also have interactive whiteboards in the classroom. Despite widespread use of computers in primary schools, in 2011 nearly two-thirds of pupils attended schools where the headteacher felt that the school's capacity to teach was effected by a shortage of technology for science instruction (see Table 1).

Introduction of specialist teachers for science

The majority of pupils at Key Stage 2 (ages seven–11) are taught by a generalist classroom teacher. Most pupils do not encounter subject specialists until they enter secondary school at the age of 11.

Table 1 shows that in 2011 around two-thirds of pupils were in schools where a shortage of teachers with specialisation in science was considered to affect the school's capacity to teach. This was similar to the international average but smaller than the proportion of pupils affected in Northern Ireland (75.4 per cent).

Table 1: Capacity to provide instruction

How much is your school's capacity to provide instruction affected by a shortage or inadequacy of…	% of pupils whose headteachers answered 'not at all' (international average)		% of pupils whose headteachers answered 'a little/some/a lot' (international average)	
Teaching materials, equipment and laboratories				
	ENGLAND	**NI**	**ENGLAND**	**NI**
…library materials relevant to science instruction?	34.0%	18.0% (27.5%)	65.9%	81.9% (72.5%)
…science equipment and materials?	40.2%	19.8% (19.6%)	59.8%	80.2% (80.5%)
Use of technology				
…computer software for science instruction?	34.1%	18.0% (22.7%)	65.9%	81.9% (77.3%)
…audio-visual resources for science instruction?	35.9%	21.1% (22.7%)	64.1%	78.8% (77.3%)
Introduction of specialist teachers for science				
…teachers with a specialisation in science?	34.0%	24.6% (37.3%)	65.9%	75.4% (62.6%)

Data is from the TIMSS 2011 school questionnaire, reported as *the percentage of students* taught in schools where the headteacher gave the indicated response. This is not necessarily the same as the percentage of schools which gave the response (e.g. schools vary in size, so perceived shortages in a small school may impact on fewer pupils than in a large school). Percentages may not total 100 due to rounding.

Primary pupil attitudes to science and science lessons

Table 2 shows pupil attitudes to science and science lessons from the pupil questionnaire. In general, pupil attitudes in England are slightly less positive than the international average. However, the majority of pupils in England enjoy learning science (78.5 per cent), agree they learn many interesting things in science (87.3 per cent) and like science (75.8 per cent). Nearly all pupils say it is important to do well in science (90.3 per cent) and that their teacher gives them interesting things to do in science lessons (87.9 per cent).

Table 2: Pupil attitudes to science and science lessons

How much do you agree that…	% of pupils who 'agree a lot/agree a little' (international average)		% of pupils who 'disagree a lot/ disagree a little' (international average)	
	ENGLAND	NI	ENGLAND	NI
…you enjoy learning science?	78.5%	87.1% (88.0%)	21.6%	13.0% (11.9%)
…you learn many interesting things in science?	87.3 %	88.1% (90.2%)	12.7%	11.9% (9.8%)
…you like science?	75.8%	84.1% (85.7%)	24.1%	15.9% (14.4%)
…it is important to do well in science?	90.3%	87.9% (91.0%)	9.7%	12.1% (9.0%)
…your teacher gives you interesting things to do in your science lessons?	87.9%	89.5% (85.6%)	12.1%	10.6% (14.3%)

Data from the TIMSS 2011 student questionnaire. Percentages may not total 100 due to rounding.

5.3.4 Teaching science to the TIMSS class[12]

In England, fewer than one-fifth of pupils in 2011 experienced science as a separate subject. The remaining 72.3 per cent were taught it as an integrated subject (see Table 3). Average science teaching time in the TIMSS class in England was 76 hours a year, very similar to the average in Northern Ireland (slightly fewer hours than the international average) (see Table 4).

Table 3: Science in the primary curriculum

Is science taught mainly as a separate subject?	% of pupils whose teachers answered 'no' (international average)	
	ENGLAND	NI
	13.3% (23.0%)	72.3%

Data from the TIMSS 2011 teacher questionnaire.

Table 4: Teaching hours in primary science

Teaching hours per year	Total teaching hours (international average)		Science teaching hours (international average)	
	ENGLAND	NI	ENGLAND	NI
	970 (897)	970	76 (85)	72

Data from Martin *et al. (2012),* Exhibit 8.6.

To investigate teachers' confidence in teaching science, teachers were asked to indicate how confident they feel about the specified tasks when teaching science to the TIMSS class. In England, the proportion of pupils who had teachers who were very confident in answering pupils' questions about science (61.7 per cent) and helping pupils appreciate the value of learning science (65.4 per cent) was similar to the international average. However, the data suggests teachers in England are more confident than teachers in Northern Ireland where fewer than average pupils have teachers who feel very confident about these specified tasks (see Table 5).

[12] This refers to the primary class(es) in the schools who took part in the TIMSS 2011 assessment in England.

Table 5: Teacher confidence

In teaching science to this class, how confident do you feel…	% of pupils whose teachers answered 'very confident' (international average)	
	ENGLAND	**NI**
…answering students' questions about science?	61.7%	41.6% (62.1%)
…explaining science concepts or principles by doing science experiments?	58.5%	36.3% (51.1%)
…helping students appreciate the value of learning science?	65.4%	43.9% (68.0%)

Data is from the TIMSS 2011 teacher questionnaire, and reported as the *percentage of students* taught by teachers who gave each response. This is not necessarily the same as the percentage of teachers who gave the response. For example, one teacher might teach science to a single class while another might teach it to several classes. Similarly, numbers of pupils in classes may vary. Thus, each teacher's science teaching practice will impact differently on the overall pupil population.

Table 6: Learning activities

In teaching science to this class, how often do you usually ask students to…	% of pupils whose teachers answered 'half the lessons' or more (international average)		% of pupils whose teachers answered 'never' (international average)	
	ENGLAND	NI	ENGLAND	NI
…observe natural phenomena such as the weather or a plant growing and describe what they see?	35.9%	18.7% (44.3%)	1.0%	3.4% (1.7%)
…watch you demonstrate an experiment or investigation?	26.2%	8.9% (38.7%)	5.5%	11.3% (4.3%)
…design or plan experiments or investigations?	64.6%	18.6% (33.7%)	0.0%	4.0% (9.1%)
…conduct experiments or investigations?	68.4%	22.1% (38.6%)	0.0%	4.2% (3.9%)
…read their textbooks or other resource materials?	12.0%	22.3% (69.9%)	26.3%	11.2% (3.0%)
…memorise facts and principles?	11.7%	8.0% (51.5%)	28.8%	31.7% (11.2%)
…give explanations about something they are studying?	83.9%	52.7% (81.7%)	0.0%	0.8% (0.5%)
…relate what they are learning in science to their daily lives?	82.9%	60.4% (84.9%)	0.0%	0.7% (0.4%)
…do field work outside the class?	18.4%	7.1% (19.1%)	4.0%	19.8% (10.7%)
…take a written test or quiz?	3.1%	2.6% (33.3%)	19.2%	39.4% (6.2%)

Data is taken from the TIMSS 2011 teacher questionnaire.
Percentages do not total 100 as not all response categories are reported.

Teachers' emphasis on specific science activities was measured by responses to statements about how often they asked their pupils to undertake a variety of learning activities in their science lessons, shown in Table 6. Compared to the international average, a higher proportion of pupils in England had teachers who designed/planned experiments/investigations and conducted investigations in half or more of their lessons (64.6 per cent and 68.4 per cent respectively). In contrast, with notably more than average never asked to memorise facts (28.8 per cent) or take a test or quiz (19.2 per cent). The proportions of pupils who experienced these activities in half or more of their lessons was similar to the proportion in Northern Ireland.

Table 7 shows that the percentage of pupils taught each of the specified topics, before or in the TIMSS assessment year in England, was just below the international average for life science (72 per cent) and earth science (62 per cent), but above the international average for physical science (78 per cent).

Table 7: Primary pupils taught the TIMSS science topics

TIMSS Grade 4 science topics	% of pupils mostly taught the topic before or in the assessment year (international average)	
	ENGLAND	NI
All (20 topics)	71%	61% (64%)
Life science (6 topics)	72%	74% (75%)
Physical science (8 topics)	78%	57% (57%)
Earth science (6 topics)	62%	53% (63%)

Data from Martin *et al. (2012),* Exhibit 8.8.

Table 8 reports on teachers' preparedness to teach the science topics in the fourth grade assessment. Across this grade (Year 5 in England), 69 per cent of pupils were taught by teachers who felt very well prepared to teach the TIMSS science topics (slightly higher than the international average). Across the content domains, a larger percentage of pupils had teachers who felt very well prepared to teach the physical science topics (77 per cent) than the life science (71 per cent) and earth science topics (57 per cent). The range for earth science was particularly wide (considerably wider than the international average), with the majority of pupils taught by teachers who felt very well prepared to teach the earth's solar system (81.5 per cent) and less than a third with teachers with high levels of preparedness for teaching about fossils (28.4 per cent).

Table 8: Teacher preparedness

TIMSS Grade 4 science topics	% of pupils whose teachers feel 'very well prepared' to teach the topics (international average)		Highest and lowest percentages within each topic area (international range)	
	ENGLAND	NI	ENGLAND	NI
All (20 topics)	69%	54% (62%)	28.4% - 84.0%	27.6% - 62.8% (30.6% - 66.6%)
Life science (6 topics)	71%	62% (70%)	52.8% - 74.6%	43.1% - 62.2% (54.2% - 66.6%)
Physical science (8 topics)	77%	56% (62%)	55.1% - 84.0%	34.2% - 62.8% (35.2% - 62.4%)
Earth science (6 topics)	57%	44% (53%)	28.4% - 81.5%	27.6% - 59.9% (30.6% - 61.6%)

Data from Martin *et al. (2012),* Exhibit 7.9 and TIMSS 2011 teacher questionnaire.

There are no official policies in England on science homework at Key Stage 2. In 2011, 39 per cent of pupils in England were assigned no science homework. This is lower than the international average, and considerably smaller than the proportion seen in Northern Ireland. Only a very small percentage of pupils in England (0.3 per cent) were assigned homework three times a week or more (see Table 9).

Table 9: Science homework

How often do you usually assign science homework to the students in this class?	% of pupils whose teachers assign no homework (international average)		% of pupils whose teachers assign homework 3 times a week or more (international average)	
	ENGLAND	NI	ENGLAND	NI
	39%	62.1% (18.3%)	0.3%	0.0% (12.4%)

Data from TIMSS 2011 teacher questionnaire.

5.3.5 Teacher education specific to science

Teaching in England is an all-graduate profession into which there are two main routes: concurrent – a three- to four-year degree combining the study of one or more academic subjects with professional training in aspects of education; and consecutive - a three-year bachelor's degree, followed by a one-year Postgraduate Certificate in Education (PGCE). For each route, prospective teachers must pass five or more subjects with a grade of C or higher in their General Certificate of Secondary Education examinations (GCSEs), including English and mathematics, and pass two or more Advanced Level examinations (A-Levels) or their equivalent prior to acceptance into a teacher education programme. Prospective teachers must also pass professional skills tests in numeracy and literacy and those who intend to teach pupils ages three–11 must have achieved a grade C or above in a science subject at GCSE.

Primary teachers are trained to teach all subjects in the national curriculum, often coupled with a curriculum specialisation. About 25 per cent of England's primary TIMSS pupils were taught by teachers who studied post secondary science, and a further 20 per cent by teachers who had science as a specialism in their teacher education degree (see Table 10). Both figures are closer to the international average than is the case in Northern Ireland.

Table 10: Teacher specialisation

During your post-secondary education…	% of pupils whose teachers answered 'yes' (international average)	
	ENGLAND	**NI**
…was science your major or main area of study?	25.6%	11.7% (28.0%)
If your major or main area of study was education, was science your specialisation?	22.1%	9.7% (31.3%)

Data from the TIMSS 2011 teacher questionnaire.

Professional development

There are a variety of opportunities for continuing professional development (CPD) for teachers in England, ranging from in-school development opportunities and short, one-day, courses to higher degrees, studied part-time over several years and provided by local authorities, higher education institutions, or specialist companies or consultants. Most publicly funded schools allocate five days in each academic year to professional development, deciding which specific days and focuses best suit their needs. The National Network of Science Learning Centres has been set up to provide ongoing support for science teacher professional development.

Many pupils had teachers who had experienced science-related professional development in the previous two years (see Table 11). This ranged from 23.2 per cent for those teachers who had learned about integrating information technology into science to 42.5 per cent whose teachers had learned about and science pedagogy/instruction (higher than the international average). Interestingly, in England over 40 per cent of pupils were taught by teacher who had received training on science assessment, this was considerably more than the Northern Ireland and the international average.

Table 11: Professional development

In the past two years, have you participated in professional development in…	% of pupils whose teachers answered 'yes' (international average)	
	ENGLAND	**NI**
…science content?	28.9%	26.0% (34.9%)
…science pedagogy/instruction?	42.5%	27.9% (33.7%)
…science curriculum?	28.3%	28.6% (33.7%)
…integrating information technology into science?	23.2%	22.3% (27.9%)
…science assessment?	41.8%	5.1% (26.8%)
…addressing individual students' needs?	32.1%	12.5% (32.2%)

Data from the TIMSS 2011 teacher questionnaire.

5.3.6 Monitoring pupil progress in science

In order to monitor national standards in Key Stage 2 science, an externally marked science test, comprising two written papers, is administered to a representative sample of pupils; since 2014 this science test has been biennial. The Department for Education reports the proportion of pupils who attained Level 4 or above nationally in the science monitoring test. There is no reporting of this test at the school or local level. Teacher assessment results in science at Key Stage 2 (age 11) are also reported at a national summary level.

As part of reforms to the national curriculum, the national curriculum tests and teacher assessment at the end of Key Stages 1 and 2 will be reported in levels for the last time in summer 2015. The first new Key Stage 1 and Key Stage 2 tests in science, based on the new national curriculum, will be taken by pupils for the first time in the summer of 2016.

Table 12 shows how much emphasis teachers placed on a number of activities for monitoring pupil progress in science. It shows the evaluation of pupils' ongoing work is paramount; 100 per cent of pupils in England had teachers who placed major emphasis or some emphasis on this. The teachers of three-quarters of all pupils also placed emphasis on classroom tests to monitor progress and just over half of pupils

had teachers who placed emphasis on national or regional achievement tests to monitor pupil progress in science.

Table 12: Monitoring progress

How much emphasis do you place on … to monitor students' progress in science?	% of pupils whose teachers answered 'major/some' emphasis (international average)	
	ENGLAND	**NI**
…the evaluation of students' ongoing work…	100%	96.1% (98.5%)
…classroom tests…	77.1%	54.7% (93.0%)
…national or regional achievement tests…	52.3%	27.2% (67.7%)

Data from the TIMSS 2011 teacher questionnaire.

