

# Chapter 4

## Content Coverage: Development Over Time and Correlation with Achievement



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### 4.1 Introduction

From a didactical perspective, alignment between the intended and implemented curriculum (educational goals at the system and classroom level) and the achieved or attained curriculum (learning outcomes as gained by students) is considered to support students' learning. Such alignment is thus seen as a vital characteristic of effective teacher practice (Daus et al., 2019) and as essential in offering equal opportunities to students across schools. These different levels of content coverage develop continuously, as educational reforms change national curricula, didactical principles develop, and teachers' experiences and the materials they have access to shape how they implement the curriculum over time. For an example of the latter, one need to look no further than how much the use of information technology (IT) in schools has changed between the most recent rounds of TIMSS.<sup>1</sup> However, it can be difficult to compare the three different levels of content coverage as they describe the content in three different ways. A national curriculum describes the intended curriculum in relatively broad and abstract terms, extending across several school years. The implemented curriculum in the form of teachers' descriptions of the content covered when responding to the TIMSS teacher questionnaire's section on

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<sup>1</sup> The share of Danish fourth grade students with access to their own device in all lessons increased from 32 percent in TIMSS 2015 to 72 percent in TIMSS 2019 (Kjeldsen et al., 2020).

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content coverage is based on somewhat technical terms associated with the subject, while their everyday descriptions are presumably closer to the terminology they use during lessons. Finally, the attained curriculum in terms of students' learning outcomes is described empirically, using specific test items within the subject that may not be clearly associated with the different topics within the curriculum.

This chapter presents how these three curriculum levels are measured and the changes that have occurred based on the 2011, 2015, and 2019 cycles of the TIMSS fourth-grade study conducted in the Nordic countries. Furthermore, it comments on the Icelandic curriculum where relevant, as the only Nordic country not participating in TIMSS.

## **4.2 TIMSS and Curricula in the Nordic Countries**

The TIMSS goal of assessing and comparing student learning necessitates close collaboration with representatives from all participating educational systems. In general, the student assessments implemented in TIMSS and described in the TIMSS Assessment Frameworks (Mullis & Martin, 2013, 2017; Mullis et al., 2009) are considered to cover the participating countries' curricula relatively well. However, the overlap between assessment frameworks and the national curriculum varies between countries (Wagner & Hastedt, 2022).

### ***4.2.1 The Test-Curriculum Matching Analysis***

To measure how well TIMSS covers a country's curriculum, a Test-Curriculum Matching Analysis (TCMA) was conducted for each country, comparing student performance based on all items included in TIMSS with performance based only on those items that were considered within the country's curriculum. A summary of the TCMA for the four Nordic countries participating in TIMSS is presented in Table 4.1 (mathematics) and Table 4.2 (science) for the years 2011 to 2019. The tables show the number of score points for test items within each domain and the number of score points considered as falling within each country's curriculum in each cycle. In 2011 and 2015, the results of the analyses were presented as the average percentage of correct test-item responses for all test items compared to the average percentage corrected for country specific test items. This was changed in 2019 to the calculated student score based on all test items vs the score based on the test items considered to be within the country's curriculum. Thus, the TCMA analyses cannot be compared before 2019.

**Table 4.1** Test-curriculum matching analysis for the years 2011 to 2019 in mathematics

Mathematics	2011	2015	2019
Number of test items in TIMSS	175	169	171
Number of test-item score points in TIMSS	184	178	183
<i>Denmark</i>			
Test items included in national curriculum	170	140	164
Test-item score points in national curriculum	179	146	176
Mathematics achievement based on all items			525 (1.9)
Mathematics achievement on country test items			526 (1.9)
Percentage correct, all test items	59 (0.6)	61 (0.7)	
Percentage correct, national test items	60 (0.6)	56 (0.7)	
<i>Finland</i>			
Test items included in national curriculum	163	156	163
Test-item score points in national curriculum	169	166	175
Mathematics achievement based on all items			532 (2.3)
Mathematics achievement on country test items			532 (2.4)
Percentage correct, all test items	60 (0.6)	55 (0.5)	
Percentage correct, national test items	61 (0.6)	56 (0.5)	
<i>Norway</i>			
Test items included in national curriculum	172	167	157
Test-item score points in national curriculum	181	176	168
Mathematics achievement based on all items			543 (2.2)
Mathematics achievement on country test items			543 (2.2)
Percentage correct, all test items	48 (0.7)	59 (0.7)	
Percentage correct, national test items	49 (0.7)	59 (0.7)	
<i>Sweden</i>			
Test items included in national curriculum	149	130	131
Test-item score points in national curriculum	156	138	142
Mathematics achievement based on all items			521 (2.8)
Mathematics achievement on country test items			525 (2.8)
Percentage correct, all test items	53 (0.5)	51 (0.7)	
Percentage correct, national test items	50 (0.5)	55 (0.7)	

Source Mullis et al. (2012a, 2012b, 2016, 2020). Standard errors in parentheses

**Table 4.2** Test-curriculum matching analysis for the years 2011 to 2019 in science

Science	2011	2015	2019
Number of test items in TIMSS	169	168	169
Number of test-item score points in TIMSS	181	180	174
<i>Denmark</i>			
Test items included in national curriculum	164	139	155
Test-item score points in national curriculum	177	149	159
Science achievement based on all items			522 (2.4)
Science achievement on country test items			524 (2.4)
Percentage correct, all test items	54 (0.5)	53 (0.4)	
Percentage correct, national test items	55 (0.5)	58 (0.4)	
<i>Finland</i>			
Test items included in national curriculum	124	107	97
Test-item score points in national curriculum	133	113	99
Science achievement based on all items			555 (2.6)
Science achievement on country test items			555 (2.6)
Percentage correct, all test items	63 (0.4)	58 (0.4)	
Percentage correct, national test items	66 (0.5)	62 (0.4)	
<i>Norway</i>			
Test items included in national curriculum	138	109	143
Test-item score points in national curriculum	149	116	146
Science achievement based on all items			539 (2.2)
Science achievement on country test items			541 (2.2)
Percentage correct, all test items	47 (0.4)	55 (0.5)	
Percentage correct, national test items	47 (0.4)	59 (0.5)	
<i>Sweden</i>			
Test items included in national curriculum	140	101	128
Test-item score points in national curriculum	152	107	131
Science achievement based on all items			537 (3.3)
Science achievement on country test items			539 (3.3)
Percentage correct, all test items	55 (0.5)	56 (0.7)	
Percentage correct, national test items	56 (0.5)	58 (0.7)	

Source Martin et al. (2012, 2016) and Mullis et al. (2020). Standard errors in parentheses

The TIMSS 2019 curriculum questionnaire was administered online with the suggestion to draw “on the expertise of curriculum specialists and educators”<sup>2</sup> to judge whether an item falls within the curriculum, but without documentation of the procedures used or measures for reliability checks (Martin et al., 2020).

The test items in TIMSS usually assigned one score point for a correct answer, but in each cycle a few test items could assign up to two score points, with one point assigned for a partially correct answer to the test item. The number of score points that were assigned to the test items solved by students differed slightly between cycles. By contrast, according to responses to the curriculum questionnaires, there were considerable variations in the number of score points assigned to test items in a cycle that were considered within the national curriculum. In general, fewer test items were considered to be covered by the national curricula in science than in mathematics, and there was greater variation in the number of test items not reported as covered by the national curricula in science than mathematics—both between countries and within countries between cycles. As around one-third of the test items were released and replaced with new items in each cycle, some variation should be expected. However, the swapping out of test items does not seem able to explain the changes seen in differences between the total number of test-item score points and score points for test items in the national curriculum. For example, Table 4.2 shows a fall from 149 score points for test items in the Norwegian national science curriculum in the 2011 cycle to 116 score points in the 2015 cycle before increasing again to 146 score points in 2019. Whether the 2015 rise in the number of excluded test items due to previous items being replaced by test items outside the curriculum, should be reflected in the TCMA for the 2019 cycle, which would still include items introduced in 2015. As the tested grade level changed in Norway from fourth to fifth grade in the 2015 cycle, the Norwegian drop seems to be for some unaccountable reason. There were similar patterns in science for Sweden (score points 2011: 152, 2015: 107, 2019: 131) and mathematics for Denmark (score points 2011: 179, 2015: 146, 2019: 176). It seems implausible that these fluctuations were caused by the swapping out of test items alone as all test items were based on the TIMSS Assessment Framework, which only underwent minor revisions between 2011, 2015, and 2019 (Mullis & Martin, 2013, 2017).

Turning our attention to the consequences of the measurement of students’ ability by the TIMSS assessments, the 2019 analyses showed no clear and significant differences between the countries’ average scale scores based on all test items and scale scores based only on country-specific test items. Observed differences ranged from zero points (Finland, both for mathematics and science, Norway for mathematics) to four points on the TIMSS scale (Sweden for mathematics). The rest of the analyses showed differences of one (Denmark for mathematics) or two points on the TIMSS scale.

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<sup>2</sup> Quotation from the introduction to the TIMSS 2019 online curriculum questionnaire (<https://timssandpirls.bc.edu/timss2019/questionnaires/index.html>).

A significant difference was seen in the percentage of correct test-item score points between the 2011 and 2015 cycles. The difference varied between countries, subjects, and cycles, but there was a clear pattern showing a higher difference in the years when a country had marked relatively many of the test items as being outside the curriculum. The TCMA's showed no clear patterns of coherence between the TIMSS Assessment Framework, and the test items considered part of the individual country's curriculum for each cycle. In some cases, there appeared to be a strong and stable connection with little variation in the number of excluded items (e.g., for mathematics in Finland and Norway) while in other cases, the differences seemed more substantial (e.g., the generally lower number of included items for mathematics in Sweden). Nonetheless, there was variation across cycles, (e.g., for mathematics in Denmark).

#### ***4.2.2 Test Items Covered by the Nordic Curricula Over Time***

As described above in Sect. 4.2.1, there were relatively large variations in the number of test items considered not covered in the national curricula. Examining these test items (see the respective appendices of the international reports on each TIMSS cycle, Martin et al., 2012, 2016; Mullis et al., 2012a, 2016a, 2020), revealed inconsistencies across the three cycles in all four countries in terms of which test items were counted as covered in the national curricula. In all countries, there are examples of test items that were considered part of the curriculum in one cycle but not covered in the next cycle—and vice versa—with no obvious link to changes to the national curriculum. While some of these differences might be ascribable to adjustments in the respective curricula, as described in Sect. 4.3.1, it must be assumed that others were caused by national changes in interpretations of which test items were within the curriculum.

Hence, the results of the TCMA should be regarded as an indicator of the degree to which the curriculum covered the assessment framework rather than a clear indication of whether or not specific test items were within the curriculum. Further, these inconsistencies demonstrate that rather than a statement of objective truth, such measures are based on subjective judgments. However, we agree with Wagner and Hastedt's (2022) conclusion that TIMSS provides a relatively accurate measurement of student performance also in relation to the national curriculum. This certainly seems to be the case in the Nordic countries, with comparisons between the 2019 assessments of achievement based on all test items and achievement based solely on those test items included in the national curriculum showing only minor differences—likewise when looking at cases where relatively many test-items were considered outside the curriculum. Nonetheless, there was an unexplained variance between the three cycles of TIMSS in the number of excluded items within countries.