5.4 Finland[13]

5.4.1 Overview of the primary education system

Recent educational policy in Finland is working toward accentuating core competencies and defining standards of proficiency levels in core subject areas. A review of basic education has just been published as well as a review of the curriculum; this will be implemented from 2016.[14]

Structure of the primary education system in Finland

Age	7-16
Stage	A nine-year educational programme, split into two stages Grades 1-6 and 7-9
ISCED level	Grade 1-6 (ages 7-13) = ISCED level 1 Grade 7-9 (ages 13-16) = ISCED level 2
Curriculum	Mother tongue and literature (Finnish or Swedish); the other national language (Swedish or Finnish); foreign languages; environmental studies; health education; religion or ethics; history; social studies; mathematics; physics; chemistry; biology; geography; physical education; music; visual arts; craft; home economics.

Children begin their primary education when they reach seven years of age, when compulsory education usually starts. The basic education syllabus spans nine years, which nearly all children complete by attending comprehensive school. Basic education is free of charge for all pupils and includes textbooks and other materials, a free daily meal, and school health care and other welfare services.

The majority of pupils attend publicly funded schools. Municipalities or federations of municipalities maintain most primary level institutions. Private schools receive the same level of public funding as publicly funded schools. Municipalities have significant freedom in organising schooling along the general guidelines provided by the Ministry and the National Board. In addition, schools (and teachers) have autonomy regarding pedagogical practices and methods of pupil assessment within the guidelines of the national curriculum.

Finland has two official languages; Finnish is spoken by 93 per cent of the country's 5.4 million inhabitants and Swedish is spoken by approximately six per cent of the population, most of whom can also speak Finnish. The constitution of Finland stipulates that the two national languages are equal throughout the country with

[13] Main source of information: TIMSS 2011 Encyclopaedia, with updated information indicated and updated sources (and other data sources) given as applicable.
http://timssandpirls.bc.edu/timss2011/encyclopedia-timss.html
[14] Review of basic education:.
http://www.minedu.fi/OPM/Julkaisut/2015/tulevaisuuden_peruskoulu.html?lang=fi&extra_locale=en
Review of the curriculum:
http://www.oph.fi/english/current_issues/101/0/what_is_going_on_in_finland_curriculum_reform_2016

respect to dealing with authorities and schooling and are languages of instruction for all educational levels and school subjects.

5.4.2 Science curriculum in primary education

Environmental and natural studies is taught in Grades 1-4 (ages seven to 11) as an integrated subject encompassing the fields of biology, geography, physics, chemistry, and health education. Instruction is focussed on sustainable development and on pupils knowing and understanding nature and the man-made environment, themselves and other people, human diversity, and health and disease. Instruction also relies on an investigative, problem-centred approach in which the starting points include pupils' existing knowledge, skills and experiences, and things, phenomena and events connected to their environment and the pupils themselves. With the aid of experiential instruction, the curriculum steers pupils towards developing a positive relationship with nature and the environment.

During these first four years, the core content of studies in environmental and natural studies includes: organisms and living environments; immediate environment, home region, and the globe as human living environments; natural phenomena; substances around us; the individual and health; and safety. From the fifth through to the ninth grade, science is taught as separate subjects including biology, geography, physics, chemistry, and health.

5.4.3 Teaching science in primary education

Teaching materials, equipment and laboratories

In Finland, the main materials for teaching science are textbooks published by commercial publishers. These are not subject to official approval but they must comply with national curriculum guidelines. There are two to three widely used textbook series for primary level (Grade 4) education. Schools and teachers are free to choose any textbook series they find suitable.

The Finnish curriculum specifies that, when studying science, pupils should have an opportunity to observe and analyse. Consequently, being able to work and move about safely is essential. The number of teaching facilities specially equipped for science instruction is based on the number of science lesson hours per week: one room is needed for up to 27 lesson hours. In addition, appropriate laboratory equipment should be available for teachers and pupils (e.g. draught, germination, heat cupboards, sinks, faucets, and hot plates).

Despite these specifications, in 2011 over 80 per cent of primary pupils were in schools where the headteacher considered that the capacity to teach was affected by a shortage of science equipment and materials. This was slightly higher than the international average (see Table 1).

Use of technology

The National Core Curriculum includes six cross-curricular themes, and their objectives and contents are incorporated into a range of subjects. Integrating

education and instruction, the cross-curricular themes also respond to topical educational challenges. One cross-curricular theme, 'technology and the individual', has the goal of helping pupils understand an individual's relationship to technology and recognise the importance of technology in daily life.

There are 5.5 pupils for each computer in basic education in Finland, on average, and, in primary schools, nearly 80 per cent of schools have fewer than ten pupils per computer. Although the use of technology is becoming more common in science instruction, in spring 2006, only 13 per cent of science teachers reported using ICT regularly in their teaching. In science instruction, ICT is used for measurements, reporting results, and searching and processing knowledge. Various types of measurement equipment and mobile devices are used both in the classroom and in outdoor studies.

Over three-quarters of pupils in 2011 were in schools where the headteacher felt that the school's capacity to teach was affected by a shortage of software and audio-visual resources for science instruction. As was the case in Northern Ireland, this perceived shortage was slightly higher than the international average.

Introduction of specialist teachers for science

There are specialist teachers for science in Grades 7–9 (lower-secondary level of the comprehensive school, ages 14-16). Classroom teachers teach environmental and natural studies mainly in Grades 1–6 (primary level, ages seven-13).

In 2011, about two-thirds of primary pupils were in schools where a shortage of teachers with a specialisation in science was considered to affect the schools capacity to teach. This was similar to the international average (although smaller proportion of pupils than were affected in Northern Ireland).

Table 1: Capacity to provide instruction

How much is your school's capacity to provide instruction affected by a shortage or inadequacy of…	% of pupils whose headteachers answered 'not at all' (international average)		% of pupils whose headteachers answered 'a little/some/a lot' (international average)	
Teaching materials, equipment and laboratories				
	FINLAND	**NI**	**FINLAND**	**NI**
…library materials relevant to science instruction?	24.9%	18.0% (27.5%)	75.2%	81.9% (72.5%)
…science equipment and materials?	14.4%	19.8% (19.6%)	85.5%	80.2% (80.5%)
Use of technology				
…computer software for science instruction?	17.2%	18.0% (22.7%)	82.8%	81.9% (77.3%)
…audio-visual resources for science instruction?	16.7%	21.1% (22.7%)	83.3%	78.8% (77.3%)
Introduction of specialist teachers for science				
…teachers with a specialisation in science?	34.8%	24.6% (37.3%)	65.2%	75.4% (62.6%)

Data is from the TIMSS 2011 school questionnaire, reported as the *percentage of students* taught in schools where the headteacher gave the indicated response. This is not necessarily the same as the percentage of schools which gave the response (e.g. schools vary in size, so perceived shortages in a small school may impact on fewer pupils than in a large school). Percentages may not total 100 due to rounding.

Primary pupil attitudes to science and science lessons

Table 2 shows pupil attitudes to science and science lessons are less positive in Finland compared with the international average and those seen in Northern Ireland. A large majority of pupils in Finland agree that they learn many interesting things in science (80.7 per cent) and that it is important to do well in science (80.5 per cent). Just over three-quarters of pupils enjoy learning science (75.8 per cent).

Table 2: Pupil attitudes to science and science lessons

How much do you agree that…	% of pupils who 'agree a lot/agree a little' (international average)		% of pupils who 'disagree a lot/ disagree a little' (international average)	
	FINLAND	NI	FINLAND	NI
…you enjoy learning science?	75.8%	87.1% (88.0%)	24.3%	13.0% (11.9%)
…you learn many interesting things in science?	80.7%	88.1% (90.2%)	19.3%	11.9% (9.8%)
…you like science?	70.2%	84.1% (85.7%)	29.8%	15.9% (14.4%)
…it is important to do well in science?	80.5%	87.9% (91.0%)	19.5%	12.1% (9.0%)
…your teacher gives you interesting things to do in your science lessons?	69.0%	89.5% (85.6%)	31.0%	10.6% (14.3%)

Data from the TIMSS 2011 student questionnaire.
Percentages may not total 100 due to rounding.

5.4.4 Teaching science to the TIMSS class[15]

In Finland fewer than 4 per cent of pupils in 2011 experienced science as an integrated subject, compared with nearly a quarter internationally. The remaining 96 per cent were taught science as a separate subject (see Table 3). Average teaching time for science for the TIMSS class in Finland was 98 hours a year, higher than the international average and 26 more hours a year than in Northern Ireland (see Table 4).

[15] This refers to the primary class(es) in the schools who took part in the TIMSS 2011 assessment in Finland.

Table 3: Science in the curriculum

Is science taught mainly as a separate subject?	% of pupils whose teachers answered 'no' (international average)	
	FINLAND	NI
	3.7% (23.0%)	72.3%

Data from the TIMSS 2011 teacher questionnaire.

Table 4: Teaching hours in primary science

Teaching hours per year	Total teaching hours (international average)		Science teaching hours (international average)	
	FINLAND	NI	FINLAND	NI
	779 (897)	970	98 (85)	72

Data from Martin *et al. (2012),* Exhibit 8.6.

Fewer than average pupils (see Table 5) had teachers who were very confident about explaining science concepts by doing experiments (29.4 per cent), answering questions (42.8 per cent), or helping pupils appreciate the value of learning science (65.2 per cent).

Table 5: Teacher confidence

In teaching science to this class, how confident do you feel…	% of pupils whose teachers answered 'very confident' (international average)	
	FINLAND	**NI**
…answering students' questions about science?	42.8%	41.6% (62.1%)
…explaining science concepts or principles by doing science experiments?	29.4%	36.3% (51.1%)
…helping students appreciate the value of learning science?	65.2%	43.9% (68.0%)

Data is from the TIMSS 2011 teacher questionnaire, and reported as the *percentage of students* taught by teachers who gave each response. This is not necessarily the same as the percentage of teachers who gave the response. For example, one teacher might teach science to a single class while another might teach it to several classes. Similarly, numbers of pupils in classes may vary. Thus, each teacher's science teaching practice will impact differently on the overall pupil population.

Percentages may not total 100 due to rounding.

Teachers' emphasis on specific science activities was measured by responses to statements about how often they asked their pupils to undertake a variety of learning activities in their science lessons, shown in Table 6. In Finland, fewer than average pupils had teachers who carried out a number of the specified science activities in half or more of their science lessons. Most notably far fewer pupils in Finland were asked to watch the teacher demonstrate an experiment/investigation, plan an experiment or investigation or conduct experiments/investigations. However, more than average were asked to read their textbooks or other resource materials (93.9 per cent); relate what they are learning in science to their daily lives (87.7 per cent) and to give explanations about something they are studying (87.4 per cent).

Table 6: Learning activities

In teaching science to this class, how often do you usually ask students to…	% of pupils whose teachers answered 'half the lessons' or more (international average)		% of pupils whose teachers answered 'never' (international average)	
	FINLAND	NI	FINLAND	NI
…observe natural phenomena such as the weather or a plant growing and describe what they see?	42.7%	18.7% (44.3%)	0.5%	3.4% (1.7%)
…watch you demonstrate an experiment or investigation?	13.3%	8.9% (38.7%)	2.9%	11.3% (4.3%)
…design or plan experiments or investigations?	3.3%	18.6% (33.7%)	23.2%	4.0% (9.1%)
…conduct experiments or investigations?	11.1%	22.1% (38.6%)	5.5%	4.2% (3.9%)
…read their textbooks or other resource materials?	93.9%	22.3% (69.9%)	0%	11.2% (3.0%)
…memorise facts and principles?	29.0%	8.0% (51.5%)	10%	31.7% (11.2%)
…give explanations about something they are studying?	87.4%	52.7% (81.7%)	0%	0.8% (0.5%)
…relate what they are learning in science to their daily lives?	87.7%	60.4% (84.9%)	0%	0.7% (0.4%)
…do field work outside the class?	13.4%	7.1% (19.1%)	12.5%	19.8% (10.7%)
…take a written test or quiz?	8.2%	2.6% (33.3%)	1.8%	39.4% (6.2%)

Data is taken from the TIMSS 2011 teacher questionnaire.
Percentages do not total 100 as not all response categories are reported.

Table 7 shows that, in Finland, the percentage of pupils taught each of the specified topics, before or in the TIMSS assessment year, was below the international average for each of, earth science (53 per cent) and physical science (43 per cent), although coverage of life science (73 per cent) was close to the international average.

Table 7: Primary pupils taught the TIMSS science topics

TIMSS Grade 4 science topics	% of pupils mostly taught the topic before or in the assessment year (international average)	
	FINLAND	NI
All (20 topics)	55%	61% (64%)
Life science (6 topics)	73%	74% (75%)
Physical science (8 topics)	43%	57% (57%)
Earth science (6 topics)	53%	53% (63%)

Data from Martin *et al. (2012),* Exhibit 8.8.

Table 8 reports teachers' preparedness to teach the science topics in the fourth grade assessment.

Fifty-one per cent of pupils in Finland were taught by very well prepared teachers; lower than the percentage in Northern Ireland and the international average. Across the content domains, a larger percentage of pupils had teachers who felt very well prepared to teach the life science topics (63 per cent) than the earth science topics (51 per cent) or the physical science topics (41 per cent); again lower than the international average. The ranges for earth science and physical science were relatively wide, wider than the international average. Some topics (fossils, firming and separating mixtures and electrical circuits and magnets) had around a quarter of pupils taught by teachers who felt very well prepared, while others (energy sources, water on earth and air, and weather) had higher levels of preparedness (around half or more of pupils taught by such teachers).

Table 8: Teacher preparedness

TIMSS Grade 4 science topics	% of pupils whose teachers feel 'very well prepared' to teach the topics (international average)		Highest and lowest percentages within each topic area (international range)	
	FINLAND	NI	FINLAND	NI
All (20 topics)	51%	54% (62%)	18.7% - 69.6%	27.6% - 62.8% (30.6% - 66.6%)
Life science (6 topics)	63%	62% (70%)	50.6% - 69.6%	43.1% - 62.2% (54.2% - 66.6%)
Physical science (8 topics)	41%	56% (62%)	18.7% - 51.9%	34.2% - 62.8% (35.2% - 62.4%)
Earth science (6 topics)	51%	44% (53%)	21.9% - 68.0%	27.6% - 59.9% (30.6% - 61.6%)

Data from Martin *et al. (2012),* Exhibit 7.9 and TIMSS 2011 teacher questionnaire.

Finland has no official homework policy. The Decree on Basic Education, however, does specify that, after the school day, and travelling to and from school and completing homework, the pupil must have enough time for rest, hobbies and recreation. In practice, teachers assign homework from pupil textbooks.

Table 9 shows that, in 2011, less than one per cent of pupils in the Finland were assigned no science homework, far lower than the international average of 18.3 per cent. Just over a third were assigned science homework three times a week or more, more than double the international average and considerably higher than is seen in Northern Ireland.

Table 9: Science homework

How often do you usually assign science homework to the students in this class?	% of pupils whose teachers assign no homework (international average)		% of pupils whose teachers assign homework 3 times a week or more (international average)	
	FINLAND	NI	FINLAND	NI
	0.7%	62.1% (18.3%)	32.6%	0.0% (12.4%)

Data from TIMSS 2011 teacher questionnaire.

5.4.5 Teacher education specific to science

In Finland, a master's degree is a prerequisite for teacher qualification. Eight universities provide teacher education for both general classroom teachers as well as specialist teachers. The general content and structure of teacher education programmes, as well as the master's degree programme requirements, are regulated by central government, but universities have independence regarding the specific content of teacher education programmes.

Classroom teachers are responsible for teaching pupils in Grades 1–6. Prospective classroom teachers major in education and normally complete their master's degree programmes within five years. In chemistry and physics education, the amount of compulsory study is three credits in each subject. In addition to the compulsory courses, prospective classroom teachers may complete an elective minor subject (60 credits), which qualifies them to teach this particular subject as a specialist teacher in Grades 7–9 (lower secondary education). Altogether, 20 credits are allocated to guided teaching practice during pedagogical studies.

Specialist teacher education is provided in cooperation with different university departments and faculties. In general, specialist teacher education lasts five to six years. Prospective specialist teachers in science choose a major (160 credits) and a minor (60 credits) within the subjects they intend to teach. Specialist teachers are required to take 60 credits of pedagogical studies, one-third of which consists of guided teaching practice (20 credits). Prospective specialist teachers complete their master's thesis (40 credits) in their subject-area major.

In Finland, less than one per cent of pupils had primary teachers with science as their main area of post-secondary study (see Table 10); this is much lower than the percentage seen in Northern Ireland. Fewer than fifteen per cent had teachers with a science education specialism, considerably lower than the international average.

Table 10: Teacher specialisation

During your post-secondary education…	% of pupils whose teachers answered 'yes' (international average)	
	FINLAND	**NI**
… was science your major or main area of study?	0.8%	11.7% (28.0%)
If your major or main area of study was education, was science your specialisation?	14.9%	9.7% (31.3%)

Data from the TIMSS 2011 teacher questionnaire.

Professional development

There is no specific legislation governing continuing teacher education and training, but teachers are obliged to participate in in-service training for one to five days a year according to the relevant statutes and collective agreements. The primary responsibility for in-service teacher training lies with the education providers. These bodies ensure that teachers participate in continuing professional development as laid down in legislation and collective agreements. Teachers themselves have also been given greater responsibility for developing their professional skills and expertise. More and more attention is being paid to self-motivated continuing education and training, and local authorities support this within their financial limits and with financial support from the State. The State is primarily responsible for continuing education that is important for implementing education policy and which promotes its aims, that is, education providers and teachers are supported by government funding in terms of reforms significant to education policy. Most of the funding is channelled through the Finnish National Board of Education and the Regional State Administrative Agencies. Continuing professional development (CPD) for those providing teacher training is funded directly by the Ministry of Education on the basis of applications from these providers.

In 2008, the Ministry of Education appointed an advisory board for the professional development of education personnel and the development of training for teaching staff. The board was tasked to anticipate the changes in the learning needs of teaching staff, to follow up on the status of continuing training and its development needs and propose initiatives for the development of continuing training. A fixed-term national programme was set up in 2010 to support education providers in providing CPD to their education personnel and ensuring staff opportunities to improve their professional competence; this was foreseen to continue until 2016. In monitoring developments at the national level, CPD has been included in the national teacher data collection commissioned on a regular basis. The most recent data collection was carried out in 2013.

Relative to the international average, few pupils had teachers who had participated in science-related professional development in the previous two years (see Table 11). This ranged from 2.5 per cent for those teachers had learned about science curriculum, up to 14.3 per cent for those teachers who had received training about addressing individual needs. In general, these percentages were lower than those seen in Northern Ireland.

Table 11: Professional development

In the past two years, have you participated in professional development in…	% of pupils whose teachers answered 'yes' (international average)	
	FINLAND	**NI**
…science content?	10.4%	26.0% (34.9%)
…science pedagogy/instruction?	10.0%	27.9% (33.7%)
…science curriculum?	2.5%	28.6% (33.7%)
…integrating information technology into science?	5.1%	22.3% (27.9%)
…science assessment?	3.6%	5.1% (26.8%)
…addressing individual students' needs?	14.3%	12.5% (32.2%)

Data from the TIMSS 2011 teacher questionnaire.

5.4.6 Monitoring pupil progress in science

The Finnish National Board of Education is responsible for conducting national assessments of learning outcomes. National assessments are sample-based and focus on the central content of the national curriculum, mainly at the end of basic education (Grade 9). There are no national assessments during basic education. Since 1998, the Finnish National Board of Education has implemented two national assessments of natural sciences (in Grade 9, in 1998 and 2011). These national assessments provide schools and teachers with regular updates on the knowledge and skills of their pupils in relation to other schools and national objectives of instruction.

Teachers are responsible for pupil assessment in the classroom and may decide on the methods of assessment, which typically include teacher-produced tests, tests based on the textbook and continuous observation of pupil progress.

Table 12 shows how much emphasis teachers placed on a number of activities for monitoring pupil progress in science. It shows that the evaluation of pupils' work is paramount; almost all pupils (99.6 per cent) are taught by teachers who monitor their progress based on ongoing evaluation of their work (similar to the international average). In contrast, only a quarter of pupils are assessed through national or regional achievement tests, much lower than the international average.

Table 12: Monitoring progress

How much emphasis do you place on … to monitor students' progress in science?	% of pupils whose teachers answered 'major/some' emphasis (international average)	
	FINLAND	**NI**
…the evaluation of students' ongoing work…	99.6%	96.1% (98.5%)
…classroom tests…	98.5%	54.7% (93.0%)
…national or regional achievement tests…	21.7%	27.2% (67.7%)

Data from the TIMSS 2011 teacher questionnaire.

5.5 Hungary[16]

5.5.1 Overview of the primary education system

The largest organiser of schools in Hungary is the Government itself, and most federally operated schools and pupil residence facilities are maintained by local governments. Some specialist vocational training institutions (e.g. for the police and the military) are operated by ministries or nationally funded organisations. Religious institutions maintain another substantial proportion of schools. Foundation schools, or private non-denominational schools, comprise the smallest group.

The Hungarian Government finances the public education system and the institutions related to it. The Ministry of Human Resources distributes the primary source of this funding through a monthly subsidy to those responsible for school management. Each school's subsidy is based on the number of children attending the school, and the organisation responsible for administering the school pays the remaining operational costs. Religious institutions may obtain additional government financing if they perform duties in the public education system.

Between 1998 and 2011, education in Hungary was compulsory for children up to age 18. Under the Public Education Act of 2011, education became compulsory only until the age of 16. This change is being phased in: the new lower age (16) applied to pupils starting Grade 9 from the 2012/13 school year; the higher school leaving age (18) continues to apply to pupils in the grades above. Education consists of three levels: pre-primary, primary and secondary.

Structure of the primary education system in Hungary

Age	5 –14 years (5- to 6- year-olds attend a compulsory kindergarten year)
Stage	Basic education consists of two stages: Primary (Grades 1 to 4, ages 6-10) Lower secondary (Grades 5 to 8, ages 10-14)
ISCED level	Age 5-6 ISCED 0 Age 6-10 ISCED 1 Age 10-14 ISCED 2
Curriculum	Hungarian language and literature, living foreign language, mathematics, humans and society, humans in nature, our earth and environment, arts, IT, lifestyle and practical skills, physical exercise and sports.

[16] Main source of information: TIMSS 2011 Encyclopaedia, with updated information indicated and updated sources (and other data sources) given as applicable. http://timssandpirls.bc.edu/timss2011/encyclopedia-timss.html

Practically all children ages five–14 attend pre-primary and basic general school programmes, with an enrolment rate of 98.9 percent in 2009. In Hungary, all children must take part in institutional education and complete compulsory education. Basic education is mandatory for eight years and is free. The basic education phase consists of two stages: the primary phase (Grades 1 to 4) and the lower secondary phase (Grades 5 to 8).

In the summer of 2010, the newly elected Government started a large-scale conceptualisation and codification process to write a completely new educational law to replace the Public Education Act LXXXIX of 1993.

Hungarian is the official language as well as the language of instruction. However, some minorities, such as Croatians, Germans, Romanians, Serbs, Slovaks, and Slovenes, have their own educational institutions within the system. In 2010, 4.6 per cent of pupils attended minority-operated mother tongue, bilingual, or language-teaching schools and kindergartens. Since 2004, classes have also been offered in Bulgarian, Greek, Polish, Armenian, Ruthenian, and Ukrainian. The largest minority in Hungary is the Roma community; Roma institutions of cultural education cater to 3.8 per cent of children.

5.5.2 Science curriculum in primary education

In Grade 4 (age 9-10), science is taught as an integrated natural science subject, while in Grade 8 (age 13-14), the curriculum is separated into studies of physics, chemistry, biology, and earth and environment.

The integrated natural science topics for Grade 4 pupils are: methods of cognition; basics of inanimate nature; maps and mapping; basics of animate nature; and the human body and its functions. The integrated natural science topics for Grade 8 pupils are: physics – motion, energy, work and heat, electricity; chemistry – basic concepts, relationships and laws in chemistry, and applications of matter; biology and hygiene – ecosystems and biomes, human body and health; earth and the environment – our earth and the environment, basics of geology, the hydrosphere, the atmosphere, and formation of the geosphere.

A new National Core Curriculum was phased in from September 2013, and the related detailed framework curricula for the various school types and school subjects provide a new framework for the content of school education. These define the content of learning to be passed on, the shared values and deliverables, as well as skills and competence requirements. The frameworks are accompanied by new textbooks (printed and digital), which are being tested by 126 schools in the 2014/15 school year.

5.5.3 Teaching science in primary education

Teaching materials, equipment and laboratories

Textbooks, exercise books, and teachers' editions of textbooks are the main instructional materials for teaching science, both for integrated science courses in Grades 1–6 and for the separate subject areas in Grades 7–8. According to the

Public Education Act, teachers can choose textbooks and other instructional materials to correspond with their local curriculum, selecting from a range of texts accredited by the Educational Authority, an institute of the Ministry of Education.

Science teaching and learning in the primary basic education phase (Grades 1–4) takes place in the classroom. Generally, a special science room or laboratory is not provided at this level. The need for these teaching aids has been recognised and, as a result, a number of projects have recently started throughout the country to supply schools with laboratories and equipment for teaching science. It is perhaps unsurprising, therefore, that in 2011over 80 per cent of primary pupils were in schools where the headteacher considered that capacity to teach was affected by a shortage of science equipment and materials (similar to the international average and the percentage in Northern Ireland).

Use of technology

The 2007 amendment of the National Core Curriculum has led to computer-aided learning becoming more common across the school system. Partly as a result of this, more and more schools use technology (for example mobile phones and digital cameras) in the implementation of the new learning methodologies. The use of electronic curricula is supported by a national online educational portal, Sulinet Digitális Tudásbázis (www.sdt.hu). However, the use of ICT tools is not typically seen in the teaching of physics, biology and chemistry (taught from Grade 7 onwards). This situation is similar for primary science, where there little use of technology in science lessons. The number of science lessons in primary schools restricts the time available for teacher demonstrations and for pupils to undertake experiments[17].

It is unsurprising, therefore that in 2011, the vast majority of pupils were in schools where the headteacher considered that the capacity to teach was affected by a shortage of computer software and audio-visual resources for science instruction (83.9 and 78.0 per cent respectively).The perceived shortage of computer software was similar to Northern Ireland but higher than the international average.

Introduction of specialist teachers for science

In primary schools, one teacher is responsible for teaching all subjects to a single cohort of pupils (known as a class) from first through to fourth grade, although many schools have specialist teachers for science. Specialist education takes place in Grades 7 to 8, where a specialist teacher is responsible for teaching each specialist subject. Given that many primary schools have a specialist science teacher, it is unsurprising that in 2011 less than a third of pupils were in schools where the capacity to teach was affected by a lack of specialist science teachers. This is in stark contrast to Northern Ireland where this was the case for three-quarters of primary pupils.

[17] Eurypedia: https://webgate.ec.europa.eu/fpfis/mwikis/eurydice/index.php/Hungary:Teaching_and_Learning_in_Single_Structure_Education

Table 1: Capacity to provide instruction

How much is your school's capacity to provide instruction affected by a shortage or inadequacy of…	% of pupils whose headteachers answered 'not at all' (international average)		% of pupils whose headteachers answered 'a little/some/a lot' (international average)	
Teaching materials, equipment and laboratories				
	HUNGARY	**NI**	**HUNGARY**	**NI**
…library materials relevant to science instruction?	33.6%	18.0% (27.5%)	66.3%	81.9% (72.5%)
…science equipment and materials?	17.5%	19.8% (19.6%)	82.5%	80.2% (80.5%)
Use of technology				
…computer software for science instruction?	16.2%	18.0% (22.7%)	83.9%	81.9% (77.3%)
…audio-visual resources for science instruction?	21.9%	21.1% (22.7%)	78.0%	78.8% (77.3%)
Introduction of specialist teachers for science				
…teachers with a specialisation in science?	70.7%	24.6% (37.3%)	29.3%	75.4% (62.6%)

Data is from the TIMSS 2011 school questionnaire, reported as *the percentage of students* taught in schools where the headteacher gave the indicated response. This is not necessarily the same as the percentage of schools which gave the response (e.g. schools vary in size, so perceived shortages in a small school may impact on fewer pupils than in a large school). Percentages may not total 100 due to rounding.

Primary pupil attitudes to science and science lessons

Table 2 shows pupil attitudes to science and science lessons (from the TIMSS 2011 pupil questionnaire). Pupil attitudes in Hungary are broadly similar to the international average. Slightly more pupils than the international average consider it is important to do well in science (92.5 per cent). However, slightly fewer than the international average enjoy learning science or like science.

Table 2: Pupil attitudes to science and science lessons

How much do you agree that…	% of pupils who 'agree a lot/agree a little' (international average)		% of pupils who 'disagree a lot/ disagree a little' (international average)	
	HUNGARY	NI	HUNGARY	NI
…you enjoy learning science?	82.9%	87.1% (88.0%)	17.2%	13.0% (11.9%)
…you learn many interesting things in science?	90.2%	88.1% (90.2%)	9.9%	11.9% (9.8%)
…you like science?	81.4%	84.1% (85.7%)	18.6%	15.9% (14.4%)
…it is important to do well in science?	92.5%	87.9% (91.0%)	7.5%	12.1% (9.0%)
…your teacher gives you interesting things to do in your science lessons?	88.3%	89.5% (85.6%)	11.7%	10.6% (14.3%)

Data from the TIMSS 2011 student questionnaire. Percentages may not total 100 due to rounding.

5.5.4 Teaching science to the TIMSS class[18]

Although in Hungary at Grade 4 science is taught as an integrated natural science subject, fewer than ten per cent of pupils in 2011 experienced science as an integrated subject. The remaining 92 per cent were taught it as a separate subject (see Table 3). Average science teaching time in the TIMSS class in Hungary was 72 hours a year (lower than the international average) (see Table 4). Although the average number of hours a year spent teaching science was the same in Hungary and Northern Ireland, in Hungary this represented a larger proportion of the overall teaching hours per year.

[18] This refers to the primary class(es) in the schools who took part in the TIMSS 2011 assessment in Hungary.