### 4.3 TIMSS and the Intended Curriculum

The intended curriculum in a school or country changes over time, governed by changes in national legislation and, to the extent that local adaptation is permitted, changes in municipal or school-level curriculum frameworks. The following section describes broad overall changes in the national curricula for Denmark, Finland, Norway, and Sweden based on the reporting of the respective curricula in the Encyclopedia entries in the international reports for each cycle of TIMSS, including a few comments on the Icelandic curriculum based on national curriculum documents.

#### 4.3.1 *The Nordic Curricula and Changes Over Time*

A simple overview of curricular development in the Nordic countries is provided in Table 4.3. For the 2019 cycle of TIMSS, all countries reported that a national curriculum was in place with some possibilities for local (municipal or school-level) adaptations.

All the Nordic countries had presented the national curriculum in a format describing the intended content for each subject across a range of grade levels. However, these grade-specific curriculum objectives were not aligned with the grade levels at which TIMSS was conducted, with the exception of science in Denmark and the 2011 TIMSS cycle in Norway. Thus, the curricula described what students should have achieved one (Finland) or two (Denmark for mathematics, Norway, and Sweden for both subjects) grade levels later than those measured in TIMSS. Consequently, it is difficult to ascertain precise learning objectives for the point at which TIMSS was administered as no particular order was stipulated for the implementation of various elements of the curriculum.

Table 4.3 shows that the Nordic countries have changed their respective curricula at different times relative to the last three TIMSS cycles. In Norway, there was no reform of the curriculum between the three cycles, but while TIMSS 2011 assessed fourth grade students, later cycles assessed students in fifth grade. As such, it might be expected that students in the 2015 and 2019 cycles would have covered more of the curriculum objectives than students in the 2011 cycle. A reform of the Swedish curriculum was implemented after the 2011 cycle of TIMSS with some later minor revisions, and reforms were enacted in Finland and Denmark between the 2015 and 2019 cycles. In Iceland, a new curriculum came into force in 2014 following a revision of the school act in 2008.

Looking across the curriculum changes implemented in the four countries that participated in TIMSS, in all cases, a revision seemed to be curriculum-wide, implementing changes in both mathematics and science. According to the TIMSS Encyclopedias (Kelly et al., 2020; Mullis et al., 2012b, 2016b), the curricula all outlined a number of broad motivations and an overall purpose for the subject, as well as underlining the importance of nurturing students' engagement and self-confidence

**Table 4.3** Overview of curriculum revisions in the years 2011 to 2019

	TIMSS cycle	Curriculum in force	Grades covered, mathematics	Grades covered, science
Denmark	2019	2015	Grade 1–3, 4–6, 7–9	Grade 1–2, 3–4, 5–6
	2015	2003	Grade 1–3, 4–6, 7–9	Grade 1–2, 3–4, 5–6
	2011	2003	Grade 1–3, 4–6, 7–9	Grade 1–2, 3–4, 5–6
Finland	2019	2016	Grade 1–2, 3–6, 7–9	Grade 1–2, 3–6, 7–9
	2015	2004	Grade 1–2, 3–5, 6–9	Grade 1–5
	2011	2004	Grade 1–2, 3–5, 6–9	Grade 1–5
Norway	2019	2006	Grade 1–2, 3–4, 5–7, 8–10	Grade 1–4, 5–7
	2015	2006	Grade 1–2, 3–4, 5–7, 8–10	Grade 1–4, 5–7
	2011	2006	Grade 1–2, 3–4, 5–7, 8–10	Grade 1–4, 5–7
Sweden	2019	2011, with minor revisions in 2017/18	Grade 1–3, 4–6, 7–9	Grade 1–3, 4–6, 7–9
	2015	2011	Grade 1–3, 4–6, 7–9	Grade 1–3, 4–6, 7–9
	2011	1994	Goals to be met by grade 5	Goals to be met by grade 5
Iceland	2019	2014	Grade 1–4, 5–7	Grade 1–4, 5–7
	2015	2014	Grade 1–4, 5–7	Grade 1–4, 5–7
	2011	2007	Grade 1–4, 5–7	Grade 1–4, 5–7

in the subject. Further, they stipulated general goals, which was also the case for the Icelandic curriculum (Icelandic Ministry of Education Science & Culture, 2014). Revisions shifted descriptions towards more specific learning goals that students should reach by the end of the grade levels covered.

#### 4.4 Students' Opportunity to Learn—The Implemented Curriculum According to Teachers

Students' opportunity to learn (OTL) specific content areas (Scheerens, 2017) was measured using the teacher questionnaire, which asked teachers whether they had taught specific content in previous years, during the current school year leading up



to TIMSS, or whether they expected to cover it later. Consequently, teachers had no opportunity to indicate that a given content area was not part of the national curriculum. The National Research Coordinators (NRC) also reported on whether or not the various content areas were part of the national curriculum at the fourth-grade level, with the same content areas included in the curriculum and teacher questionnaires. Appendix 1 shows the items used, whether an area was considered within the national curriculum, and provides an overview of the content coverage as reported by teachers for the last three cycles of TIMSS (2011, 2015, and 2019). As the TIMSS Assessment Framework has changed over time, the corresponding questions to both teachers and NRCs concerning content coverage also changed slightly between cycles.

#### ***4.4.1 Content Coverage in Mathematics in the Intended and Implemented Curriculum***

For fourth grade assessment in TIMSS, mathematics content was divided into three content domains across the three cycles. In 2019, the three content domains were labeled number, measurement and geometry, and data. In each cycle, 50 percent of test items in the assessment relate to the content domain number, while the proportion of test items assessing measurement and geometry decreased from 35 to 30% from 2015 to 2019, with a corresponding increase in test items concerning data from 15 to 20%.

The curriculum questionnaire and teacher questionnaire were used to determine whether topics within each of these three content domains were included in the national (intended) curriculum and covered in class (implemented curriculum), with 17 items in the 2011 and 2015 cycles and 18 items in the 2019 cycle. For example, within the content domain data, teachers and NRCs were asked whether students had or would be expected to have worked with “reading and representing data from tables, pictographs, bar graphs, line graphs, and pie charts”. As this item illustrates, the questions addressing whether a topic had been covered could address multiple sub-topics. An overview of the items is provided in Appendix 1, which also illustrates that there were minor changes in phrasing between cycles.

Based on responses from NRCs, there were fluctuations between countries and cycles concerning the number of topics that were expected to have been covered, with no clear link to changes to the curriculum or the number of topics considered outside the respective curriculum (Sect. 4.2.2). Norway, where there were no major revisions to the national curriculum between cycles, provides an illustrative case. Despite the switch from assessing grade four students to grade five students between the 2011 and 2015 cycles, there was no change in the number of topics that were expected to have been covered. This was followed by an increase in the number of excluded topics in 2019.

Integers and the four basic arithmetic operations seemed to comprise the core content within mathematics, considered part of the curriculum by NRCs across all cycles and countries except for Denmark in 2011, and taught to between 96 and 100% of students across all cycles. All other topics within mathematics seemed to be less central, and with large variations. When a topic was not considered within the curriculum by the NRC, it tended to have lower coverage by teachers, but all topics had been presented to some students, however, in cases where the NRC indicated that a topic was included in the curriculum during one cycle but not the next, or vice versa, teachers' responses regarding their implementation of this topic in classroom teaching did not reflect such fluctuations.

#### ***4.4.2 Content Coverage in Science in the Intended and Implemented Curriculum***

Fourth grade science content was likewise divided into three content domains: life science, physical science, and earth science. These domains were covered by 45%, 35%, and 20% of the test items respectively. There was an increase in the number of items in the curriculum questionnaire and teacher questionnaire concerning whether various topics were included in the curriculum and covered in class, rising from 20 items in 2011 to 26 items in 2019. There were likewise changes in how each topic was worded. For instance, in 2011, the topic of fossils was referred to as “fossils of animals and plants (age, location, formation)”; in 2015, the word “understanding” was part of the question on the topic; and in 2019, it was rephrased as “fossils and what they can tell us about past conditions on Earth”, thus shifting the focus.

Among teacher responses, the content domain of life science had the highest coverage, with an apparent correlation between the number of students encountering each topic and whether the topic was considered part of the national curriculum. However, the content domain of life science differed from the content domain of number within mathematics in the sense that no topic was covered by teachers to the same extent as the central topics within number. The topic with the highest coverage within life science was “physical and behavioral characteristics of living things and major groups of living things (e.g., mammals, birds, insects, flowering plants)” with 93% coverage by the end of fourth grade among students in Finland in 2015 and 91% in 2019. However, the vast majority of topics had less than 90% coverage.

In general, more topics were considered outside the curriculum in science than in mathematics by the NRCs, with between 25 and 69% of topics considered not included in the country's national curriculum in a given cycle. The exception was Sweden, which only reported one topic that was not included in each of the three cycles. Of the 26 topics identified in the 2019 questionnaires, 7 topics were considered not included in the Danish curriculum, and 17 not included in the Finnish and Norwegian curricula.

Compared to mathematics, larger variations were found in teachers' coverage of topics within science, which was to be expected given the NRCs' indication that fewer topics were included in the respective national curricula. However, teachers reported covering all topics to a limited extent, with some correlation as to whether or not NRCs indicated that the topic was included in the national curriculum.