Table 3: Science in the curriculum

Is science taught mainly as a separate subject?	% of pupils whose teachers answered 'no' (international average)	
	HUNGARY	NI
	7.4% (23.0%)	72.3%

Data from the TIMSS 2011 teacher questionnaire.

Table 4: Teaching hours in primary science

Teaching hours per year	Total teaching hours (and international average)		Science teaching hours (and international average)	
	HUNGARY	NI	HUNGARY	NI
	760 (897)	970	72 (85)	72

Data from Martin *et al*. (2012), Exhibit 8.6.

In Finland, the percentage of pupils with teachers who were very confident about explaining science concepts or principles by doing science experiments (52.1 per cent) and answering pupils' questions about science (60.1 per cent) was similar to the international average. Compared with the international average, more pupils had teachers who were very confident about helping pupils appreciate the value of learning science (79.9 per cent), nearly twice the percentage in Northern Ireland (see Table 5).

Table 5: Teacher confidence

In teaching science to this class, how confident do you feel…	% of pupils whose teachers answered 'very confident' (international average)	
	HUNGARY	**NI**
…answering students' questions about science?	60.1%	41.6% (62.1%)
… explaining science concepts or principles by doing science experiments?	52.1%	36.3% (51.1%)
… helping students appreciate the value of learning science?	79.9%	43.9% (68.0%)

Data is from the TIMSS 2011 teacher questionnaire, and reported as the *percentage of students* taught by teachers who gave each response. This is not necessarily the same as the percentage of teachers who gave the response. For example, one teacher might teach science to a single class while another might teach it to several classes. Similarly, numbers of pupils in classes may vary. Thus, each teacher's science teaching practice will impact differently on the overall pupil population.

Percentages may not total 100 due to rounding.

Teachers' emphasis on specific science activities was measured by responses to statements about how often they asked their pupils to undertake a variety of learning activities in their science lessons. In Hungary, fewer than average pupils had teachers who carried out activities involving experiments or investigations in half or more of their science lessons (see Table 6). However, notably more than average were asked to relate, what they were learning to their daily lives (94.6 per cent), read their text books or other resource materials (93.7 per cent) and take written tests or quizzes (59.9 per cent). The percentage of pupils who were never asked to carry out the specified activities was generally small. However, nearly a fifth of pupils were never asked to design or plan experiments or investigations (19.4 per cent), this was much higher than in Northern Ireland (four per cent) and the international average.

Table 6: Learning activities

In teaching science to this class, how often do you usually ask students to…	% of pupils whose teachers answered 'half the lessons' or more (international average)		% of pupils whose teachers answered 'never' (international average)	
	HUNGARY	NI	HUNGARY	NI
…observe natural phenomena such as the weather or a plant growing and describe what they see?	35.3%	18.7% (44.3%)	0.0%	3.4% (1.7%)
…watch you demonstrate an experiment or investigation?	27.8%	8.9% (38.7%)	0.7%	11.3% (4.3%)
…design or plan experiments or investigations?	8.1%	18.6% (33.7%)	19.4%	4.0% (9.1%)
…conduct experiments or investigations?	8.5%	22.1% (38.6%)	4.9%	4.2% (3.9%)
…read their textbooks or other resource materials?	93.7%	22.3% (69.9%)	0.0%	11.2% (3.0%)
…memorise facts and principles?	67.0%	8.0% (51.5%)	6.1%	31.7% (11.2%)
…give explanations about something they are studying?	84.1%	52.7% (81.7%)	0.0%	0.8% (0.5%)
…relate what they are learning in science to their daily lives?	94.6%	60.4% (84.9%)	0.1%	0.7% (0.4%)
…do field work outside the class?	22.4%	7.1% (19.1%)	3.7%	19.8% (10.7%)
…take a written test or quiz?	59.9%	2.6% (33.3%)	0.0%	39.4% (6.2%)

Data is taken from the TIMSS 2011 teacher questionnaire.
Percentages do not total 100 as not all response categories are reported.

In Hungary, the percentage of pupils taught each of the specified topics, before or in the TIMSS Grade 4 assessment year, was above the international average for life science (91 per cent) and earth science (67 per cent), but below the international average for physical science (49 per cent) (see Table 7).

Table 7: Primary pupils taught the TIMSS science topics

TIMSS Grade 4 science topics	% of pupils mostly taught the topic before or in the assessment year (international average)	
	HUNGARY	NI
All (20 topics)	67%	61% (64%)
Life science (6 topics)	91%	74% (75%)
Physical science (8 topics)	49%	57% (57%)
Earth science (6 topics)	67%	53% (63%)

Data from Martin *et al. (2012),* Exhibit 8.8.

In Hungary, slightly fewer pupils than average had teachers who felt very well prepared to teach the science topics (see Table 8). Across the content domains, a larger percentage of pupils have teachers who feel very well prepared to teach life science (71 per cent) than physical science (56 per cent) with earth science lowest (49 per cent).The ranges for all three sub-domains were wider than the international average. The ranges for earth science and physical science were particularly wide. Some topics (fossils, light, electrical circuits and magnets, and forces) had fewer than a fifth of pupils taught by teachers who felt very well prepared, while others (physical properties, features of the earth's landscape and weather) had higher levels of preparedness (around half or more of pupils taught by such teachers).

Table 8: Teacher preparedness

TIMSS Grade 4 science topics	% of pupils whose teachers feel 'very well prepared' to teach the topics (international average)		Highest and lowest percentages within each topic area (international range)	
	HUNGARY	NI	HUNGARY	NI
All (20 topics)	58%	54% (62%)	7.7% - 76.8%	27.6% - 62.8% (30.6% - 66.6%)
Life science (6 topics)	71%	62% (70%)	37.9% - 76.8%	43.1% - 62.2% (54.2% - 66.6%)
Physical science (8 topics)	56%	56% (62%)	7.7% - 65.3%	34.2% - 62.8% (35.2% - 62.4%)
Earth science (6 topics)	49%	44% (53%)	13.1% - 72.4%	27.6% - 59.9% (30.6% - 61.6%)

Data from Martin *et al. (2012),* Exhibit 7.9. and TIMSS 2011 teacher questionnaire.

Homework policies are determined locally. An acceptable homework policy needs to account for the daily learning capacity of pupils with average abilities and average preparedness, the weekly schedule of school instruction, and leisure time. Local policies must link to the quantity and distribution of written tests, which can be given on specific school days, especially on the first school day of the week. Table 9 shows that, in 2011, less than one per cent of pupils in Hungary were assigned no science homework, far lower than the international average of 18.3 per cent and considerably lower than Northern Ireland (62.1 per cent). Fewer than three per cent were assigned science homework three times a week or more, again far lower than the international average.

Table 9: Science homework

How often do you usually assign science homework to the students in this class?	% of pupils whose teachers assign no homework (international average)		% of pupils whose teachers assign homework 3 times a week or more (international average)	
	HUNGARY	NI	HUNGARY	NI
	0.7%	62.1% (18.3%)	2.8%	0.0% (12.4%)

Data from TIMSS 2011 teacher questionnaire.

5.5.5 Teacher education specific to science

Following the adoption of the Bologna Process in 2006, teachers in the lower (primary) levels of basic education are required to have a bachelor's degree, which can be earned in eight semesters at teacher training colleges that are independent institutions or parts of universities. During current teacher education in Hungary, pupils take courses in their specialist subjects as well as in pedagogy, and develop their teaching skills. In the last semester pupils participate in a continuous eight- to ten-week teaching practice. Teacher education ends with an in-classroom teaching examination and a state examination. Teachers who have earned a bachelor's degree can teach all subjects in Grades 1–4 but teach only the subject of their specialisation in Grades 5–6. Teacher qualification at the master's level allows teaching in Grades 5–12.

Nearly seven per cent of pupils had primary teachers with science as their main area of post-secondary study (see Table 10). Just over sixteen per cent had teachers with a science education specialism, just over half the international average.

Table 10: Teacher specialisation

During your post-secondary education…	% of pupils whose teachers answered 'yes' (international average)	
	HUNGARY	**NI**
… was science your major or main area of study?	6.9%	11.7% (28.0%)
If your major or main area of study was education, was science your specialisation?	16.4%	9.7% (31.3%)

Data from the TIMSS 2011 teacher questionnaire.

Professional development

Teachers are required to participate in at least 90 hours of professional development every seven years. School principals have the choice to reduce teachers' workload if teachers are currently involved in in-service training programmes. Furthermore, the employer may cover the total cost of professional development. Generally, schools cover 80 per cent of professional development costs; coverage of the additional costs (e.g. travel or accommodation) can vary.

Subject-specific exam preparatory courses are the most common form of professional development. These classes usually cover education management, pedagogy, and professional services. However, assessment and evaluation courses are becoming increasingly popular. After completing a subject-specific exam preparatory course, teachers advance a step on the pay scale, can request inclusion in the national list of experts, and can undertake specialist public education tasks.

Relative to the international average, few pupils had teachers who had experienced science-related professional development in the previous two years (see Table 11). This ranged from 6.3 per cent of pupils whose teachers had learned about the science curriculum, up to 27.5 per cent for those teachers who had learned about addressing individual needs. Apart from training related to science assessment, fewer pupils in Hungary than in Northern Ireland had teachers who had participated in science-related professional development in the previous two years.

Table 11: Professional development

In the past two years, have you participated in professional development in…	% of pupils whose teachers answered 'yes' (international average)	
	HUNGARY	**NI**
…science content?	16.5%	26.0% (34.9%)
…science pedagogy/instruction?	26.3%	27.9% (33.7%)
…science curriculum?	6.3%	28.6% (33.7%)
…integrating information technology into science?	19.8%	22.3% (27.9%)
…science assessment?	6.8%	5.1% (26.8%)
…addressing individual students' needs?	27.5%	12.5% (32.2%)

Data from the TIMSS 2011 teacher questionnaire.

5.5.6 Monitoring pupil progress in science

Since the 2001–02 academic year, Hungary has administered the National Assessment of Basic Competencies (NABC) nine times to examine pupil performance in mathematics and reading; pupils in Grades 6, 8, and 10 have taken part in the testing. Compulsory testing of reading, maths, problem solving and writing skills is mandatory and systems are set up to track pupil progress. Since the 2005/06 school year, testing of pupils in Grade 4 has taken place every May.

In addition to assessments, pupil performance and progress are regularly evaluated through grades. Teachers use interim grades as the basis for mid-term and end-of-term grades. The class teacher also records a grade for pupil conduct and diligence after consulting with other teachers who also work with that pupil.

Schools inform parents about pupil performance on a regular basis. Pupils keep their grades and school notices in a notebook that their parents and class teachers sign every month. Additionally, the school sends notices to parents at mid-term and the end of the school year. In Grades 1–3 and mid-term in Grade 4, teachers present a written evaluation of pupil progress, describing it as excellent, good, or adequate and noting if the pupil requires tutoring.

Teachers must provide a detailed evaluation of pupil performance in the basic domains of speech, oral expressiveness and attitude. If a pupil needs tutoring, schools evaluate pupil performance with the parents, note the factors impeding progress, and suggest further measures.

Hungary's grade retention policy has been subject to change in recent years. Schools do not usually recommend that pupils in the lower (primary) school years repeat a year, although parents may make that request.

TIMSS 2011 data reflects this emphasis both on ongoing evaluation and the use of assessments to monitor progress. All pupils in Hungary were taught by teachers who monitor progress based on ongoing evaluation of learning. Almost all pupils (97.9 per cent) were assessed through classroom tests, fewer were assessed through national/regional tests (78.5 per cent), both considerably higher than in Northern Ireland and higher than the international averages.

Table 12: Monitoring progress

How much emphasis do you place on … to monitor students' progress in science?	% of pupils whose teachers answered 'major/some' emphasis (international average)	
	HUNGARY	**NI**
…the evaluation of students' ongoing work…	100%	96.1% (98.5%)
…classroom tests…	97.9%	54.7% (93.0%)
…national or regional achievement tests…	78.5%	27.2% (67.7%)

Data from the TIMSS 2011 teacher questionnaire.

5.6 The Netherlands[19]

5.6.1 Overview of the primary education system

The Minister of Education, Culture, and Science is primarily responsible for the structure of the system, school funding, inspection, the quality of national examinations, and pupil support. Freedom of education averages that any resident has the right to establish a school. Two-thirds of primary schools are privately run. Most are Roman Catholic or Protestant, but there are other religious and philosophically based schools. School boards (of both private and public schools) are funded by government and, to some extent, municipalities. School administration is decentralised, with boards responsible for implementing the curriculum and for personnel policy, pupil admission, and financial policy. Schools or their boards decide how, and to a large extent when, to teach the core curriculum objectives. Schools are inspected at least once every four years (or more frequently, if not meeting standards).

Structure of the primary education system in the Netherlands

Age	4 -12 years
Stage	Single stage
ISCED level	Age 4-6 ISCED 0 Age 6-12 ISCED 1
Curriculum	Core curriculum: Dutch; English; arithmetic and mathematics; social and environmental studies (including, for instance, geography, history, science (including biology), citizenship, social and life skills (including road safety), healthy living, social structures (including political studies) and religious and ideological movements); creative expression (including, for instance, music, drawing and handicrafts); sports and movement.

Primary schools offer two years of pre-primary (Kindergarten) education, with most children starting at age four, although compulsory education begins immediately after the month of the child's fifth birthday. Kindergarten has social and academic functions, but the basics of reading, writing, and mathematics are usually taught from the first year of primary education. Together, pre-primary and primary comprise eight grades, so most children are aged 12 when they begin secondary school (Grade 7), and 16 or 18 when they leave, depending on the track chosen after two years of basic secondary education: pre-vocational education (VMBO), senior general education (HAVO), or pre-university education (VWO). Dutch is the first language of instruction in schools. Frisian or a regional dialect may also be taught.

[19] Main source of information: TIMSS 2011 Encyclopaedia, with updated information indicated and updated sources (and other data sources) given as applicable. http://timssandpirls.bc.edu/timss2011/encyclopedia-timss.html

5.6.2 Science curriculum in primary education

The content of teaching and the teaching methods to be used are not prescribed. Core objectives (attainment targets) have been formulated however and it is up to the schools themselves to group these into subjects, projects, areas of learning and so on, to work them out in detail by type of education, to set standards, choose teaching aids etc. Primary science is part of the subject area 'personal and world orientation', which encourages pupils to 'orientate on themselves, on how people relate to each other, how they solve problems, and how they give meaning to their existence'.[20] The seven core objectives for the 'nature and technology' element of the subject cover: plants, animals and humans; materials and physical phenomena (including light, sound, electricity, power, magnetism, and temperature); weather and climate; solutions to technical problems; and the earth, seasons, night and day. Teachers are encouraged to address content and skills in context. Het leergebied biedt leerlingen een inhoudelijke oriëntatie op de levende en niet-levende natuur, techniek en zorg.Several organisations support schools in implementing the curriculum objectives, such as the Netherlands Institute for Curriculum Development (SLO),[21] which provides advice and support in all subjects, and translates the core objectives into more detailed indicators. A national dialogue about education is in progress culminating, in autumn 2015, in a broad-based vision about what children must know and be able to do by the time they finish school.