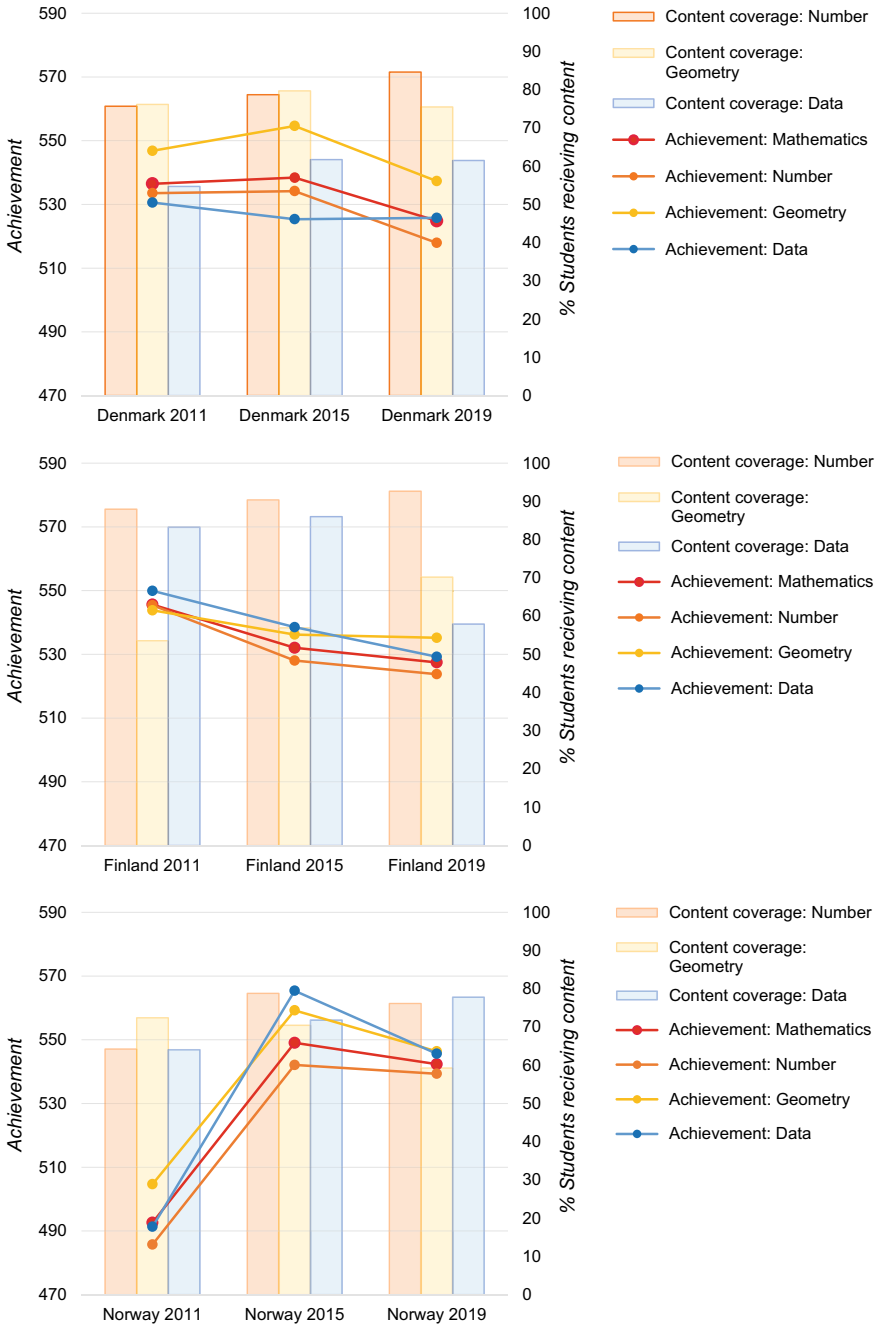
## **4.5 The Attained Curriculum—Student Learning and Its Relationship with the Implemented Curriculum**

In TIMSS, the attained curriculum is measured by an overall score and scores within each of the three content domains in both mathematics and science, based on all test items. This implies that the measure of attained curriculum covers more than the intended and implemented curriculum, as described above in Sect. 4.2. The following section describes how this measure relates to the implemented curriculum.

### ***4.5.1 The Attained Curriculum in Mathematics***

Figure 4.1 shows the development in teachers' reported content coverage within the three different mathematical content domains across the three cycles, as well as student attainment. As described in the previous sections, there were some variations in content coverage within countries. It is notable that, at the national level, an increase or decrease in content coverage in one content domain was shadowed by similar changes in other content domains. One notable exception can be observed in Finland, where coverage of the data domain decreased sharply from 2015 to 2019 following changes in the curriculum.

Average student scores within the different content domains generally fluctuated in line with the overall score, with minor variations between cycles. The large increase in scores seen in Norway from 2011 to 2015 can be attributed to the shift in the target population from grade four to grade five students between the two cycles. However, it is noteworthy that this shift did not seem to lead to major changes in the reported content coverage in geometry, which decreased with each cycle from 2011 to 2019. While the content domains numbers and data saw minor increases in coverage from 2011 to 2015, for data, this increase was not significantly greater than the increase between the 2015 and 2019 cycles, suggesting a general trend to focus more on topics related to processing and interpreting data rather than a direct result of an additional year of teaching.



**Fig. 4.1** Bar graphs showing achievement in mathematics content domains for the years 2011 to 2019 for all countries. *Note* One bar graph per country.

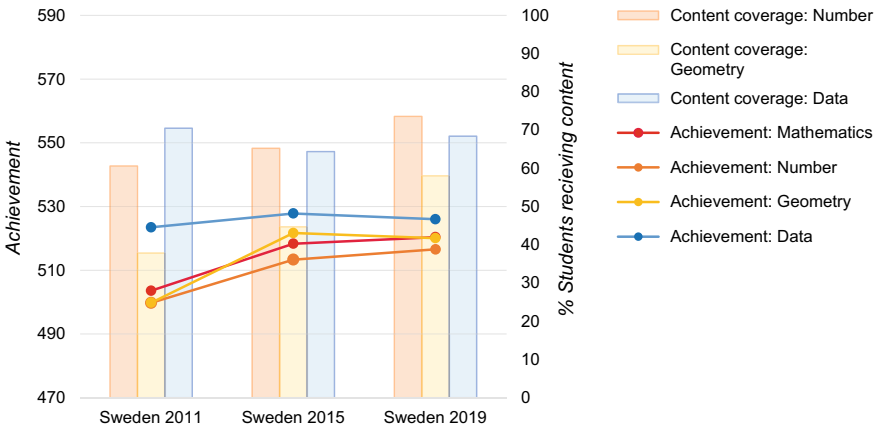


Fig. 4.1 (continued)

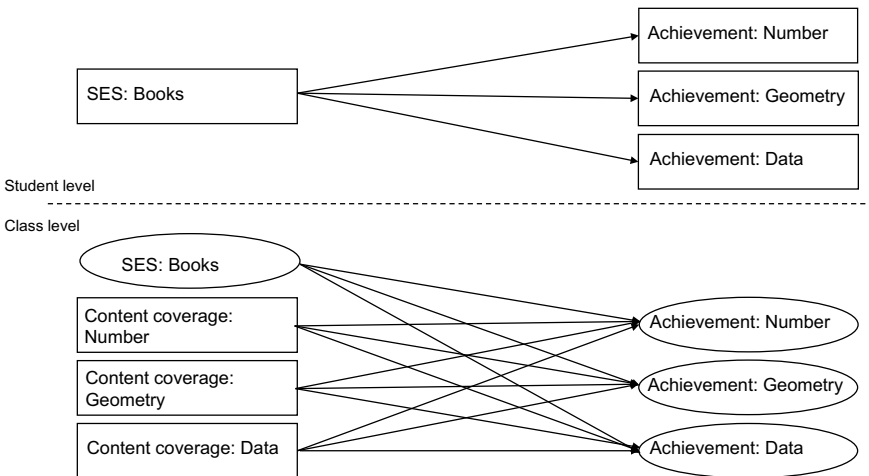


Fig. 4.2 Structural equation model of the relationships between content coverage and scores. *Note* Content coverage = percentage of students taught topics.

The data used to produce Fig. 4.1 are presented in greater detail in the table in Appendix 2, divided into teachers with and without specialization as a mathematics teacher. This revealed differences in both content coverage and achievement scores, with specialized mathematics teachers in general covering slightly more of the curriculum and their students achieving slightly higher scores on average, although the differences go in both directions. It should be noted that not all countries require specialized mathematics training to teach the subject.

Appendix 3 presents the results of a structural equation model (SEM) of the relationship between content coverage in the three content domains and student scores in these domains for all three cycles, as described in Chap. 3. The model, as shown in Fig 4.2, controls for student socioeconomic background (SES) using the student-reported number of books in the home, as students in general are found to profit differently from teaching quality based on their SES level (Atlay et al., 2019).

Some clear relationships are seen in certain countries in some years. However, although the number of significant predictions (all being positive) exceeded what would be expected by chance alone, no clear pattern emerged in the analyses in terms of which content domain predicts scores or across countries.

### 4.5.2 *The Attained Curriculum in Science*

Content coverage for the three content domains life science, physical science, and earth science fluctuated slightly between cycles and between countries, with physical science having a lower degree of coverage than the other two content domains in all countries. A higher proportion of missing data was observed for content coverage in science than for mathematics in all countries and cycles, which means that the results should be interpreted with some reservations, especially in relation to Denmark where the rate of missing data exceeded 50 percent for all content domains in each cycle. Appendix 4 provides similar content to Fig. 4.1 for the subject science.

Examining student scores in the different content domains as well as the overall score revealed similar patterns to those found for mathematics. The scores followed similar trends within countries across cycles, with a minor exception being an increase in the Danish students' average score in earth science between 2015 and 2019 while scores in the other domains decreased between these two cycles.

Dividing student scores and content coverage between teachers with and without subject specialization in science, as presented in Appendix 2, some variations were found in both content domain scores and content coverage—both within countries between cycles and within cycles across countries. Once again, it should be noted that subject specialization in science is not a requirement in all countries.

The SEM analyses assessing whether coverage in science content domains predicted student scores within these domains are presented in Appendix 4. These analyses revealed a slight deviation from the patterns previously described for mathematics. Content coverage in physical science significantly predicted student scores in all three content domains for Denmark in 2011 and Finland in 2015, as well as predicting Swedish students' scores in physical science and earth science in 2019. However, a negative correlation was found between content coverage in earth science and scores in physical and earth science in Finland in 2019. Thus, while there seemed to be some significant correlations between content coverage and achievement within and across content domains, there were no consistent patterns across countries or cycles.

## 4.6 Conclusion

The starting point for this chapter is the didactical expectation that there is (and should be) a connection between the intended, implemented, and achieved curriculum. The analyses presented here do not corroborate the conclusion from Wagner and Hastedt (2022) that TIMSS can be used to draw inferences about the performance of education systems, including those of the Nordic countries, due to the study's coverage of national curricula. Instead, the analyses highlight difficulties in measuring and describing the intended, implemented, and achieved curriculum.

The chapter shows that the measures of implemented curriculum in TIMSS correlate with the measures of achieved curriculum in terms of students' scores in mathematics and science (for further analyses, see Chap. 6). However, the results also illustrate divergence between the different measures of intended and implemented curriculum, which are less reliable than one might hope. Based on the analyses, a range of possible explanations for the low reliability of the measures can be identified.

The first of these explanations relates to differences in how content is defined across the different measures. National curricula are described in general terms with content covering broad areas that students should be taught—often within a time span covering a longer period than the grade where outcomes are measured in TIMSS. As a result, decisions as to whether or not a TIMSS measure of intended, implemented, or achieved curriculum falls within the national curriculum must be based on subjective judgment by the NRC.

Secondly, the terminology that teachers use in their daily work may differ from the terms used in the questionnaires developed to measure teachers' implementation of the curriculum. This can once again introduce reliability issues by requiring interpretations of questions by teachers, which might be complicated further by some questions being ambiguous and hence, force teachers to make a choice about content coverage if only parts of the content are covered. As outlined in the description of curriculum development processes, local adaptations of national curricula can likewise muddy the waters.

Thirdly, whether or not a test item concerns a topic covered by the national curriculum is based on an assessment of whether or not it is included in the curriculum's description of learning objectives and an estimate of the point at which it is taught, given that the curricula generally cover a period extending beyond the TIMSS assessment. For example, there are test items covering the order of operations when using parentheses in mathematics. While not directly mentioned in the Danish curriculum, this is something students would be expected to have learned by the end of the period covered by the curriculum, which ends with sixth grade, but it is difficult to determine more precisely whether this is a topic that will have been covered at the time of the TIMSS assessment. One possible solution might be to consult commonly used textbooks to determine whether the use of parentheses is generally introduced.

Fourthly, and especially relevant when measuring the intended curriculum, some measures are reported for the whole country by a single person, whether the NRC or someone delegated the task by the NRC. Thus, the uncertainties outlined in our previous point will have more serious implications for reliability than the measures conducted at the teacher or student level, where the samples are much larger. These variations in measures may be explained by a change of NRC or in the staff reporting on behalf of the NRC with other content knowledge or other preferences related questionnaire answering.

As indicated throughout this chapter, changes between cycles in the TIMSS Assessment Framework have led to changes in the phrasing of questions collecting information on the intended and implemented curriculum. One limitation of the analyses presented here is that they do not consider how such changes are implemented in the national translations of the teacher questionnaire or whether the translations have been revised without any changes in the international source.

The identified changes in the TIMSS Assessment Framework and its measures of content coverage at different levels are to be expected as they reflect developments in national curricula and teaching practices. As such, we conclude that this framework is well-suited to measuring attained curriculum in the forms of Nordic students' achievement in mathematics and science and to monitoring changes over time despite reliability issues in measuring development in specific areas within the curriculum.

## **Appendices**

### **Appendix 1 OTL Descriptives from TIMSS 2011, 2015, and 2019**

#### *OTL Descriptives 2011—Students*



2011	Denmark			Finland		
	Topic inclusion in curriculum <sup>a</sup>	Proportion of students with teacher reporting topic taught in or before G4 (%)	Average achievement by content domain <sup>b</sup>	Topic inclusion in curriculum <sup>a</sup>	Proportion of students with teacher reporting topic taught in or before G4 (%)	Average achievement by content domain <sup>b</sup>
Number	(a) Concepts of whole numbers, including place value and ordering	Not included in the curriculum through grade 4	534	All or almost all students	99	545
	(b) Adding, subtracting, multiplying, and/or dividing with whole numbers	All or almost all students	98	All or almost all students	100	
	(c) Concepts of fractions (fractions as parts of a whole or of a collection, or as a location on a number line; comparing and ordering fractions)	Not included in the curriculum through grade 4	88	All or almost all students	93	
	(d) Adding and subtracting with fractions	Not included in the curriculum through grade 4	31	Not included in the curriculum through grade 4	86	

(continued)

		Denmark			Finland		
		Topic inclusion in curriculum <sup>a</sup>	Proportion of students with teacher reporting topic taught in or before G4 (%)	Average achievement by content domain <sup>b</sup>	Topic inclusion in curriculum <sup>a</sup>	Proportion of students with teacher reporting topic taught in or before G4 (%)	Average achievement by content domain <sup>b</sup>
Measurement & Geometry	(e) Concepts of decimals, including place value and ordering	Not included in the curriculum through grade 4	68		Not included in the curriculum through grade 4	75	
	(f) Adding and subtracting with decimals	Not included in the curriculum through grade 4	75		Not included in the curriculum through grade 4	70	
	(g) Number sentences (finding the missing number, modeling simple situations with number sentences)	Not included in the curriculum through grade 4	58		All or almost all students	79	
	(h) Number patterns (extending number patterns and finding missing terms)	All or almost all students	84		All or almost all students	95	
	(a) Lines: measuring, estimating length of; parallel and perpendicular lines	All or almost all students	92	548	All or almost all students	80	543

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2011		Denmark			Finland		
		Topic inclusion in curriculum <sup>a</sup>	Proportion of students with teacher reporting topic taught in or before G4 (%)	Average achievement by content domain <sup>b</sup>	Topic inclusion in curriculum <sup>a</sup>	Proportion of students with teacher reporting topic taught in or before G4 (%)	Average achievement by content domain <sup>b</sup>
	(b) Comparing and drawing angles	All or almost all students	73		All or almost all students	68	
	(c) Using informal coordinate systems to locate points in a plane (e.g., in square B4)	All or almost all students	81		All or almost all students	62	
	(d) Elementary properties of common geometric shapes	All or almost all students	90		All or almost all students	84	
	(e) Reflections and rotations	All or almost all students	76		All or almost all students	43	
	(f) Relationships between two-dimensional and three-dimensional shapes	Not included in the curriculum through grade 4	41		Not included in the curriculum through grade 4	17	
	(g) Finding and estimating areas, perimeters and volumes	Not included in the curriculum through grade 4	74		Not included in the curriculum through grade 4	28	

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		Denmark			Finland		
		Topic inclusion in curriculum <sup>a</sup>	Proportion of students with teacher reporting topic taught in or before G4 (%)	Average achievement by content domain <sup>b</sup>	Topic inclusion in curriculum <sup>a</sup>	Proportion of students with teacher reporting topic taught in or before G4 (%)	Average achievement by content domain <sup>b</sup>
Data	(a) Reading data from tables, pictographs, bar graphs, or pie charts	All or almost all students	68	532	All or almost all students	92	551
	(b) Drawing conclusions from data displays	All or almost all students	54		All or almost all students	76	
	(c) Displaying data using tables, pictographs, and bar graphs	All or almost all students	40		All or almost all students	80	
Life Science	(a) Major body structures and their functions in humans and other organisms (plants and animals)	All or almost all students	72	530	All or almost all students	66	574
	(b) Life cycles and reproduction in plants and animals	All or almost all students	56		Not included in the curriculum through grade 4	73	
	(c) Physical features, behavior, and survival of organisms living in different environments	All or almost all students	67		All or almost all students	71	

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2011		Denmark			Finland		
		Topic inclusion in curriculum <sup>a</sup>	Proportion of students with teacher reporting topic taught in or before G4 (%)	Average achievement by content domain <sup>b</sup>	Topic inclusion in curriculum <sup>a</sup>	Proportion of students with teacher reporting topic taught in or before G4 (%)	Average achievement by content domain <sup>b</sup>
Physical Science	(d) Relationships in a given community (e.g., simple food chains, predator-prey relationships)	All or almost all students	75		Not included in the curriculum through grade 4	86	
	(e) Changes in environments (effects of human activity, pollution and its prevention)	All or almost all students	51		Not included in the curriculum through grade 4	72	
	(f) Human health (e.g., transmission/prevention of communicable diseases, signs of health/illness, diet, exercise)	All or almost all students	56		All or almost all students	71	
	(a) States of matter (solids, liquids, gases) and differences in their physical properties (shape, volume), including changes in state of matter by heating and cooling	Not included in the curriculum through grade 4	47	526	All or almost all students	71	568

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2011

	Denmark			Finland		
	Topic inclusion in curriculum <sup>a</sup>	Proportion of students with teacher reporting topic taught in or before G4 (%)	Average achievement by content domain <sup>b</sup>	Topic inclusion in curriculum <sup>a</sup>	Proportion of students with teacher reporting topic taught in or before G4 (%)	Average achievement by content domain <sup>b</sup>
(b) Classification of objects/materials based on physical properties (e.g., weight/mass, volume, magnetic attraction)	Not included in the curriculum through grade 4	41		Not included in the curriculum through grade 4	36	
(c) Forming and separating mixtures	Not included in the curriculum through grade 4	26		Not included in the curriculum through grade 4	13	
(d) Familiar changes in materials (e.g., decaying, burning, rusting, cooking)	All or almost all students	29		All or almost all students	35	
(e) Common energy sources/forms and their practical uses (e.g., the Sun, electricity, water, wind)	All or almost all students	79		Not included in the curriculum through grade 4	64	
(f) Light (e.g., sources, behavior)	All or almost all students	51		All or almost all students	72	

(continued)

		Denmark			Finland		
		Topic inclusion in curriculum <sup>a</sup>	Proportion of students with teacher reporting topic taught in or before G4 (%)	Average achievement by content domain <sup>b</sup>	Topic inclusion in curriculum <sup>a</sup>	Proportion of students with teacher reporting topic taught in or before G4 (%)	Average achievement by content domain <sup>b</sup>
Earth Science	(g) Electrical circuits and properties of magnets	Not included in the curriculum through grade 4	59	All or almost all students	52		
	(h) Forces that cause objects to move (e.g., gravity, push/pull forces)	Not included in the curriculum through grade 4	54	Not included in the curriculum through grade 4	26		
	(a) Water on Earth (location, types, and movement) and air (composition, proof of its existence, uses)	All or almost all students	58	All or almost all students	54	566	
	(b) Common features of Earth's landscape (e.g., mountains, plains, rivers, deserts) and relationship to human use (e.g., farming, irrigation, land development)	All or almost all students	54	Not included in the curriculum through grade 4	52		
	(c) Weather conditions from day to day or over the seasons	All or almost all students	83	All or almost all students	82		

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2011		Denmark			Finland		
		Topic inclusion in curriculum <sup>a</sup>	Proportion of students with teacher reporting topic taught in or before G4 (%)	Average achievement by content domain <sup>b</sup>	Topic inclusion in curriculum <sup>a</sup>	Proportion of students with teacher reporting topic taught in or before G4 (%)	Average achievement by content domain <sup>b</sup>
	(d) Fossils of animals and plants (age, location, formation)	All or almost all students	24		Not included in the curriculum through grade 4	7	
	(e) Earth's solar system (planets, Sun, moon)	All or almost all students	63		All or almost all students	63	
	(f) Day, night, and shadows due to Earth's rotation and its relationship to the Sun	Not included in the curriculum through grade 4	65		All or almost all students	63	



2011	Norway			Sweden		
	Topic inclusion in curriculum <sup>a</sup>	Proportion of students with teacher reporting topic taught in or before G4 (%)	Average achievement by content domain <sup>b</sup>	Topic inclusion in curriculum <sup>a</sup>	Proportion of students with teacher reporting topic taught in or before G4 (%)	Average achievement by content domain <sup>b</sup>
Number	(a) Concepts of whole numbers, including place value and ordering	100	488	All or almost all students	100	500
	(b) Adding, subtracting, multiplying, and/or dividing with whole numbers	98		All or almost all students	99	
	(c) Concepts of fractions (fractions as parts of a whole or of a collection, or as a location on a number line; comparing and ordering fractions)	50		All or almost all students	41	
	(d) Adding and subtracting with fractions	Not included in the curriculum through grade 4	18	Not included in the curriculum through grade 4	18	
	(e) Concepts of decimals, including place value and ordering	All or almost all students	43	All or almost all students	20	

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		Norway			Sweden			
		Topic inclusion in curriculum <sup>a</sup>	Proportion of students with teacher reporting topic taught in or before G4 (%)	Average achievement by content domain <sup>b</sup>	Topic inclusion in curriculum <sup>a</sup>	Proportion of students with teacher reporting topic taught in or before G4 (%)	Average achievement by content domain <sup>b</sup>	
2011	(f) Adding and subtracting with decimals	Not included in the curriculum through grade 4	27		All or almost all students	16		
		(g) Number sentences (finding the missing number; modeling simple situations with number sentences)	75		All or almost all students	93		
	Measurement and Geometry	(h) Number patterns (extending number patterns and finding missing terms)	All or almost all students	90		All or almost all students	94	
		(a) Lines: measuring, estimating length of; parallel and perpendicular lines	All or almost all students	74	507	All or almost all students	59	500
	(b) Comparing and drawing angles	All or almost all students	50		All or almost all students	21		