5.6.3 Teaching science in primary education

Teaching materials, equipment and laboratories

Schools select their own teaching materials, with no prescription. The SLO advises about the appropriateness of commercially developed materials and teaching methods. Unlike secondary schools, primaries do not usually have science laboratories. In 2011, almost 95 per cent of primary pupils (more than the international average) were in schools where the school's capacity to teach was perceived to be affected by a shortage of science equipment and materials. Fewer than average pupils (under two-thirds) were in schools where the same applied to a shortage of library materials (see Table 1).

Use of technology

The use of information and communication technology (ICT) is not mandatory, but nearly all primary teachers use it, supported by Kennisnet.[22] About three-quarters of primary classrooms have an electronic blackboard. On average, schools have one

[20] Stichting Leerplan Ontwikkeling (SLO), (2006). *Appendix: Core Objectives Primary Education* [online]. Available: http://www.slo.nl/primair/kerndoelen/Dutch_Core_objectives_Primary_Education__2006_.pdf/
[21] http://international.slo.nl/ [29, April 2015].
[22] http://www.kennisnet.nl/over-ons/international-visitors/

computer for every five pupils, virtually all with Internet access. Software comprises 29 per cent of primary teaching materials.[23]

Almost three-quarters of primary pupils in 2011 were in schools where a shortage of computer software was perceived to affect the school's capacity to teach science. This was slightly lower than (but possibly not significantly different from) the international average. A little over two-thirds (fewer than average) were in schools where the same applied to audio-visual resources (see Table 1).

Introduction of specialist teachers for science

Unlike secondary teaching, primary science is not usually taught by specialists. In 2011, 82.3 per cent of primary pupils (higher than the international average) were in schools where a shortage of teachers with a science specialism was seen as affecting capacity to teach (see Table 1).

[23] https://webgate.ec.europa.eu/fpfis/mwikis/eurydice/index.php/Netherlands:Teaching_and_Learning_in_Primary_Education

Table 1: Capacity to provide instruction

How much is your school's capacity to provide instruction affected by a shortage or inadequacy of…	% of pupils whose headteachers answered 'not at all' (international average)		% of pupils whose headteachers answered 'a little/some/a lot' (international average)	
Teaching materials, equipment and laboratories				
	NETHERLANDS	**NI**	**NETHERLANDS**	**NI**
…library materials relevant to science instruction?	36.1%	18.0% (27.5%)	63.9%	81.9% (72.5%)
…science equipment and materials?	5.5%	19.8% (19.6%)	94.6%	80.2% (80.5%)
Use of technology				
…computer software for science instruction?	25.8%	18.0% (22.7%)	74.2%	81.9% (77.3%)
…audio-visual resources for science instruction?	31.2%	21.1% (22.7%)	68.8%	78.8% (77.3%)
Introduction of specialist teachers for science				
…teachers with a specialisation in science?	17.7%	24.6% (37.3%)	82.3%	75.4% (62.6%)

Data is from the TIMSS 2011 school questionnaire, reported as *the percentage of students* taught in schools where the principal (or delegated person) gave the indicated response. This is not necessarily the same as the percentage of schools which gave the response (e.g. schools vary in size, so perceived shortages in a small school may impact on fewer pupils than in a large school). Data available for fewer than 85 per cent of pupils in the Netherlands Percentages may not total 100 due to rounding.

Primary pupil attitudes to science and science lessons

In 2011, over three-quarters of pupils (75.8 to 87.9 per cent) were positive about science (see Table 2). These figures were below the international average.

Table 2: Pupil attitudes to science and science lessons

How much do you agree that…	% of pupils who 'agree a lot/agree a little' (international average)		% of pupils who 'disagree a lot/ disagree a little' (international average)	
	NETHERLANDS	NI	NETHERLANDS	NI
…you enjoy learning science?	83.0%	87.1% (88.0%)	17.0%	13.0% (11.9%)
…you learn many interesting things in science?	87.9%	88.1% (90.2%)	12.2%	11.9% (9.8%)
…you like science?	75.8%	84.1% (85.7%)	24.3%	15.9% (14.4%)
…it is important to do well in science?	84.5%	87.9% (91.0%)	15.5%	12.1% (9.0%)
…your teacher gives you interesting things to do in your science lessons?	81.6%	89.5% (85.6%)	18.5%	10.6% (14.3%)

Data from the TIMSS 2011 student questionnaire.
Data met the response target in the Netherlands (see Martin *et al*., 2012, Exhibit 8.1).
Percentages may not total 100 due to rounding.

5.6.4 Teaching science to the TIMSS class[24]

Although science is taught as part of personal and world orientation, fewer than one-fifth of pupils in 2011 experienced science as an integrated subject. The remaining 81.3 per cent were taught it as a separate subject (see Table 3). Average science teaching time in the TIMSS class in the Netherlands was 42 hours a year, approximately half the international average and 30 hours less than in Northern Ireland (see Table 4).

[24] This refers to the primary class(es) in the schools who took part in the TIMSS 2011 assessment in the Netherlands

Table 3: Science in the curriculum

Is science taught mainly as a separate subject?	% of pupils whose teachers answered 'no' (international average)	
	NETHERLANDS	NI
	18.7% (23.0%)	72.3%

Data from the TIMSS 2011 teacher questionnaire.
No Grade 4 report in Martin *et al.* (2012), hence no data is available regarding the percentage of pupils whose teachers responded.

Table 4: Teaching hours in primary science

Teaching hours per year	Total teaching hours (international average)		Science teaching hours (international average)	
	NETHERLANDS	NI	NETHERLANDS	NI
	1074 (897)	970	42 (85)	72

Data from Martin *et al.* (2012), Exhibit 8.6. Data available for fewer than 85 per cent of pupils in the Netherlands.

Fewer than average pupils (see Table 5) had teachers who were very confident about explaining science concepts by doing experiments (20.7 per cent), answering questions (46.3 per cent), or helping pupils appreciate the value of learning science (50.9 per cent).

Table 5: Teacher confidence

In teaching science to this class, how confident do you feel…	% of pupils whose teachers answered 'very confident' (international average)	
	NETHERLANDS	**NI**
…answering students' questions about science?	46.3%	41.6% (62.1%)
…explaining science concepts or principles by doing science experiments?	20.7%	36.3% (51.1%)
…helping students appreciate the value of learning science?	50.9%	43.9% (68.0%)

Data is taken from the TIMSS 2011 teacher questionnaire, and reported as the *percentage of pupils* taught by teachers who gave each response. This is not necessarily the same as the percentage of teachers who gave the response. For example, one teacher might teach science to a single class while another might teach it to several classes. Similarly, numbers of pupils in classes may vary. Thus, each teacher's science teaching practice will impact differently on the overall pupil population.
Data available for fewer than 85 per cent of pupils in the Netherlands (see Martin *et al*., 2012, Exhibit 7.11).

Teachers' emphasis on specific science activities was measured by responses to statements about how often they asked their pupils to undertake a variety of learning activities in their science lessons. In most cases, far fewer pupils than average in the Netherlands carried out the specified activities in half or more of their lessons (see Table 6). Giving explanations and relating science learning to daily life were closer to the averages (77.4 and 72.1 per cent of pupils respectively), while more than the average read their textbooks or other materials in half their lessons or more (85.1 per cent). Relatively high proportions were never asked to design or plan experiments (41.2 per cent), memorise facts (27.5 per cent), do field work (25.8 per cent), take a written test or quiz (25.4 per cent), conduct experiments (21.8 per cent), or watch a demonstrated experiment (19.4 per cent).

Table 6: Learning activities

In teaching science to this class, how often do you usually ask students to…	% of pupils whose teachers answered 'half the lessons' or more (international average)		% of pupils whose teachers answered 'never' (international average)	
	NETHERLANDS	NI	NETHERLANDS	NI
…observe natural phenomena such as the weather or a plant growing and describe what they see?	13.8%	18.7% (44.3%)	9.5%	3.4% (1.7%)
…watch you demonstrate an experiment or investigation?	9.7%	8.9% (38.7%)	19.4%	11.3% (4.3%)
…design or plan experiments or investigations?	3.3%	18.6% (33.7%)	41.2%	4.0% (9.1%)
…conduct experiments or investigations?	6.8%	22.1% (38.6%)	21.8%	4.2% (3.9%)
…read their textbooks or other resource materials?	85.1%	22.3% (69.9%)	1.9%	11.2% (3.0%)
…memorise facts and principles?	24.5%	8.0% (51.5%)	27.5%	31.7% (11.2%)
…give explanations about something they are studying?	77.4%	52.7% (81.7%)	1.4%	0.8% (0.5%)
…relate what they are learning in science to their daily lives?	72.1%	60.4% (84.9%)	0.7%	0.7% (0.4%)
…do field work outside the class?	7.6%	7.1% (19.1%)	25.8%	19.8% (10.7%)
…take a written test or quiz?	7.6%	2.6% (33.3%)	25.4%	39.4% (6.2%)

Data is taken from the TIMSS 2011 teacher questionnaire.
Data available for fewer than 85 per cent of pupils in the Netherlands (see Martin *et al.,* 2012, Exhibit 8.27).
Percentages do not total 100 as not all response categories are reported.

Fewer Grade 4 primary pupils than average had been taught the TIMSS science topics in or before the year of the assessment. This was true for all topic areas, with physical science particularly low at only 32 per cent of pupils having been taught the topics (see Table 7). Physical science topics with especially low percentages were

classification of materials by their properties (9.3 per cent) and forming and separating mixtures (7.3 per cent).

Table 7: Primary pupils taught the TIMSS science topics

TIMSS Grade 4 science topics	% of pupils mostly taught the topic before or in the assessment year (international average)	
	NETHERLANDS	NI
All (20 topics)	47%	61% (64%)
Life science (6 topics)	60%	74% (75%)
Physical science (8 topics)	32%	57% (57%)
Earth science (6 topics)	54%	53% (63%)

Data from Martin *et al.* (2012), Exhibit 8.8. Data available for fewer than 85 per cent of pupils in the Netherlands.

Fewer pupils than average had teachers who felt very well prepared to teach the topics (see Table 8), with physical science lowest at 37 per cent. The ranges for earth science and physical science were wide. Some topics (fossils, electrical circuits and magnetism, forming and separating mixtures) had fewer than a fifth of pupils taught by teachers who felt very well prepared, while others (energy sources, features of earth's landscape, and weather) had higher levels of preparedness (around half or more of pupils taught by such teachers). Generally, more pupils had teachers who felt well prepared for the life science topics.

Table 8: Teacher preparedness

TIMSS Grade 4 science topics	% of pupils whose teachers feel 'very well prepared' to teach the topics (international average)		Highest and lowest percentages within each topic area (international range)	
	NETHERLANDS	NI	NETHERLANDS	NI
All (20 topics)	45%	54% (62%)	12.4% - 67.7%	27.6% - 62.8% (30.6% - 66.6%)
Life Science (6 Topics)	58%	62% (70%)	42.0% - 59.1%	43.1% - 62.2% (54.2% - 66.6%)
Physical Science (8 Topics)	37%	56% (62%)	12.4% - 48.6%	34.2% - 62.8% (35.2% - 62.4%)
Earth Science (6 Topics)	43%	44% (53%)	17.7% - 67.7%	27.6% - 59.9% (30.6% - 61.6%)

Data from Martin *et al.* (2012), Exhibit 7.9 and TIMSS 2011 teacher questionnaire.
Data available for fewer than 85 per cent of pupils in the Netherlands.

Schools decide their own homework policies. Homework is not expected in primary schools, although some assign it to prepare pupils for the practice in secondary school. Table 9 shows that, in 2011, almost 69 per cent of pupils in the Netherlands were assigned no science homework, far higher than the international average of 18.3 per cent. None were assigned science homework three times a week or more.

Table 9: Science homework

How often do you usually assign science homework to the students in this class?	% of pupils whose teachers assign no homework (international average)		% of pupils whose teachers assign homework 3 times a week or more (international average)	
	NETHERLANDS	NI	NETHERLANDS	NI
	68.9%	62.1% (18.3%)	0.0%	0.0% (12.4%)

Data from TIMSS 2011 teacher questionnaire.
No Grade 4 report in Martin *et al.* (2012), hence no data is available regarding the percentage of pupils whose teachers responded.

5.6.5 Teacher education specific to science

Unlike secondary teachers (who train in one subject and in teaching skills), primary teachers complete a four-year diploma, training for all grades and all subjects (except physical education). Trainees are tested on language and mathematics skills and undertake regular teaching practice. Halfway through training, they choose to specialise in lower or upper primary.

Table 10: Teacher specialisation

During your post-secondary education…	% of pupils whose teachers answered 'yes' (international average)	
	NETHERLANDS	NI
…was science your major or main area of study?	0.0% †	11.7% (28.0%)
If your major or main area of study was education, was science your specialisation?	9.3%	9.7% (31.3%)

† This question was not administered in the Netherlands.
Data from the TIMSS 2011 teacher questionnaire.
Data available for fewer than 85 per cent of pupils in the Netherlands (see Martin *et al.*, 2012, Exhibit 7.3).

No pupils had primary teachers with science as their main area of post-secondary study (see Table 10). Fewer than ten per cent had teachers with a science education specialism, considerably lower than the average.

Professional development

Development activities for qualified teachers include subject-related workshops or conferences, and the *VTB-Pro* programme[25] offers professional development in science and technology for primary teachers and trainees, aiming to influence their attitudes, make science and technology more attractive to pupils and increase girls' confidence in the subject.

In 2011, few pupils had teachers who had experienced science-related professional development in the previous two years (see Table 11). This ranged from 2.7 and 2.8 per cent of pupils whose teachers had learned about science assessment and the science curriculum, to 8.7 per cent whose teachers had learned about integrating ICT into science education. More (29.0 per cent, close to the average) had teachers who had learned about addressing individual needs.

Table 11: Professional development

In the past two years, have you participated in professional development in…	% of pupils whose teachers answered 'yes' (international average)	
	NETHERLANDS	**NI**
…science content?	4.4%	26.0% (34.9%)
…science pedagogy/instruction?	3.4%	27.9% (33.7%)
…science curriculum?	2.8%	28.6% (33.7%)
…integrating information technology into science?	8.7%	22.3% (27.9%)
…science assessment?	2.7%	5.1% (26.8%)
…addressing individual students' needs?	29.0%	12.5% (32.2%)

Data from the TIMSS 2011 teacher questionnaire.
Data available for fewer than 85% of pupils in the Netherlands (see Martin *et al*, 2012, Exhibit 7.7)

[25] Part of the *Platform Beta Techniek* initiative, which encourages students to pursue a mathematics- or science-related career: http://www.platformbetatechniek.nl/extra/english

5.6.6 Monitoring pupil progress in science

Most schools report to parents three times a year on pupil progress in each subject, giving marks and/or written summaries. Many use intermediate targets and tests to measure progress (commonly, Cito's[26] multiple-choice tests, which include assessment of world orientation skills). Schools decide when to assess pupils. There are no primary national examinations although, from 2014/2015, it became compulsory for schools to use a pupil monitoring system and for pupils in the final year of primary school to sit some form of attainment test.[27] These final-year test results, along with teachers' recommendations, help determine the appropriate secondary school track for each pupil.