(continued)

		Norway			Sweden		
		Topic inclusion in curriculum <sup>a</sup>	Proportion of students with teacher reporting topic taught in or before G4 (%)	Average achievement by content domain <sup>b</sup>	Topic inclusion in curriculum <sup>a</sup>	Proportion of students with teacher reporting topic taught in or before G4 (%)	Average achievement by content domain <sup>b</sup>
2011	(c) Using informal coordinate systems to locate points in a plane (e.g., in square B4)	All or almost all students	77		All or almost all students	27	
		All or almost all students	92		All or almost all students	85	
		All or almost all students	87		Not included in the curriculum through grade 4	12	
		All or almost all students	51		All or almost all students	17	
		All or almost all students	81		All or almost all students	37	
	(a) Reading data from tables, pictographs, bar graphs, or pie charts	Not included in the curriculum through grade 4	76	494	All or almost all students	79	523

(continued)

		Norway				Sweden		
		Topic inclusion in curriculum <sup>a</sup>	Proportion of students with teacher reporting topic taught in or before G4 (%)	Average achievement by content domain <sup>b</sup>	Topic inclusion in curriculum <sup>a</sup>	Proportion of students with teacher reporting topic taught in or before G4 (%)	Average achievement by content domain <sup>b</sup>	
2011	Life Science	(b) Drawing conclusions from data displays	All or almost all students	48		All or almost all students	75	
		(c) Displaying data using tables, pictographs, and bar graphs	All or almost all students	56		All or almost all students	70	
		(a) Major body structures and their functions in humans and other organisms (plants and animals)	All or almost all students	69	496	All or almost all students	45	534
	(b) Life cycles and reproduction in plants and animals	All or almost all students	68		All or almost all students	67		
	(c) Physical features, behavior, and survival of organisms living in different environments	Not included in the curriculum through grade 4	41		All or almost all students	66		
	(d) Relationships in a given community (e.g., simple food chains, predator-prey relationships)	Not included in the curriculum through grade 4	83		All or almost all students	62		

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		Norway			Sweden		
		Topic inclusion in curriculum <sup>a</sup>	Proportion of students with teacher reporting topic taught in or before G4 (%)	Average achievement by content domain <sup>b</sup>	Topic inclusion in curriculum <sup>a</sup>	Proportion of students with teacher reporting topic taught in or before G4 (%)	Average achievement by content domain <sup>b</sup>
Physical Science	(e) Changes in environments (effects of human activity, pollution and its prevention)	All or almost all students	74		All or almost all students	59	
	(f) Human health (e.g., transmission/prevention of communicable diseases, signs of health/illness, diet, exercise)	All or almost all students	74		All or almost all students	37	
	(a) States of matter (solids, liquids, gases) and differences in their physical properties (shape, volume), including changes in state of matter by heating and cooling	All or almost all students	53	482	All or almost all students	55	528
	(b) Classification of objects/materials based on physical properties (e.g., weight/mass, volume, magnetic attraction)	All or almost all students	17		All or almost all students	27	
	(c) Forming and separating mixtures	Not included in the curriculum through grade 4	9		All or almost all students	32	

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	Norway			Sweden		
	Topic inclusion in curriculum <sup>a</sup>	Proportion of students with teacher reporting topic taught in or before G4 (%)	Average achievement by content domain <sup>b</sup>	Topic inclusion in curriculum <sup>a</sup>	Proportion of students with teacher reporting topic taught in or before G4 (%)	Average achievement by content domain <sup>b</sup>
2011	(d) Familiar changes in materials (e.g., decaying, burning, rusting, cooking)	All or almost all students	46	All or almost all students	29	
	(e) Common energy sources/forms and their practical uses (e.g., the Sun, electricity, water, wind)	Not included in the curriculum through grade 4	61	All or almost all students	52	
	(f) Light (e.g., sources, behavior)	All or almost all students	41	All or almost all students	17	
	(g) Electrical circuits and properties of magnets	Not included in the curriculum through grade 4	10	All or almost all students	33	
	(h) Forces that cause objects to move (e.g., gravity, push/pull forces)	Not included in the curriculum through grade 4	22	All or almost all students	14	

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2011		Norway			Sweden		
		Topic inclusion in curriculum <sup>a</sup>	Proportion of students with teacher reporting topic taught in or before G4 (%)	Average achievement by content domain <sup>b</sup>	Topic inclusion in curriculum <sup>a</sup>	Proportion of students with teacher reporting topic taught in or before G4 (%)	Average achievement by content domain <sup>b</sup>
Earth Science	(a) Water on Earth (location, types, and movement) and air (composition, proof of its existence, uses)	Not included in the curriculum through grade 4	65	506	All or almost all students	57	538
	(b) Common features of Earth's landscape (e.g., mountains, plains, rivers, deserts) and relationship to human use (e.g., farming, irrigation, land development)	Not included in the curriculum through grade 4	65		All or almost all students	60	
	(c) Weather conditions from day to day or over the seasons	All or almost all students	90		All or almost all students	84	
	(d) Fossils of animals and plants (age, location, formation)	All or almost all students	72		Not included in the curriculum through grade 4	56	
	(e) Earth's solar system (planets, Sun, moon)	All or almost all students	95		All or almost all students	88	

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	Norway		Sweden	
	Topic inclusion in curriculum <sup>a</sup>	Proportion of students with teacher reporting topic taught in or before G4 (%)	Average achievement by content domain <sup>b</sup>	Topic inclusion in curriculum <sup>a</sup>
(f) Day, night, and shadows due to Earth's rotation and its relationship to the Sun	All or almost all students	81		All or almost all students
				82
				Average achievement by content domain <sup>b</sup>

*NB*<sup>a</sup> The Curriculum questionnaire for TIMSS 2011 asked NRCs: "According to the national mathematics curriculum, what proportion of grade 4 students should have been taught each of the following topics or skills by the end of grade 4?" and "According to the national science curriculum, what proportion of grade 4 students should have been taught each of the following topics or skills by the end of grade 4?"

<sup>b</sup> (Martin et al., 2012; Mullis et al., 2012a, 2012b)



***OTL Descriptives 2015—Students***

	Denmark		Finland		Average achievement by content domain <sup>b</sup>	
	Topic inclusion in curriculum <sup>a</sup>	Proportion of students with teacher reporting topic taught in or before G4 (%)	Topic inclusion in curriculum <sup>a</sup>	Proportion of students with teacher reporting topic taught in or before G4 (%)		
Number	(a) Concepts of whole numbers, including place value and ordering	Topics Taught to All or Almost All Students	100	Topics Taught to All or Almost All Students	97	532
	(b) Adding, subtracting, multiplying, and/or dividing with whole numbers	Topics Taught to All or Almost All Students	99	Topics Taught to All or Almost All Students	100	
	(c) Concepts of multiples and factors; odd and even numbers	Topics Taught to All or Almost All Students	87	Topics Taught to All or Almost All Students	94	
	(d) Concepts of fractions (fractions as parts of a whole or of a collection, or as a location on a number line)	Topics Taught to All or Almost All Students	88	Topics Taught to All or Almost All Students	92	
	(e) Adding and subtracting with fractions, comparing and ordering fractions	Topics Taught to All or Almost All Students	46	Topics Taught to All or Almost All Students	86	

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	Denmark			Finland		
	Topic inclusion in curriculum <sup>a</sup>	Proportion of students with teacher reporting topic taught in or before G4 (%)	Average achievement by content domain <sup>b</sup>	Topic inclusion in curriculum <sup>a</sup>	Proportion of students with teacher reporting topic taught in or before G4 (%)	Average achievement by content domain <sup>b</sup>
(f) Concepts of decimals, including place value and ordering, adding and subtracting with decimals	Topics Taught to All or Almost All Students	81		Topics Taught to All or Almost All Students	75	
	Topics Taught to All or Almost All Students	44		Topics Taught to All or Almost All Students	78	
	Topics Taught to All or Almost All Students	81		Topics Taught to All or Almost All Students	98	
(g) Number sentences (finding the missing number, modeling simple situations with number sentences)	Topics Taught to All or Almost All Students	95	555	Topics Taught to All or Almost All Students	80	539
(h) Number patterns (extending number patterns and finding missing terms)	Topics Taught to All or Almost All Students	80		Topics Taught to All or Almost All Students	66	
(a) Lines: measuring, estimating length of; parallel and perpendicular lines	Topics Taught to All or Almost All Students			Topics Taught to All or Almost All Students		
(b) Comparing and drawing angles	Topics Taught to All or Almost All Students			Topics Taught to All or Almost All Students		

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Measurement and Geometry

(continued)

	Denmark			Finland		
	Topic inclusion in curriculum <sup>a</sup>	Proportion of students with teacher reporting topic taught in or before G4 (%)	Average achievement by content domain <sup>b</sup>	Topic inclusion in curriculum <sup>a</sup>	Proportion of students with teacher reporting topic taught in or before G4 (%)	Average achievement by content domain <sup>b</sup>
(c) Using informal coordinate systems to locate points in a plane (e.g., in square B4)	Topics Taught to All or Almost All Students	85		Topics Taught to All or Almost All Students	65	
	Topics Taught to All or Almost All Students	96		Topics Taught to All or Almost All Students	89	
	Topics Taught to Only the More Able Students (Top Track)	75		Topics Taught to All or Almost All Students	43	
	Topics Taught to All or Almost All Students	46		Not Included in the Curriculum Through Grade 4	25	
(d) Elementary properties of common geometric shapes						
(e) Reflections and rotations						
(f) Relationships between two-dimensional and three-dimensional shapes						

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		Denmark		Finland			
		Topic inclusion in curriculum <sup>a</sup>	Proportion of students with teacher reporting topic taught in or before G4 (%)	Average achievement by content domain <sup>b</sup>	Topic inclusion in curriculum <sup>a</sup>	Proportion of students with teacher reporting topic taught in or before G4 (%)	Average achievement by content domain <sup>b</sup>
Data	(g) Finding and estimating areas, perimeters, and volumes	Topics Taught to All or Almost All Students	78		Topics Taught to All or Almost All Students	38	
	(a) Reading and representing data from tables, pictographs, bar graphs, or pie charts	Topics Taught to All or Almost All Students	72	526	Topics Taught to All or Almost All Students	92	542
	(b) Drawing conclusions from data displays	Topics Taught to All or Almost All Students	51		Topics Taught to All or Almost All Students	80	
Life Science	(a) Characteristics of living things and the major groups of living things (e.g., mammals, birds, insects, flowering plants)	Topics Taught to All or Almost All Students	79	534	Topics Taught to All or Almost All Students	93	556
	(b) Major body structures and their functions in humans, other animals, and plants	Topics Taught to All or Almost All Students	75		Topics Taught to All or Almost All Students	63	

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	Denmark		Finland		Average achievement by content domain <sup>b</sup>
	Topic inclusion in curriculum <sup>a</sup>	Proportion of students with teacher reporting topic taught in or before G4 (%)	Topic inclusion in curriculum <sup>a</sup>	Proportion of students with teacher reporting topic taught in or before G4 (%)	
(c) Life cycles of common plants and animals (e.g., humans, butterflies, frogs, flowering plants)	Topics Taught to All or Almost All Students	63	Not Included in the Curriculum Through Grade 4	83	
(d) Understanding that some characteristics are inherited and some are the result of the environment	Not Included in the Curriculum Through Grade 4	32	Not Included in the Curriculum Through Grade 4	33	
(e) How physical features and behaviors help living things survive in their environments	Topics Taught to All or Almost All Students	54	Topics Taught to All or Almost All Students	72	
(f) Relationships in communities and ecosystems (e.g., simple food chains, predator-prey relationships, human impacts on the environment)	Topics Taught to All or Almost All Students	73	Not Included in the Curriculum Through Grade 4	91	

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	Denmark			Finland		
	Topic inclusion in curriculum <sup>a</sup>	Proportion of students with teacher reporting topic taught in or before G4 (%)	Average achievement by content domain <sup>b</sup>	Topic inclusion in curriculum <sup>a</sup>	Proportion of students with teacher reporting topic taught in or before G4 (%)	Average achievement by content domain <sup>b</sup>
Physical Science	(g) Human health (transmission and prevention of diseases, symptoms of health and illness, importance of a healthy diet and exercise)	64		Topics Taught to All or Almost All Students	75	
	(a) States of matter (solid, liquid, gas) and properties of the states of matter (volume, shape); how the state of matter changes by heating or cooling	51	516	Topics Taught to All or Almost All Students	70	547
	(b) Classifying materials based on physical properties (e.g., weight/mass, volume, conducting heat, conducting electricity, magnetic attraction)	38		Topics Taught to All or Almost All Students	39	
(c) Mixtures and how to separate a mixture into its components (e.g., sifting, filtering, evaporation, using a magnet)	23		Topics Taught to All or Almost All Students	17		

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	Denmark			Finland		
	Topic inclusion in curriculum <sup>a</sup>	Proportion of students with teacher reporting topic taught in or before G4 (%)	Average achievement by content domain <sup>b</sup>	Topic inclusion in curriculum <sup>a</sup>	Proportion of students with teacher reporting topic taught in or before G4 (%)	Average achievement by content domain <sup>b</sup>
(d) Chemical changes in everyday life (e.g., decaying, burning, rusting, cooking)	Topics Taught to All or Almost All Students	23		Topics Taught to All or Almost All Students	25	
	Topics Taught to Only the More Able Students (Top Track)	73		Not Included in the Curriculum Through Grade 4	66	
	Topics Taught to All or Almost All Students	38		Topics Taught to All or Almost All Students	71	
(e) Common sources of energy (e.g., the Sun, electricity, wind) and uses of energy (heating and cooling homes, providing light)	Topics Taught to All or Almost All Students	53		Topics Taught to All or Almost All Students	54	
(f) Light and sound in everyday life (e.g., understanding shadows and reflection, understanding that vibrating objects make sound)						
(g) Electricity and simple circuits (e.g., identifying materials that are conductors, recognizing that electricity can be changed to light or sound, knowing that a circuit must be complete to work correctly)						

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	Denmark			Finland		
	Topic inclusion in curriculum <sup>a</sup>	Proportion of students with teacher reporting topic taught in or before G4 (%)	Average achievement by content domain <sup>b</sup>	Topic inclusion in curriculum <sup>a</sup>	Proportion of students with teacher reporting topic taught in or before G4 (%)	Average achievement by content domain <sup>b</sup>
	(h) Properties of magnets (e.g., knowing that like poles repel and opposite poles attract, recognizing that magnets can attract some objects)	59		Topics Taught to All or Almost All Students	44	
	(i) Forces that cause objects to move (e.g., gravity, pushing/pulling)	44		Topics Taught to All or Almost All Students	40	
Earth Science	(a) Common features of the Earth's landscape (e.g., mountains, plains, deserts, rivers, oceans) and their relationship to human use (farming, irrigation, land development)	53	531	Topics Taught to All or Almost All Students	58	560
	(b) Where water is found on the Earth and how it moves in and out of the air (e.g., evaporation, rainfall, cloud formation, dew formation)	67		Topics Taught to All or Almost All Students	78	

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	Denmark		Finland		Average achievement by content domain <sup>b</sup>
	Topic inclusion in curriculum <sup>a</sup>	Proportion of students with teacher reporting topic taught in or before G4 (%)	Topic inclusion in curriculum <sup>a</sup>	Proportion of students with teacher reporting topic taught in or before G4 (%)	
(c) Understanding that weather can change from day to day, from season to season, and by geographic location	Topics Taught to All or Almost All Students	64	Topics Taught to All or Almost All Students	68	
	Topics Taught to Only the More Able Students (Top Track)	28	Not Included in the Curriculum Through Grade 4	20	
	Topics Taught to All or Almost All Students	76	Topics Taught to All or Almost All Students	76	
(d) Understanding what fossils are and what they can tell us about past conditions on Earth					
(e) Objects in the solar system (the Sun, the Earth, the Moon, and other planets) and their movements (the Earth and other planets revolve around the Sun, the Moon revolves around the Earth)	Topics Taught to All or Almost All Students	72	Topics Taught to All or Almost All Students	78	
(f) Understanding how day and night result from the Earth's rotation on its axis and how the Earth's rotation results in changing shadows throughout the day	Topics Taught to All or Almost All Students		Topics Taught to All or Almost All Students		

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	Denmark			Finland		
	Topic inclusion in curriculum <sup>a</sup>	Proportion of students with teacher reporting topic taught in or before G4 (%)	Average achievement by content domain <sup>b</sup>	Topic inclusion in curriculum <sup>a</sup>	Proportion of students with teacher reporting topic taught in or before G4 (%)	Average achievement by content domain <sup>b</sup>
(g) Understanding how seasons are related to the Earth's annual movement around the Sun	Topics Taught to All or Almost All Students	72		Not Included in the Curriculum Through Grade 4	77	

	Norway			Sweden			
	Topic inclusion in curriculum <sup>a</sup>	Proportion of students with teacher reporting topic taught in or before G4 (%)	Average achievement by content domain <sup>b</sup>	Topic inclusion in curriculum <sup>a</sup>	Proportion of students with teacher reporting topic taught in or before G4 (%)	Average achievement by content domain <sup>b</sup>	
Number	(a) Concepts of whole numbers, including place value and ordering	Topics Taught to All or Almost All Students	99	542	Topics Taught to All or Almost All Students	100	514
	(b) Adding, subtracting, multiplying, and/or dividing with whole numbers	Topics Taught to All or Almost All Students	100		Topics Taught to All or Almost All Students	98	
	(c) Concepts of multiples and factors; odd and even numbers	Topics Taught to All or Almost All Students	67		Topics Taught to All or Almost All Students	82	
	(d) Concepts of fractions (fractions as parts of a whole or of a collection, or as a location on a number line)	Topics Taught to All or Almost All Students	78		Topics Taught to All or Almost All Students	42	
	(e) Adding and subtracting with fractions, comparing and ordering fractions	Not Included in the Curriculum Through Grade 4	53		Topics Taught to All or Almost All Students	28	

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	Norway			Sweden		
	Topic inclusion in curriculum <sup>a</sup>	Proportion of students with teacher reporting topic taught in or before G4 (%)	Average achievement by content domain <sup>b</sup>	Topic inclusion in curriculum <sup>a</sup>	Proportion of students with teacher reporting topic taught in or before G4 (%)	Average achievement by content domain <sup>b</sup>
(f) Concepts of decimals, including place value and ordering, adding and subtracting with decimals	Topics Taught to All or Almost All Students	82		Topics Taught to All or Almost All Students	20	
	Topics Taught to All or Almost All Students	65		Topics Taught to All or Almost All Students	65	
	Topics Taught to All or Almost All Students	80		Topics Taught to All or Almost All Students	86	
(g) Number sentences (finding the missing number; modeling simple situations with number sentences)						
(h) Number patterns (extending number patterns and finding missing terms)						
(a) Lines: measuring, estimating length of; parallel and perpendicular lines	Not Included in the Curriculum Through Grade 4	84	559	Topics Taught to All or Almost All Students	59	523

(continued)

Measurement and Geometry

(continued)

	Norway			Sweden		
	Topic inclusion in curriculum <sup>a</sup>	Proportion of students with teacher reporting topic taught in or before G4 (%)	Average achievement by content domain <sup>b</sup>	Topic inclusion in curriculum <sup>a</sup>	Proportion of students with teacher reporting topic taught in or before G4 (%)	Average achievement by content domain <sup>b</sup>
(b) Comparing and drawing angles	Not Included in the Curriculum Through Grade 4	77		Topics Taught to All or Almost All Students	41	
(c) Using informal coordinate systems to locate points in a plane (e.g., in square B4)	Topics Taught to All or Almost All Students	69		Topics Taught to All or Almost All Students	22	
(d) Elementary properties of common geometric shapes	Topics Taught to All or Almost All Students	91		Topics Taught to All or Almost All Students	89	
(e) Reflections and rotations	Topics Taught to All or Almost All Students	71		Topics Taught to All or Almost All Students	22	

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	Norway			Sweden		
	Topic inclusion in curriculum <sup>a</sup>	Proportion of students with teacher reporting topic taught in or before G4 (%)	Average achievement by content domain <sup>b</sup>	Topic inclusion in curriculum <sup>a</sup>	Proportion of students with teacher reporting topic taught in or before G4 (%)	Average achievement by content domain <sup>b</sup>
Data	(f) Relationships between two-dimensional and three-dimensional shapes	31		Topics Taught to All or Almost All Students	30	
	(g) Finding and estimating areas, perimeters, and volumes	61		Topics Taught to All or Almost All Students	42	
Data	(a) Reading and representing data from tables, pictographs, bar graphs, or pie charts	84	566	Topics Taught to All or Almost All Students	63	529
	(b) Drawing conclusions from data displays	61		Topics Taught to All or Almost All Students	62	

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	Norway			Sweden		
	Topic inclusion in curriculum <sup>a</sup>	Proportion of students with teacher reporting topic taught in or before G4 (%)	Average achievement by content domain <sup>b</sup>	Topic inclusion in curriculum <sup>a</sup>	Proportion of students with teacher reporting topic taught in or before G4 (%)	Average achievement by content domain <sup>b</sup>
Life Science	(a) Characteristics of living things and the major groups of living things (e.g., mammals, birds, insects, flowering plants)	Not Included in the Curriculum Through Grade 4	546	Topics Taught to All or Almost All Students	79	540
	(b) Major body structures and their functions in humans, other animals, and plants	Topics Taught to All or Almost All Students	85	Topics Taught to All or Almost All Students	45	
	(c) Life cycles of common plants and animals (e.g., humans, butterflies, frogs, flowering plants)	Topics Taught to All or Almost All Students	63	Topics Taught to All or Almost All Students	70	
	(d) Understanding that some characteristics are inherited and some are the result of the environment	Not Included in the Curriculum Through Grade 4	45	Topics Taught to All or Almost All Students	29	