TIMSS 2011 data reflects this emphasis on ongoing evaluation: almost all pupils in the Netherlands (92.1 per cent, a little below the international average) were taught by teachers who monitor progress based on ongoing evaluation of learning. Fewer were assessed through classroom tests (78.9 per cent) or national/regional tests (41.7 per cent), both lower than the international average (see Table 12).

Table 12: Monitoring progress

How much emphasis do you place on … to monitor students' progress in science?	% of pupils whose teachers answered 'major/some' emphasis (international average)	
	NETHERLANDS	**NI**
…the evaluation of students' ongoing work…	92.1%	96.1% (98.5%)
…classroom tests…	78.9%	54.7% (93.0%)
…national or regional achievement tests…	41.7%	27.2% (67.7%)

Data from the TIMSS 2011 teacher questionnaire.
No Grade 4 report in Martin *et al*. (2012), hence no data is available regarding the percentage of pupils whose teachers responded.

[26] http://www.cito.com/products_and_services/education/monitoring_and_evaluation_system/monitoring_and_evaluation_system_for_primary_pupils
[27] https://webgate.ec.europa.eu/fpfis/mwikis/eurydice/index.php/Netherlands:Assessment_in_Primary_Education

5.7 Sweden[28]

5.7.1 Overview of the primary education system

The Swedish education system is highly decentralised. The Parliament and Government define national goals, curriculum and syllabus while central authorities, municipalities and various institutions ensure that educational activities are implemented in line with the legislative framework and the national education goals. On July 1 2011, the Swedish school system underwent significant reform which saw the introduction of a new national curriculum and syllabus, a new school law, a new system for grading and national tests; these reforms were introduced after the TIMSS 2011 assessment.

The education system comprises compulsory school (*grundskola*), Sami school (*sameskola*) for Sami-speaking children in Grades 1–6 (ages seven-13), special schools for children and adolescents who are deaf or hearing-impaired and cannot attend compulsory school (*specialskola*), and schools for children with learning disabilities (*grundsarskola*).

Structure of the primary education system in Sweden

Age	7 –16 years (compulsory school)
Stage	Four two-year phases: introductory (Grades 1–2), beginner (Grades 3–4), basic (Grades 5–6), and developmental (Grades 7–8).
ISCED level	7-13 = ISCED level 1 13-16 =ISCED Level 2
Curriculum	Art, crafts, English, home and consumer studies, second foreign language, mathematics, music, physical education and health, Swedish/Swedish as a second language, social studies subjects (geography, history, religion, civics), science studies (biology, chemistry, technology, physics)

Compulsory education, which covers primary and lower secondary education, lasts nine years and is divided into two stages: the first five years (*låg- och mellanstadiet*) (ages seven to 12) correspond to primary level education, and the last four years (*högstadiet*) (ages 12-16) correspond to lower secondary education. About 12 per cent of pupils attended independent compulsory schools in 2010–11.

Until the age of 12, children may also attend leisure-time centres offering afterschool programmes after the regular school day at preschool or compulsory school.

[28] Main source of information: TIMSS 2011 Encyclopaedia, with updated information indicated and updated sources (and other data sources) given as applicable. http://timssandpirls.bc.edu/timss2011/encyclopedia-timss.html

Compulsory education usually takes place in the nine-year comprehensive school for pupils aged seven to 16 (Grades 1–9), though if parents prefer, children may start school at age six.

Excluding pre-primary education for children up to the age of six, all education in Sweden is free of charge and available to all. The principal language of instruction is Swedish.

5.7.2 Science curriculum in primary education

The syllabus outlines the following core content for the study of science in the primary stage (relevant to TIMSS Grade 4):

Biology, Years 1-3 - Seasons of the year in nature; body and health; force and motion; materials and substances in our surroundings; narratives about nature and science; methods and ways of working.

Biology, Years 4-6 - Nature and society; body and health; biology and world views; biology, its methods and ways of working.

Physics, Years 1-3 - Seasons of the year in nature; body and health; force and motion; materials and substances in our surroundings; narratives about nature and science; methods and ways of working.

Physics, Years 4-6 - Physics in nature and society; physics and everyday life; physics and world views; physics, its methods and ways of working.

Chemistry, Years 1-3 - Seasons of the year in nature; body and health; force and motion; materials and substances in our surroundings; narratives about nature and science; methods and ways of working.

Chemistry, Years 4-6 - Chemistry in nature; chemistry in everyday life and society; chemistry and world views; chemistry, its methods and ways of working. [29]

5.7.3 Teaching science in primary education

Teaching materials, equipment and laboratories

In line with Sweden's decentralised education system, municipalities and schools are free to make their own decisions about the length of the school year and teaching arrangements.

The timetable (part of the Education Act and adopted by Parliament) guarantees each pupil a minimum of 6665 hours of instruction in compulsory school (Grades 1–9). The timetable also specifies the number of hours for each subject; there should be at least 800 hours of biology, chemistry, physics, and technology instruction over the nine years. The sciences (biology, chemistry, and physics) are taught either as an integrated subject or as three separate subjects. In the 2010–11 academic year, approximately 87 per cent of Grade 9 pupils received grades in separate science subjects.

[29] https://webgate.ec.europa.eu/fpfis/mwikis/eurydice/images/b/bf/Curriculum_for_the_compulsory_schoo%2C_preschool_class_and_the_leisure-time_centre%2C_2011.pdf

Teachers themselves choose teaching methods, topics to be covered in lessons and teaching materials. Teachers are free to select materials such as books, audiovisual materials, and ICT, limited only by financial constraints. Schools purchase teaching materials from various publishers and distribute them to pupils free of charge.

In 2011, over three-quarters of primary pupils (close to the international average) were in schools where the school's capacity to teach was perceived to be affected by a shortage of library materials and science equipment and materials (see Table 1).

Use of technology

Many schools and municipalities have the goal of a one-to-one computer to pupil ratio, and continue to invest in this goal. Although most schools have access to computers, the Internet, and other technological aids, the use of technology varies widely, depending on teacher interest and the availability of financial resources in each school. There is approximately one computer for every six pupils in public compulsory school and one computer for every 4.5 pupils in independent compulsory schools. Despite the investment in this technology goal, over 70 per cent of primary pupils in 2011 were in schools where a shortage of computer software was perceived to affect the school's capacity to teach science. This was slightly lower than the international average.

Introduction of specialist teachers for science

Between 1988 and 2001, there was no specialist training for teachers in the lower years of compulsory education. In 2006, a specialisation in teaching Swedish and mathematics for Grades 1–3 became mandatory for teachers of Grades 1–6. Since 2011, the degree in primary school education has allowed for three specialisations: the first directed at work in the pre-school class (for children the year before they start compulsory school) and Years 1–3; the second for Years 4–6; and the third directed at work in out-of-school care (in so called leisure time centres which cater for children before and after the school day and during holidays). In 2011, 66 per cent of primary pupils (slightly higher than the international average) were in schools where a shortage of teachers with a science specialism was seen as affecting capacity to teach (see Table 1).

Table 1: Capacity to provide instruction

How much is your school's capacity to provide instruction affected by a shortage or inadequacy of…	% of pupils whose headteachers answered 'not at all' (international average)		% of pupils whose headteachers answered 'a little/some/a lot' (international average)	
Teaching materials, equipment and laboratories				
	SWEDEN	**NI**	**SWEDEN**	**NI**
…library materials relevant to science instruction?	21.1%	18.0% (27.5%)	78.9%	81.9% (72.5%)
…science equipment and materials?	23.5%	19.8% (19.6%)	76.4%	80.2% (80.5%)
Use of technology				
…computer software for science instruction?	26.1%	18.0% (22.7%)	74.0%	81.9% (77.3%)
…audio-visual resources for science instruction?	22.0%	21.1% (22.7%)	78.0%	78.8% (77.3%)
Introduction of specialist teachers for science				
…teachers with a specialisation in science?	33.9%	24.6% (37.3%)	66.0%	75.4% (62.6%)

Data is from the TIMSS 2011 school questionnaire, reported as *the percentage of students* taught in schools where the headteacher gave the indicated response. This is not necessarily the same as the percentage of schools which gave the response (e.g. schools vary in size, so perceived shortages in a small school may impact on fewer pupils than in a large school). Percentages may not total 100 due to rounding.

Primary pupil attitudes to science and science lessons

In 2011, over 80 per cent of pupils (81.1 to 93 percent) were positive about science (see Table 2). These figures were similar to the international average. Compared with Northern Ireland, a higher proportion of pupils in Sweden agree that it is important to do well in science.

Table 2: Pupil attitudes to science and science lessons

How much do you agree that…	% of pupils who 'agree a lot/agree a little' (international average)		% of pupils who 'disagree a lot/ disagree a little' (international average)	
	SWEDEN	NI	SWEDEN	NI
…you enjoy learning science?	88.3%	87.1% (88.0%)	11.7%	13.0% (11.9%)
…you learn many interesting things in science?	87.9%	88.1% (90.2%)	12.1%	11.9% (9.8%)
…you like science?	81.1%	84.1% (85.7%)	18.9%	15.9% (14.4%)
…it is important to do well in science?	93.0%	87.9% (91.0%)	6.9%	12.1% (9.0%)
…your teacher gives you interesting things to do in your science lessons?	86.1%	89.5% (85.6%)	13.9%	10.6% (14.3%)

Data from the TIMSS 2011 student questionnaire. Percentages may not total 100 due to rounding.

5.7.4 Teaching science to the TIMSS class[30]

Around one-fifth of pupils in 2011 experienced science as an integrated subject. The remaining 78.1 per cent were taught it as a separate subject (see Table 3). Average science teaching time in the TIMSS class in Sweden was 75 hours a year, just under the international average (see Table 4).

[30] This refers to the primary class(es) in the schools who took part in the TIMSS 2011 assessment in Sweden.

Table 3: Science in the curriculum

Is science taught mainly as a separate subject?	% of pupils whose teachers answered 'no' (international average)	
	SWEDEN	NI
	21.9% (23.0%)	72.3%

Data from the TIMSS 2011 teacher questionnaire.

Table 4: Teaching hours in primary science

Teaching hours per year	Total teaching hours (international average)		Science teaching hours (international average)	
	SWEDEN	NI	SWEDEN	NI
	849 (897)	970	75 (85)	72

Data from Martin *et al.* (2012), Exhibit 8.6.

Fewer than average pupils (see Table 5) had teachers who were very confident at answering pupils' questions about science (57.2 per cent), helping pupils appreciate the value of learning science (54.9 per cent) and explaining science concepts or principles by doing science experiments (40.8 per cent). Compared with Northern Ireland, a higher percentage of pupils in Sweden are taught by teachers who are very confident in teaching their science class.

Table 5: Teacher confidence

In teaching science to this class, how confident do you feel…	% of pupils whose teachers answered 'very confident' (international average)	
	SWEDEN	**NI**
…answering students' questions about science?	57.2%	41.6% (62.1%)
…explaining science concepts or principles by doing science experiments?	40.8%	36.3% (51.1%)
…helping students appreciate the value of learning science?	54.9%	43.9% (68.0%)

Data is taken from the TIMSS 2011 teacher questionnaire, and reported as the *percentage of students taught* by teachers who gave each response. This is not necessarily the same as the percentage of teachers who gave the response. For example, one teacher might teach science to a single class while another might teach it to several classes. Similarly, numbers of pupils in classes may vary. Thus, each teacher's science teaching practice will impact differently on the overall pupil population.

Percentages may not total 100 due to rounding.

Teachers' emphasis on specific science activities was measured by responses to statements about how often they asked their pupils to undertake a variety of learning activities in their science lessons. In most cases, far fewer pupils than average in Sweden carried out the specified activities in half or more of their lessons (see Table 6). Most notably, the percentage of pupils who are asked to memorise facts and principles (18 per cent) and take written tests or quizzes (3.7 per cent) are considerably lower than the international average.

The percentage of pupils whose teachers never asked them to carry out the specified activities was generally small. However, just over a quarter of pupils were never asked to take a written test or quiz (30.9 per cent) nearly five times the international average, and do field work outside the class (27.3 per cent), more than double the international average.

Table 6: Learning activities

In teaching science to this class, how often do you usually ask students to…	% of pupils whose teachers answered 'half the lessons' or more (international average)		% of pupils whose teachers answered 'never' (international average)	
	SWEDEN	NI	SWEDEN	NI
…observe natural phenomena such as the weather or a plant growing and describe what they see?	29.4%	18.7% (44.3%)	1.9%	3.4% (1.7%)
… watch you demonstrate an experiment or investigation?	21.0%	8.9% (38.7%)	5.0%	11.3% (4.3%)
…design or plan experiments or investigations?	32.7%	18.6% (33.7%)	10.6%	4.0% (9.1%)
… conduct experiments or investigations?	43.5%	22.1% (38.6%)	1.3%	4.2% (3.9%)
… read their textbooks or other resource materials?	48.7%	22.3% (69.9%)	1.2%	11.2% (3.0%)
… memorise facts and principles?	18.0%	8.0% (51.5%)	15.1%	31.7% (11.2%)
…give explanations about something they are studying?	65.6%	52.7% (81.7%)	0.4%	0.8% (0.5%)
… relate what they are learning in science to their daily lives?	75.9%	60.4% (84.9%)	0.4%	0.7% (0.4%)
… do field work outside the class?	7.3%	7.1% (19.1%)	27.3%	19.8% (10.7%)
… take a written test or quiz?	3.7%	2.6% (33.3%)	30.9%	39.4% (6.2%)

Data is taken from the TIMSS 2011 teacher questionnaire.
Percentages do not total 100 as not all response categories are reported.

In Sweden, fewer pupils than average had been taught the TIMSS science topics in or before the year of assessment. This was true for life science (59 per cent) and physical science (34 per cent), but notably earth science (73 per cent) was above the international average (see Table 7).

Table 7: Primary pupils taught the TIMSS science topics

TIMSS Grade 4 science topics	% of pupils mostly taught the topic before or in the assessment year (international average)	
	SWEDEN	NI
All (20 topics)	53%	61% (64%)
Life science (6 topics)	59%	74% (75%)
Physical science (8 topics)	34%	57% (57%)
Earth science (6 topics)	73%	53% (63%)

Data from Martin *et al. (2012),* Exhibit 8.8.

In general, fewer Grade 4 primary pupils than average had teachers who felt well prepared to teach the TIMSS science topics (see Table 8). This was true for all topic areas apart from earth science which was similar to the international average. In Sweden, larger percentage of pupils had teachers who felt very well prepared to teach the life science topics (55 per cent) than the earth science topics (52 per cent) or the physical science topics (45 per cent).The range within each topic was relatively wide, the range for earth science was particularly wide (32.6 - 66.5 per cent). Within earth science, the topic ‘fossils’ had the lowest percentage of pupils with very well-prepared teacher – this mirrored what was seen on average internationally.