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	Norway			Sweden		
	Topic inclusion in curriculum <sup>a</sup>	Proportion of students with teacher reporting topic taught in or before G4 (%)	Average achievement by content domain <sup>b</sup>	Topic inclusion in curriculum <sup>a</sup>	Proportion of students with teacher reporting topic taught in or before G4 (%)	Average achievement by content domain <sup>b</sup>
(e) How physical features and behaviors help living things survive in their environments	Not Included in the Curriculum Through Grade 4	42		Topics Taught to All or Almost All Students	62	
	Topics Taught to All or Almost All Students	54		Topics Taught to All or Almost All Students	74	
	Topics Taught to All or Almost All Students	64		Topics Taught to All or Almost All Students	38	
(f) Relationships in communities and ecosystems (e.g., simple food chains, predator-prey relationships, human impacts on the environment)	Not Included in the Curriculum Through Grade 4	54	522	Topics Taught to All or Almost All Students	84	534
(g) Human health (transmission and prevention of diseases, symptoms of health and illness, importance of a healthy diet and exercise)	Not Included in the Curriculum Through Grade 4	54		Topics Taught to All or Almost All Students	84	
(a) States of matter (solid, liquid, gas) and properties of the states of matter (volume, shape); how the state of matter changes by heating or cooling	Not Included in the Curriculum Through Grade 4	54		Topics Taught to All or Almost All Students	84	

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	Norway			Sweden		
	Topic inclusion in curriculum <sup>a</sup>	Proportion of students with teacher reporting topic taught in or before G4 (%)	Average achievement by content domain <sup>b</sup>	Topic inclusion in curriculum <sup>a</sup>	Proportion of students with teacher reporting topic taught in or before G4 (%)	Average achievement by content domain <sup>b</sup>
(b) Classifying materials based on physical properties (e.g., weight/mass, volume, conducting heat, conducting electricity, magnetic attraction)	Not Included in the Curriculum Through Grade 4	29		Topics Taught to All or Almost All Students	35	
	(c) Mixtures and how to separate a mixture into its components (e.g., sifting, filtering, evaporation, using a magnet)	44		Topics Taught to All or Almost All Students	60	
	(d) Chemical changes in everyday life (e.g., decaying, burning, rusting, cooking)	51		Topics Taught to All or Almost All Students	42	
	(e) Common sources of energy (e.g., the Sun, electricity, wind) and uses of energy (heating and cooling homes, providing light)	48		Topics Taught to All or Almost All Students	56	

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	Norway			Sweden		
	Topic inclusion in curriculum <sup>a</sup>	Proportion of students with teacher reporting topic taught in or before G4 (%)	Average achievement by content domain <sup>b</sup>	Topic inclusion in curriculum <sup>a</sup>	Proportion of students with teacher reporting topic taught in or before G4 (%)	Average achievement by content domain <sup>b</sup>
	(f) Light and sound in everyday life (e.g., understanding shadows and reflection, understanding that vibrating objects make sound)	Not Included in the Curriculum Through Grade 4	28	Topics Taught to All or Almost All Students	26	
	(g) Electricity and simple circuits (e.g., identifying materials that are conductors, recognizing that electricity can be changed to light or sound, knowing that a circuit must be complete to work correctly)	Not Included in the Curriculum Through Grade 4	17	Topics Taught to All or Almost All Students	41	
	(h) Properties of magnets (e.g., knowing that like poles repel and opposite poles attract, recognizing that magnets can attract some objects)	Not Included in the Curriculum Through Grade 4	63	Topics Taught to All or Almost All Students	26	
	(i) Forces that cause objects to move (e.g., gravity, pushing/pulling)	Not Included in the Curriculum Through Grade 4	42	Topics Taught to All or Almost All Students	37	

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	Norway			Sweden			
	Topic inclusion in curriculum <sup>a</sup>	Proportion of students with teacher reporting topic taught in or before G4 (%)	Average achievement by content domain <sup>b</sup>	Topic inclusion in curriculum <sup>a</sup>	Proportion of students with teacher reporting topic taught in or before G4 (%)	Average achievement by content domain <sup>b</sup>	
Earth Science	(a) Common features of the Earth's landscape (e.g., mountains, plains, deserts, rivers, oceans) and their relationship to human use (farming, irrigation, land development)	Not Included in the Curriculum Through Grade 4	67	549	Topics Taught to All or Almost All Students	53	552
	(b) Where water is found on the Earth and how it moves in and out of the air (e.g., evaporation, rainfall, cloud formation, dew formation)	Not Included in the Curriculum Through Grade 4	57		Topics Taught to All or Almost All Students	89	
	(c) Understanding that weather can change from day to day, from season to season, and by geographic location	Topics Taught to All or Almost All Students	70		Topics Taught to All or Almost All Students	63	
	(d) Understanding what fossils are and what they can tell us about past conditions on Earth	Topics Taught to All or Almost All Students	68		Not Included in the Curriculum Through Grade 4	55	

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	Norway			Sweden		
	Topic inclusion in curriculum <sup>a</sup>	Proportion of students with teacher reporting topic taught in or before G4 (%)	Average achievement by content domain <sup>b</sup>	Topic inclusion in curriculum <sup>a</sup>	Proportion of students with teacher reporting topic taught in or before G4 (%)	Average achievement by content domain <sup>b</sup>
(e) Objects in the solar system (the Sun, the Earth, the Moon, and other planets) and their movements (the Earth and other planets revolve around the Sun, the Moon revolves around the Earth)	Topics Taught to All or Almost All Students	71		Topics Taught to All or Almost All Students	77	
	(f) Understanding how day and night result from the Earth's rotation on its axis and how the Earth's rotation results in changing shadows throughout the day	71		Topics Taught to All or Almost All Students	75	
	(g) Understanding how seasons are related to the Earth's annual movement around the Sun	68		Topics Taught to All or Almost All Students	76	

NB <sup>a</sup> The Curriculum questionnaire for TIMSS 2015 asked NRCs: “According to the national mathematics curriculum, what proportion of grade 4 students should have been taught each of the following topics or skills by the end of grade 4?” and “According to the national science curriculum, what proportion of grade 4 students should have been taught each of the following topics or skills by the end of grade 4?”

<sup>b</sup> (Martin et al., 2016; Mullis et al., 2016)

*OTL Descriptives 2019—Students*

	2019	Denmark			Finland		
		Topic inclusion in curriculum <sup>a</sup>	Proportion of students with teacher reporting topic taught in or before G4 (%)	Average achievement by content domain <sup>b</sup>	Topic inclusion in curriculum <sup>a</sup>	Proportion of students with teacher reporting topic taught in or before G4 (%)	Average achievement by content domain <sup>b</sup>
Number	(a) Concepts of whole numbers, including place value and ordering	All or almost all the students	98	518	All or almost all the students	98	528
	(b) Adding, subtracting, multiplying, and dividing with whole numbers	All or almost all the students	97		All or almost all the students	100	
	(c) Concepts of multiples and factors; odd and even numbers	All or almost all the students	82		All or almost all the students	93	
	(d) Number sentences (finding the missing number, representing problem situations with number sentences)	All or almost all the students	81		Only the more able students	74	
	(e) Number patterns (extending number patterns and finding missing terms)	All or almost all the students	84		All or almost all the students	97	
	(f) Concepts of fractions, including representing, comparing and ordering, adding and subtracting simple fractions	All or almost all the students	73		All or almost all the students	98	

(continued)

		2019				Finland		Average achievement by content domain <sup>b</sup>
		Denmark		Finland				
		Topic inclusion in curriculum <sup>a</sup>	Proportion of students with teacher reporting topic taught in or before G4 (%)	Average achievement by content domain <sup>b</sup>	Topic inclusion in curriculum <sup>a</sup>	Proportion of students with teacher reporting topic taught in or before G4 (%)	Average achievement by content domain <sup>b</sup>	
Measurement and Geometry	(g) Concepts of decimals, including place value and ordering, adding and subtracting with decimals	All or almost all the students	77		All or almost all the students	94		
	(a) Solving problems involving length, including measuring and estimating	All or almost all the students	92	536	All or almost all the students	86	538	
	(b) Solving problems involving mass, volume, and time	All or almost all the students	57		All or almost all the students	66		
	(c) Finding and estimating perimeter, area, and volume	All or almost all the students	86		All or almost all the students	52		
	(d) Parallel and perpendicular lines	All or almost all the students	88		All or almost all the students	89		
	(e) Comparing and drawing angles	All or almost all the students	83		All or almost all the students	71		
	(f) Elementary properties of common geometric shapes	All or almost all the students	95		All or almost all the students	88		

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		2019				(continued)			
		Denmark		Finland		Denmark		Finland	
		Topic inclusion in curriculum <sup>a</sup>	Proportion of students with teacher reporting topic taught in or before G4 (%)	Average achievement by content domain <sup>b</sup>	Topic inclusion in curriculum <sup>a</sup>	Proportion of students with teacher reporting topic taught in or before G4 (%)	Average achievement by content domain <sup>b</sup>		
Data	(g) Three-dimensional shapes, including relationships with their two-dimensional representations	All or almost all the students	33		Not included in the curriculum through Grade 4	32			
	(a) Reading and representing data from tables, pictographs, bar graphs, line graphs, and pie charts	All or almost all the students	70	525	All or almost all the students	72	534		
	(b) Organizing and representing data to help answer questions	All or almost all the students	63		All or almost all the students	48			
	(c) Drawing conclusions from data displays	All or almost all the students	54		All or almost all the students	54			
Life Science	(a) Physical and behavioral characteristics of living things and major groups of living things (e.g., mammals, birds, insects, flowering plants)	All or almost all the students	88	526	All or almost all the students	91	558		

(continued)

	Denmark			Finland		
	Topic inclusion in curriculum <sup>a</sup>	Proportion of students with teacher reporting topic taught in or before G4 (%)	Average achievement by content domain <sup>b</sup>	Topic inclusion in curriculum <sup>a</sup>	Proportion of students with teacher reporting topic taught in or before G4 (%)	Average achievement by content domain <sup>b</sup>
2019						
(b) Major body structures and their functions in humans, other animals, and plants	All or almost all the students	78		All or almost all the students	60	
(c) Life cycles of common plants and animals (e.g., flowering plants, butterflies, frogs)	All or almost all the students	79		All or almost all the students	79	
(d) Characteristics of plants and animals that are inherited	Not included in the curriculum through Grade 4	37		Not included in the curriculum through Grade 4	17	
(e) Interactions between organisms and their environments (e.g., physical features and behaviors that help living things survive in their environments)	All or almost all the students	56		Not included in the curriculum through Grade 4	68	
(f) Relationships in ecosystems (e.g., simple food chains, predator-prey relationships, competition)	All or almost all the students	85		All or almost all the students	89	

(continued)