Table 8: Teacher preparedness

TIMSS Grade 4 science topics	% of pupils whose teachers feel 'very well prepared' to teach the topics (international average)		Highest and lowest percentages within each topic area (international range)	
	SWEDEN	NI	SWEDEN	NI
All (20 topics)	50%	54% (62%)	26.8% - 66.5%	27.6% - 62.8% (30.6% - 66.6%)
Life science (6 topics)	55%	62% (70%)	44.9% - 52.7%	43.1% - 62.2% (54.2% - 66.6%)
Physical science (8 topics)	45%	56% (62%)	26.8% - 48.7%	34.2% - 62.8% (35.2% - 62.4%)
Earth science (6 topics)	52%	44% (53%)	32.6% - 66.5%	27.6% - 59.9% (30.6% - 61.6%)

Data from Martin *et al. (2012),* Exhibit 7.9 and TIMSS 2011 teacher questionnaire.

Sweden has no system-wide policy on homework. Table 9 shows that, in 2011, 45.8 per cent of pupils in Sweden were assigned no science homework, far higher than the international average of 18.3 per cent. As was the case in Northern Ireland, none were assigned science homework three times a week or more.

Table 9: Science homework

How often do you usually assign science homework to the students in this class?	% of pupils whose teachers assign no homework (international average)		% of pupils whose teachers assign homework 3 times a week or more (international average)	
	SWEDEN	NI	SWEDEN	NI
	45.8%	62.1% (18.3%)	0.0%	0.0% (12.4%)

Data from TIMSS 2011 teacher questionnaire.

5.7.5 Teacher education specific to science

Since 2013, to be qualified to teach at a school, a teacher must be registered and qualified for certain subjects and school years. Registration is required for a teacher to be able to independently set grades, and the general rule is that only registered teachers qualify for permanent employment.

For the compulsory education level, teacher education takes between three-and-a half and five years, with teachers of older pupils receiving longer training than teachers of younger pupils. All teacher education includes a supervised teaching element.

Since the autumn term of 2011 four new professional degrees have been introduced. They include knowledge objectives in the subject to be taught, and objectives concerning other key knowledge, and skills of a more general nature, for school and pre-school teachers. The new degrees lead to greater clarity regarding the three components of teacher education: studies in the subject to be taught, a school placement comprising 30 higher education credits and an educational science core of 60 higher education credits. (Sixty higher education credits (ECTS equivalents) are equivalent to one year of full-time studies.)

Nearly forty per cent of Sweden's primary pupils were taught by teachers who studied post-secondary science (see Table 10). Just over two thirds had teachers with a science education specialism, considerably higher than the average and six time more than is seen in Northern Ireland.

Table 10: Teacher specialisation

During your post-secondary education…	% of pupils whose teachers answered 'yes' (international average)	
	SWEDEN	**NI**
… was science your major or main area of study?	39.5%	11.7% (28.0%)
If your major or main area of study was education, was science your specialisation?	62.6%	9.7% (31.3%)

Data from the TIMSS 2011 teacher questionnaire.

Professional development

Municipalities and independent schools are responsible for professional development, the scope of which is determined locally.

In recent years, there have been various campaigns to increase teachers' education level and professional standing. In 2008, an initiative was introduced to increase the number of teachers with research experience. Teachers were offered the opportunity to participate in a two-year post graduate programme – at ten different universities - in several subjects which included science.

In 2007, a campaign called the Continuing Professional Development Programme for Teachers (*Lararlyftet*) was introduced. This project aimed to raise pupil achievement levels by improving teacher competence. Teachers were given the opportunity to

deepen their competence in subjects for which they already had a degree, as well as broaden their competence in subjects for which they lacked education. The project continued during the period 2012–15 for teachers with a teaching degree who are currently teaching subjects or grade levels that they did not study when they earned their degree. The National Agency for Education organised the courses in cooperation with universities, and municipalities can receive government grants to help cover the costs of the reduced teaching hours of teachers who attend the courses.

Relative to the international average, few pupils were taught science by teachers who had participated in science-related professional development in the previous two years (see Table 11). This ranged from 4.4 of pupils whose teachers had learned about integrating ICT into science education (considerably lower than the international average), to 24.4 per cent, whose teachers had learned about the science curriculum.

Table 11: Professional development

In the past two years, have you participated in professional development in…	% of pupils whose teachers answered 'yes' (international average)	
	SWEDEN	**NI**
…science content?	20.2%	26.0% (34.9%)
…science pedagogy/instruction?	14.3%	27.9% (33.7%)
… science curriculum?	24.4%	28.6% (33.7%)
… integrating information technology into science?	4.4%	22.3% (27.9%)
… science assessment?	12.4%	5.1% (26.8%)
… addressing individual students' needs?	8.2%	12.5% (32.2%)

Data from the TIMSS 2011 teacher questionnaire.

5.7.6 Monitoring pupil progress in science

Sweden monitors and assesses pupils in compulsory school through a system of national tests, diagnostic materials, and written reports with individual development

plans and grades. National tests are given in Grade 3, Grade 6[31] and Grade 9 in Swedish/Swedish as a second language, maths, English, social science or natural science subject.

Designed by the National Agency for Education, the national tests provide support for teachers in monitoring pupil progress according to the curriculum and syllabus. The tests also provide support for teachers in assigning grades and applying the curriculum and syllabus. The National Agency for Education also provides diagnostic materials, tests, and individual test items that are intended to highlight individual pupil strengths and weaknesses, help teachers monitor pupil progress, and make impartial judgments. These materials are available for science for Grades 1–3.

Teachers monitor pupil progress through continuous assessment. Since 2006, teachers have also been required to establish an individual development plan in cooperation with the pupil and his or her parent(s), describing what the pupil should strive to achieve. This plan is then evaluated and revised at pupil-parent-teacher meetings. Grade promotion in compulsory school is automatic, and pupils are not required at any point to pass examinations before being promoted to the next year group. Grades A-F are awarded from the sixth year of compulsory school onward and reflect pupil achievement relative to national goals and grading criteria stated in the syllabus for each subject.

If a school is concerned that a pupil might not reach the goals in the syllabus for school years three, six and nine, it develops a programme in conjunction with the pupil and his/her parents or guardians, which details the measures to be taken. Pupils who do not attain a pass level in a particular subject are not awarded a grade in that subject. Instead, a written assessment is made that identifies a pupil's aptitude for further studies.

Despite the focus on monitoring pupil progress through continuous assessment, fewer than average pupils were taught by teachers who monitor progress using classroom tests (76 per cent). However, over 95 per cent of pupils in Sweden (96.2 per cent) were taught by teachers who monitor progress based on the evaluation of ongoing work, so perhaps this rather than classroom tests is the focus of continuous assessment in Sweden. In 2011, there was also slightly less emphasis on national/regional tests for monitoring pupils compared with the international average, although this was still greater than in Northern Ireland (see Table 12).

[31] As of April 2015 participation in national tests of social science or natural science for Grade 6 will be voluntary for schools.

Table 12: Monitoring progress

How much emphasis do you place on …to monitor students' progress in science?	% of pupils whose teachers answered 'major/some' emphasis (international average)	
	Sweden	**NI**
…the evaluation of students' ongoing work…	96.2%	96.1% (98.5%)
…classroom tests…	76.0%	54.7% (93.0%)
…national or regional achievement tests…	61.2%	27.2% (67.7%)

Data from the TIMSS 2011 teacher questionnaire.

5.8 The Slovak Republic[32]

5.8.1 Overview of the primary education system

Since January 2004 the Slovak Republic has regulated the state administration and regional self-government of primary school education, decentralising the national education system into eight autonomous, self-governing regions (*samospravny kraj*). The Ministry of Education, Science, Research and Sport oversees the administration of the public school system at the national level, and is responsible for developing educational concepts and a unified educational policy, as well as for creating laws, general binding regulations, and documents related to education. In each of the eight self-governing regions, the Ministry has a school regional office (*Krajsky školsky urad*) that provides professional counselling and supervision for schools.

Structure of the primary education system in the Slovak Republic

Age	6-15 years
Stage	Primary – First stage (four years), Primary – Second stage (five years)
ISCED level	Ages 6-10 ISCED 1 Ages 10-15 ISCED level 2
Curriculum	Core subjects: Slovak language and literature, foreign language (English), mathematics, informatics, natural science, history and geography, ethics/religious education, work education, music education, art and craft, physical education.

Compulsory education in the Slovak Republic lasts ten years (ages six to 16) and consists of three stages. The first two stages provide primary school (*zakladna škola*) education for Grades 1–4 (ages six to ten) (equivalent to ISCED level 1) and for Grades 5–9 (ages ten to 15) (equivalent to ISCED level 2). Children from socially disadvantaged backgrounds who have not reached the maturity level necessary for primary school by the age of six have the option to attend an additional Grade 0. Pupils with special education needs can attend special primary schools.

After completing the fifth grade, pupils with special talents in academic subjects or art can apply for enrolment in an eight-year grammar school or the eight-year conservatory, both of which have entrance exams. In the ninth grade, pupils take the national examination. Pupils may then apply to a secondary school, which may require them to pass an additional entrance examination.

Primary schools are administered by an appropriate municipality and managed by the principal.

[32] Main source of information: TIMSS 2011 Encyclopaedia, with updated information indicated and updated sources (and other data sources) given as applicable. http://timssandpirls.bc.edu/timss2011/encyclopedia-timss.html

Until 2008, primary schools based their instruction on Ministry-approved study plans, syllabi and content and achievement standards. Within the curriculum, several study plan options offered extended or additional lessons in science, allowing schools to create differentiated classes. In 2008, the National Council of the Slovak Republic passed the School Act, according to which education in schools is conducted according to the State Education Programme (*Štatny Vzdelavaci Program—ŠVP*) and the School Education Programme (*Školsky vzdelavaci program—ŠkVP*). The State Education Programme defines the compulsory content of education in schools, while the School Education Programme is a curricular document unique to each school that describes how that particular school will attain the general achievement and content standards required by the State Educational Programme. This reform was introduced in the 2008–09 school year and initially applied to Grades 1, 5, and 10 (that is, the first years of ISCED levels 1, 2, and 3). Since then, the Act has been implemented in the remaining grades. Pupils tested in the TIMSS 2011 Grade 4 science assessments belonged to the last fourth grade cohort educated according to the previous policy.

Slovak is the language of instruction for most pupils. In certain regions, instruction also takes place in minority languages: Hungarian, Ukrainian, German, Rutheanian, and Bulgarian. Generally, instruction in a minority language is provided in separate schools, although there are schools with joint administration that have separate classes for the national language of instruction and for minority language instruction.

5.8.2 Science curriculum in primary education

Pupils assessed in the Grade 4 science TIMSS 2011 assessment had acquired elementary knowledge of natural science in the subject the 'basics of science' (*Prvouka*), and had been educated according to the previous curriculum. Pupils were encouraged to do the following: discover the distinctive features of living and non-living things; identify patterns of change in nature, plants, and animal life; and gain an understanding of how natural changes affect human activities.

In the third and fourth grades, pupils studied natural science (*Prirodoveda*), and the curriculum provided pupils with a comprehensive picture of the subject appropriate to their age. Natural science covered topics ranging from the pupils' immediate environment to basic concepts about the universe. Later, pupils deepened their experience-based understanding of various concepts including time, temperature, force, mass, weight, physical units, attributes of substances, and states of matter (and how matter changes). Pupils measured physical quantities and processes, and recorded values into tables and graphs. They gained first experiences with electric circuits, electrical and magnetic properties of matter, and gravitational force. Pupils identified body, plant, and animal structures, as well as the functions of these parts. They deepened their knowledge of basic hygiene and good nutrition and came to understand the harmful effects of smoking or other drugs. Pupils explored elementary ideas about the sun, the moon, planets, and stars, and the cause of day and night.

Science subjects were developed further at the lower secondary level within natural history (*Prirodopis*), chemistry, and physics. The subject of natural history focuses on the study of nature, with an emphasis on basic knowledge of botany, zoology, human biology, geology, ecology, and the environment of organisms. In chemistry, pupils become familiar with the composition of particulate matter (atom, molecule, and ion), and the composition and structure of atoms. In physics, pupils learn to observe physical phenomena with greater sophistication, to describe and measure physical quantities and evaluate their measurements, to use established terminology and symbols, and to apply their knowledge during experimental and problem-solving tasks.

Prior to 2008, the specific curriculum of each ministry-approved study plan determined the number of 45-minute science lessons per week for pupils in Grades 1–9. Study plans usually included three to four science lessons per week. Once pupils begin to take science as separate subjects in Grades 5–9, plans usually included two lessons per week for natural history (Grade 5-9), two lessons per week for physics (Grade 6-9) and one to two lessons per week for chemistry (Grade 8-9). This was the system of instruction in effect for pupils tested in TIMSS 2011. The up-dated curriculum specifies 84 hours of natural sciences for the first stage of primary education (across all four year groups: Grades 1 - 4) and 393 hours for the second stage (across all five year groups Grades 5 - 9). There is vertical flexibility to allocate those hours across the stage of education.

5.8.3 Teaching science in primary education

Teaching materials, equipment and laboratories

The Ministry of Education, Science, Research and Sport regulates the selection and approval process for textbooks and other print and digital instructional materials used in schools throughout the Slovak Republic. The Government pays the costs associated with textbook publication, and approved textbooks are available free of charge to all pupils. Schools also have the option of using textbooks that the Ministry has recommended but has not approved; but these textbooks are not free.

Teachers are responsible for selecting appropriate supplementary materials, and they often use children's science encyclopaedias, movies, videos, and other digital resources in the classroom and field trips outside the classroom. In recent years, a number of Internet portals have allowed teachers to share teacher-generated learning materials, as well as content produced by educational publishers.

Pupils perform laboratory experiments in physics, chemistry and natural history. Many schools have specialist classrooms equipped with the necessary teaching aids for this purpose.

In 2011, over 80 per cent of primary pupils (similar to the international average) were in schools where the school's capacity to teach was perceived to be affected by a shortage of science equipment and materials. A higher percentage of pupils were in schools affected by a shortage of library materials relevant to science instruction (83.1 per cent, higher than the international average).

Use of technology

The availability and use of technology in schools has changed extensively. In 1999, a project called *Infovek* was introduced with the aim of equipping all schools with computers, multimedia classrooms, and an Internet connection. Since the initiation of *Infovek*, 3288 schools have taken part in the project and have received free Internet connections, free antivirus software and training. Participating schools are also equipped with educational and technical software and the project has led to a number of technology initiatives. Despite this initiative, in 2011, over 80 per cent of pupils were in schools where a shortage of computer software and audio-visual equipment were perceived to affect the schools capacity to teach science. This was higher than the international average.

Introduction of specialist teachers for science

Throughout the first stage of primary education (Grades 1–4), one teacher usually teaches all subjects. During the second stage (Grades 5–9), specialist teachers teach the individual subjects of chemistry, physics and natural history. Generally, teachers at the second stage of primary school specialise in two subjects.

In 2011, around two-thirds (66.7 per cent) of pupils participating in TIMSS in the Slovak Republic had headteachers who stated that the shortage or inadequacy of teachers with a specialisation in science does not affect their school's capacity to provide science instruction. This was much higher than the international average and more than double what was seen in Northern Ireland (see Table 1).

Table 1: Capacity to provide instruction

How much is your school's capacity to provide instruction affected by a shortage or inadequacy of…	% of pupils whose headteachers answered 'not at all' (international average)		% of pupils whose headteachers answered 'a little/some/a lot' (international average)	
Teaching materials, equipment and laboratories				
	SLOVAK REPUBLIC	**NI**	**SLOVAK REPUBLIC**	**NI**
…library materials relevant to science instruction?	16.8%	18.0% (27.5%)	83.1%	81.9% (72.5%)
…science equipment and materials?	17.5%	19.8% (19.6%)	82.6%	80.2% (80.5%)
Use of technology				
…computer software for science instruction?	17.2%	18.0% (22.7%)	82.7%	81.9% (77.3%)
…audio-visual resources for science instruction?	15.5%	21.1% (22.7%)	84.4%	78.8% (77.3%)
Introduction of specialist teachers for science				
…teachers with a specialisation in science?	66.7%	24.6% (37.3%)	33.2%	75.4% (62.6%)

Data is from the TIMSS 2011 school questionnaire, reported as *the percentage of students* taught in schools where the headteacher gave the indicated response. This is not necessarily the same as the percentage of schools which gave the response (e.g. schools vary in size, so perceived shortages in a small school may impact on fewer pupils than in a large school). Percentages may not total 100 due to rounding.

Pupil attitudes to science and science lessons

Pupil attitudes in the Slovak Republic are broadly similar to the international average (see Table 2), with over 80 per cent of pupils responding that they 'liked science'. Slightly more pupils that the international average feel that they learn many interesting things in science (94.7 per cent, higher than in Northern Ireland) and consider it is important to do well in science (92.8 per cent, higher than in Northern Ireland). Whereas slightly fewer than average 'enjoy science' or agree that their teacher gives them interesting things to do.

Table 2: Pupil attitudes to science and science lessons

How much do you agree that…	% of pupils who 'agree a lot/agree a little' (international average)		% of pupils who 'disagree a lot/ disagree a little' (international average)	
	SLOVAK REPUBLIC	NI	SLOVAK REPUBLIC	NI
…you enjoy learning science?	85.7%	87.1% (88.0%)	14.4%	13.0% (11.9%)
…you learn many interesting things in science?	94.7%	88.1% (90.2%)	5.3%	11.9% (9.8%)
…you like science?	84.1%	84.1% (85.7%)	15.9%	15.9% (14.4%)
…it is important to do well in science?	92.8%	87.9% (91.0%)	7.1%	12.1% (9.0%)
…your teacher gives you interesting things to do in your science lessons?	83.3%	89.5% (85.6%)	16.7%	10.6% (14.3%)

Data from the TIMSS 2011 student questionnaire. Percentages may not total 100 due to rounding.

5.8.4 Teaching science to the TIMSS class[33]

In the Slovak Republic, less than five per cent of pupils in 2011 experienced science as an integrated subject. This means that almost all pupils (97.3 per cent) were taught it as a separate subject (see Table 3). Average science teaching time in the TIMSS class in the Slovak Republic was 101 hours a year, higher than the international average (see Table 4).

[33] This refers to the primary class(es) in the schools who took part in the TIMSS 2011 assessment in the Slovak Republic.

Table 3: Science in the curriculum

Is science taught mainly as a separate subject?	% of pupils whose teachers answered 'no' (international average)	
	SLOVAK REPUBLIC	NI
	2.7% (23.0%)	72.3%

Data from the TIMSS 2011 teacher questionnaire.

Table 4: Teaching hours

Teaching hours per year	Total teaching hours (international average)		Science teaching hours (international average)	
	SLOVAK REPUBLIC	NI	SLOVAK REPUBLIC	NI
	780 (897)	970	101 (85)	72

Data from Martin *et al. (2012),* Exhibit 8.6.

The percentage of pupils in the Slovak Republic with teachers who were very confident in answering pupils' questions about science (62 per cent) was the same as the international average. Fewer than pupils than the international average had teachers who were very confident explaining science concepts or principles by doing science experiments (45.1 per cent), and more than average had teachers who were very confident in helping pupils appreciate the value of learning science (73.5 per cent) (see Table 5).

Table 5: Teacher confidence

In teaching science to this class, how confident do you feel…	% of pupils whose teachers answered 'very confident' (international average)	
	SLOVAK REPUBLIC	NI
…answering students' questions about science?	62.0%	41.6% (62.1%)
…explaining science concepts or principles by doing science experiments?	45.1%	36.3% (51.1%)
…helping students appreciate the value of learning science?	73.5%	43.9% (68.0%)

Data is from the TIMSS 2011 teacher questionnaire, and reported as the *percentage of students* taught by teachers who gave each response. This is not necessarily the same as the percentage of teachers who gave the response. For example, one teacher might teach science to a single class while another might teach it to several classes. Similarly, numbers of pupils in classes may vary. Thus, each teacher's science teaching practice will impact differently on the overall pupil population.

Percentages may not total 100 due to rounding.

Teachers' emphasis on specific science activities was measured by responses to statements about how often they asked their pupils to undertake a variety of learning activities in their science lessons. In the Slovak Republic the picture was quite varied compared to the international average. More pupils than average were asked in half their lessons or more to relate what they are learning to their daily lives (92.5 per cent), give explanations about something they are studying (90.3 per cent), read other textbooks or resource materials (82.4 per cent) and observe natural phenomena (51.1 per cent). The percentage of pupils whose teachers never asked them to carry out the specified activities was generally small. However, nearly a quarter of pupils were never asked to memorise facts and principles (22.8 per cent) nearly twice the international average (see Table 6).

More Grade 4 primary pupils than average had been taught the TIMSS science topics in or before the year of assessment. This was true for all topic areas, with life science particularly high at 96 per cent of pupils having been taught the topics (see Table 7).

Table 6: Learning activities

In teaching science to this class, how often do you usually ask students to…	% of pupils whose teachers answered 'half the lessons' or more (international average)		% of pupils whose teachers answered 'never' (international average)	
	SLOVAK REPUBLIC	NI	SLOVAK REPUBLIC	NI
…observe natural phenomena such as the weather or a plant growing and describe what they see?	51.1%	18.7% (44.3%)	0.0%	3.4% (1.7%)
…watch you demonstrate an experiment or investigation?	30.6%	8.9% (38.7%)	0.7%	11.3% (4.3%)
…design or plan experiments or investigations?	16.0 %	18.6% (33.7%)	7.8%	4.0% (9.1%)
…conduct experiments or investigations?	23.1%	22.1% (38.6%)	1.7%	4.2% (3.9%)
…read their textbooks or other resource materials?	82.4%	22.3% (69.9%)	0.1%	11.2% (3.0%)
…memorise facts and principles?	30.7%	8.0% (51.5%)	22.8%	31.7% (11.2%)
…give explanations about something they are studying?	90.3%	52.7% (81.7%)	0.1%	0.8% (0.5%)
…relate what they are learning in science to their daily lives?	92.5%	60.4% (84.9%)	0.1%	0.7% (0.4%)
…do field work outside the class?	11.2%	7.1% (19.1%)	6.9%	19.8% (10.7%)
…take a written test or quiz?	16.1%	2.6% (33.3%)	0.6%	39.4% (6.2%)

Data is taken from the TIMSS 2011 teacher questionnaire.
Percentages do not total 100 as not all response categories are reported.

Table 7: Primary pupils taught the TIMSS science topics

TIMSS Grade 4 science topics	% of pupils mostly taught the topic before or in the assessment year (and international average)	
	SLOVAK REPUBLIC	NI
All (20 topics)	87%	61% (64%)
Life science (6 topics)	96%	74% (75%)
Physical science (8 topics)	83%	57% (57%)
Earth science (6 topics)	85%	53% (63%)

Data from Martin *et al. (2012),* Exhibit 8.8.

In the Slovak Republic, 75 per cent of pupils had teachers who felt very well prepared to teach the TIMSS science topics. This is above the international average. Life science topics were highest at 88 per cent, followed by earth science topics (71 per cent) and physical science topics (68 per cent). The ranges for physical science and earth science were particularly wide. Some topics (fossils and forming and separating mixtures) had fewer than a quarter of pupils taught by teachers who felt very well prepared, while others (change in state, weather conditions and earth's solar system) had higher levels of preparedness (more than half of pupils taught by such teachers) (see Table 8).

Table 8: Teacher preparedness

TIMSS Grade 4 science topics	% of pupils whose teachers feel 'very well prepared' to teach the topics (international average)		Highest and lowest percentages within each topic area (international range)	
	SLOVAK REPUBLIC	NI	SLOVAK REPUBLIC	NI
All (20 topics)	75%	54% (62%)	21.5% - 90.4%	27.6% - 62.8% (30.6% - 66.6%)
Life science (6 topics)	88%	62% (70%)	81.9% - 90.4%	43.1% - 62.2% (54.2% - 66.6%)
Physical science (8 topics)	68%	56% (62%)	21.5% - 71.4%	34.2% - 62.8% (35.2% - 62.4%)
Earth science (6 topics)	71%	44% (53%)	23.5% - 87.7%	27.6% - 59.9% (30.6% - 61.6%)

Data from Martin *et al. (2012),* Exhibit 7.9 and TIMSS 2011 teacher questionnaire.

In the Slovak Republic, up to September 2011, the Ministry of Education, Science, Research and Sport decreed one afternoon per week be designated for extracurricular activities and hobbies. This was intended to relax pupils and they were also expected not to receive any homework assignments for the following school day. Since September 2011, references to homework have been omitted from the Ministry decree; currently, only teachers and schools are responsible for determining when and if to assign homework, because they best know the needs of their pupils.

Schools decide their own homework policies. Table 9 shows that, in 2011, 15.4 per cent of pupils in the Slovak Republic were assigned no science homework, just lower than the international average of 18.3 per cent. A small number (2.6 per cent) were assigned science homework three times a week or more, much lower than the international average but slightly higher than Northern Ireland.

Table 9: Science homework

How often do you usually assign science homework to the students in this class?	% of pupils whose teachers assign no homework (international average)		% of pupils whose teachers assign homework 3 times a week or more (international average)	
	SLOVAK REPUBLIC	NI	SLOVAK REPUBLIC	NI
	15.4%	62.1% (18.3%)	2.6%	0.0% (12.4%)

Data from TIMSS 2011 teacher questionnaire.

5.8.5 Teacher education specific to science

Universities offer study programmes divided into three stages: the first stage usually lasts three years and results in a bachelor's degree; the second stage usually lasts two years and results in a master's degree; and the third stage lasts three to four years and results in a doctoral degree. All primary and secondary teachers are required to complete a master's degree.

Education for teachers wanting to teach the first stage of primary school (Grades 1–4) is organised within the autonomous field of pre-primary and primary education and usually takes place at Faculties of Pedagogy (university departments of education). The particular subjects taught vary among academic disciplines, but pupils acquire the necessary competence for teaching subjects at the first stage of primary school. Second-stage (Grades 5–9) primary school teachers and secondary school teachers typically choose to specialise in a combination of two subjects, and are educated in respective university departments that have respective courses of study.

Fewer than four per cent of pupils had primary teachers with science as their main area of post-secondary study, substantially lower than the international average (see Table 10). Just over fifteen per cent had teachers with a science education specialism, nearly half the international average.

Table 10: Teacher specialisation

During your post-secondary education…	% of pupils whose teachers answered 'yes' (international average)	
	SLOVAK REPUBLIC	NI
…was science your major or main area of study?	3.7%	11.7% (28.0%)
If your major or main area of study was education, was science your specialisation?	15.4%	9.7% (31.3%)

Data from the TIMSS 2011 teacher questionnaire.

Professional development

A 2009 National Council Act regarding pedagogical staff and professional employees establishes the rules of professional development for teachers, dividing teachers into four main categories: novice teachers, independent teachers, teachers with first authentication, and teachers with second authentication. In the course of their professional career, teachers are encouraged to proceed through these levels. There are several ways teachers can earn the credits necessary to proceed to a higher level: attending certified professional development courses; authoring approved or recommended textbooks or other study materials; or engaging in other creative activities, such as conducting research in education.

Professional development opportunities are offered to educational staff to update their subject area knowledge and develop their teaching methods and skills. Teachers are expected to continue their education on an ongoing basis. Professional development is offered in the form of training in educational management, continuous education, specialist innovation study, specialist qualification study, extended courses, and introducing new staff to classroom practices. Several institutions provide further training for teachers, including higher education institutions, educational organisations of the Ministry of Education and educational organisations of other ministries, which have established some schools or school facilities.

In general, fewer pupils than average were taught science by teachers who had participated in science-related professional development in the previous two years (see Table 11). However, more pupils in the Slovak Republic had teachers who learned about integrating information technology into science (42.9 per cent) and the science curriculum (41 per cent), both above the international average.

Table 11: Professional development

In the past two years, have you participated in professional development in…	% of pupils whose teachers answered 'yes' (international average)	
	SLOVAK REPUBLIC	NI
…science content?	15.6%	26.0% (34.9%)
…science pedagogy/instruction?	17.9%	27.9% (33.7%)
…science curriculum?	41.0%	28.6% (33.7%)
…integrating information technology into science?	42.9%	22.3% (27.9%)
…science assessment?	16.8%	5.1% (26.8%)
…addressing individual students' needs?	18.2%	12.5% (32.2%)

Data from the TIMSS 2011 teacher questionnaire.

5.8.6 Monitoring pupil progress in science

Pupils in the ninth grade of primary school are involved in the national examination, known as 'Testing 9'. The use of other standardised tests is not compulsory for schools, but most schools use some type of commercially prepared tests. The results from this assessment can be a decisive criterion of admission to secondary schools.

Teachers conduct ongoing assessments of pupil progress using grades (on a five-point marking scale), verbal assessment, and a combination of both. Verbal assessment as the sole means of assessment can only be used up to Grade 4. Continuous assessment is conducted throughout the school year and is based on observations, pupil activities, oral examinations, written examinations, and other assignments (e.g. projects). Twice each school year (at the end of January and the end of June), pupils receive evaluation feedback based on this assessment. The final evaluation in June is presented as a report card.

The National Institute for Certified Educational Measurement is a state organisation established in September 2008 as a part of changes introduced by the new Education Act. It provides the parts of the school leaving examination assigned by the Ministry of Education, external testing of pupils in primary schools and administers international assessments.

Table 12 shows how much emphasis teachers placed on a number of activities for monitoring pupil progress in science. It shows that the evaluation of pupils' ongoing work is paramount, with 100 per cent of pupils having teachers who place major or some emphasis on this. Similarly the teachers of nearly all pupils (98.8 per cent) placed emphasis on classroom tests to monitor progress and nearly three-quarters of pupils had teachers who placed emphasis on national or regional achievement tests to monitor pupil progress in science (71.5 per cent).

Table 12: Monitoring progress

How much emphasis do you place on … to monitor students' progress in science?	% of pupils whose teachers answered 'major/some' emphasis (international average)	
	SLOVAK REPUBLIC	**NI**
…the evaluation of students' ongoing work…	100%	96.1% (98.5%)
…classroom tests…	98.8%	54.7% (93.0%)
…national or regional achievement tests…	71.5%	27.2% (67.7%)

Data from the TIMSS 2011 teacher questionnaire.

6 References

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