(continued)		2019				Finland			
		Denmark		Average achievement by content domain <sup>b</sup>		Denmark		Average achievement by content domain <sup>b</sup>	
		Topic inclusion in curriculum <sup>a</sup>	Proportion of students with teacher reporting topic taught in or before G4 (%)	Proportion of students with teacher reporting topic taught in or before G4 (%)	Proportion of students with teacher reporting topic taught in or before G4 (%)	Topic inclusion in curriculum <sup>a</sup>	Proportion of students with teacher reporting topic taught in or before G4 (%)	Average achievement by content domain <sup>b</sup>	Average achievement by content domain <sup>b</sup>
Physical science									
		(g) Human health (transmission and prevention of diseases, everyday behaviors that promote good health)	All or almost all the students	64		All or almost all the students	83		
		(a) States of matter (solid, liquid, gas) and their properties (volume, shape)	All or almost all the students	72		All or almost all the students	80	507	544
		(b) Classifying materials based on physical properties (e.g., weight/ mass, volume, state of matter, conductivity of heat or electricity)	All or almost all the students	39		Not included in the curriculum through Grade 4	38		
	(c) Mixtures, including methods for separating a mixture into its components (e.g., sifting, filtering, evaporation, using a magnet)	All or almost all the students	27		Not included in the curriculum through Grade 4	18			

(continued)

	Denmark				Finland			
	Topic inclusion in curriculum <sup>a</sup>	Proportion of students with teacher reporting topic taught in or before G4 (%)	Average achievement by content domain <sup>b</sup>	Topic inclusion in curriculum <sup>a</sup>	Proportion of students with teacher reporting topic taught in or before G4 (%)	Average achievement by content domain <sup>b</sup>		
2019								
(d) Properties of magnets (e.g., like poles repel and opposite poles attract, magnets can attract some objects)	All or almost all the students	44		Not included in the curriculum through Grade 4	36			
(e) Physical changes in everyday life (e.g., changes of state, dissolving)	Not included in the curriculum through Grade 4	37		Not included in the curriculum through Grade 4	50			
(f) Chemical changes in everyday life (e.g., decaying, burning, rusting, cooking)	Not included in the curriculum through Grade 4	35		Not included in the curriculum through Grade 4	36			
(g) Common sources of energy (e.g., the Sun, wind, oil) and uses of energy (heating and cooling homes, providing light)	Not included in the curriculum through Grade 4	67		Not included in the curriculum through Grade 4	63			

(continued)

	Denmark			Finland		
	Topic inclusion in curriculum <sup>a</sup>	Proportion of students with teacher reporting topic taught in or before G4 (%)	Average achievement by content domain <sup>b</sup>	Topic inclusion in curriculum <sup>a</sup>	Proportion of students with teacher reporting topic taught in or before G4 (%)	Average achievement by content domain <sup>b</sup>
2019						
(h) Light and sound in everyday life (e.g., shadows and reflections, vibrating objects make sound)	All or almost all the students	44		All or almost all the students	63	
(i) Heat transfer (e.g., energy flows from a hot object to a colder object)	Not included in the curriculum through Grade 4	41		Not included in the curriculum through Grade 4	34	
(j) Electricity and simple electrical circuits (e.g., a circuit must be complete to work correctly)	All or almost all the students	63		Not included in the curriculum through Grade 4	39	
(k) Forces that cause objects to move (e.g., gravity, pushing/pulling) or change their motion (e.g., friction)	Not included in the curriculum through Grade 4	49		Not included in the curriculum through Grade 4	34	

(continued)

		2019				Finland				
		Denmark		Average achievement by content domain <sup>b</sup>		Topic inclusion in curriculum <sup>a</sup>		Proportion of students with teacher reporting topic taught in or before G4 (%)		Average achievement by content domain <sup>b</sup>
Earth Science	(1) Simple machines (e.g., levers, pulleys, wheels, ramps) that help make motion easier	Not included in the curriculum through Grade 4	39		All or almost all the students	56				
	(a) Physical makeup of Earth's surface (e.g., land and water in unequal proportions, sources of fresh and salt water)	All or almost all the students	64	535	Not included in the curriculum through Grade 4	60			563	
	(b) Earth's resources used in everyday life (e.g., water, wind, soil, forests, oil, natural gas, minerals)	All or almost all the students	65		Not included in the curriculum through Grade 4	48				
	(c) Changes in Earth's surface over time (e.g., mountain building, weathering, erosion)	All or almost all the students	47		Not included in the curriculum through Grade 4	21				

(continued)

		Denmark			Finland		
		Topic inclusion in curriculum <sup>a</sup>	Proportion of students with teacher reporting topic taught in or before G4 (%)	Average achievement by content domain <sup>b</sup>	Topic inclusion in curriculum <sup>a</sup>	Proportion of students with teacher reporting topic taught in or before G4 (%)	Average achievement by content domain <sup>b</sup>
(continued)	2019						
	(d) Fossils and what they can tell us about past conditions on Earth	All or almost all the students	41		Not included in the curriculum through Grade 4	16	
	(e) Weather and climate (e.g., daily, seasonal, and locational variations versus long term trends)	All or almost all the students	83		Not included in the curriculum through Grade 4	71	
	(f) Objects in the Solar System (the Sun, the Earth, the Moon, and other planets) and their movements	All or almost all the students	84		Not included in the curriculum through Grade 4	70	
	(g) Earth's motion and related patterns observed on Earth (e.g., day and night, seasons)	All or almost all the students	86		All or almost all the students	82	

	2019				Sweden			
	Norway		Average achievement by content domain <sup>b</sup>		Sweden		Average achievement by content domain <sup>b</sup>	
	Topic inclusion in curriculum <sup>a</sup>	Proportion of students with teacher reporting topic taught in or before G4 (%)	Proportion of students with teacher reporting topic taught in or before G4 (%)	Proportion of students with teacher reporting topic taught in or before G4 (%)	Topic inclusion in curriculum <sup>a</sup>	Proportion of students with teacher reporting topic taught in or before G4 (%)	Topic inclusion in curriculum <sup>a</sup>	Proportion of students with teacher reporting topic taught in or before G4 (%)
Number	(a) Concepts of whole numbers, including place value and ordering	All or almost all the students	100	540	All or almost all the students	100	All or almost all the students	517
	(b) Adding, subtracting, multiplying, and dividing with whole numbers	All or almost all the students	96		All or almost all the students	100		
	(c) Concepts of multiples and factors; odd and even numbers	All or almost all the students	67		All or almost all the students	86		
	(d) Number sentences (finding the missing number, representing problem situations with number sentences)	All or almost all the students	66		All or almost all the students	68		
	(e) Number patterns (extending number patterns and finding missing terms)	All or almost all the students	67		All or almost all the students	85		
	(f) Concepts of fractions, including representing, comparing and ordering, adding and subtracting simple fractions	Not included in the curriculum through Grade 4	51		Not included in the curriculum through Grade 4	48		
	(g) Concepts of decimals, including place value and ordering, adding and subtracting with decimals	All or almost all the students	90		Not included in the curriculum through Grade 4	24		

(continued)



		2019				Sweden		
		Norway		Average achievement by content domain <sup>b</sup>		Topic inclusion in curriculum <sup>a</sup>		Average achievement by content domain <sup>b</sup>
Measurement and Geometry	(continued)	Topic inclusion in curriculum <sup>a</sup>		Proportion of students with teacher reporting topic taught in or before G4 (%)		Proportion of students with teacher reporting topic taught in or before G4 (%)		Average achievement by content domain <sup>b</sup>
		(a) Solving problems involving length, including measuring and estimating	All or almost all the students	82	546	All or almost all the students	86	521
		(b) Solving problems involving mass, volume, and time	Not included in the curriculum through Grade 4	37		All or almost all the students	56	
(c) Finding and estimating perimeter, area, and volume	Not included in the curriculum through Grade 4	75		All or almost all the students	47			

(continued)

(continued)		2019				Sweden		
		Norway		Average achievement by content domain <sup>b</sup>		Topic inclusion in curriculum <sup>a</sup>		Average achievement by content domain <sup>b</sup>
		Topic inclusion in curriculum <sup>a</sup>	Proportion of students with teacher reporting topic taught in or before G4 (%)	Proportion of students with teacher reporting topic taught in or before G4 (%)	Proportion of students with teacher reporting topic taught in or before G4 (%)	Topic inclusion in curriculum <sup>a</sup>	Proportion of students with teacher reporting topic taught in or before G4 (%)	Average achievement by content domain <sup>b</sup>
	(d) Parallel and perpendicular lines	Not included in the curriculum through Grade 4	37			Not included in the curriculum through Grade 4	39	
	(e) Comparing and drawing angles	Not included in the curriculum through Grade 4	70			Not included in the curriculum through Grade 4	49	
	(f) Elementary properties of common geometric shapes	All or almost all the students	87			All or almost all the students	88	
	(g) Three-dimensional shapes, including relationships with their two-dimensional representations	Not included in the curriculum through Grade 4	33			All or almost all the students	34	

(continued)

		Norway			Sweden		
		Topic inclusion in curriculum <sup>a</sup>	Proportion of students with teacher reporting topic taught in or before G4 (%)	Average achievement by content domain <sup>b</sup>	Topic inclusion in curriculum <sup>a</sup>	Proportion of students with teacher reporting topic taught in or before G4 (%)	Average achievement by content domain <sup>b</sup>
Data	2019						
	(a) Reading and representing data from tables, pictographs, bar graphs, line graphs, and pie charts	Not included in the curriculum through Grade 4	86	547	Not included in the curriculum through Grade 4	81	527
	(b) Organizing and representing data to help answer questions	All or almost all the students	79		All or almost all the students	61	
	(c) Drawing conclusions from data displays	Not included in the curriculum through Grade 4	71		All or almost all the students	63	
Life Science	(a) Physical and behavioral characteristics of living things and major groups of living things (e.g., mammals, birds, insects, flowering plants)	Not included in the curriculum through Grade 4	75	547	All or almost all the students	78	541
	(b) Major body structures and their functions in humans, other animals, and plants	All or almost all the students	88		All or almost all the students	52	

(continued)

(continued)

	Norway			Sweden		
	Topic inclusion in curriculum <sup>a</sup>	Proportion of students with teacher reporting topic taught in or before G4 (%)	Average achievement by content domain <sup>b</sup>	Topic inclusion in curriculum <sup>a</sup>	Proportion of students with teacher reporting topic taught in or before G4 (%)	Average achievement by content domain <sup>b</sup>
2019						
(c) Life cycles of common plants and animals (e.g., flowering plants, butterflies, frogs)	All or almost all the students	64		All or almost all the students	69	
(d) Characteristics of plants and animals that are inherited	Not included in the curriculum through Grade 4	27		All or almost all the students	33	
(e) Interactions between organisms and their environments (e.g., physical features and behaviors that help living things survive in their environments)	Not included in the curriculum through Grade 4	47		All or almost all the students	65	
(f) Relationships in ecosystems (e.g., simple food chains, predator-prey relationships, competition)	All or almost all the students	62		All or almost all the students	80	
(g) Human health (transmission and prevention of diseases, everyday behaviors that promote good health)	All or almost all the students	67		All or almost all the students	38	

(continued)

		2019				Sweden					
		Norway		Average achievement by content domain <sup>b</sup>		Topic inclusion in curriculum <sup>a</sup>		Proportion of students with teacher reporting topic taught in or before G4 (%)		Average achievement by content domain <sup>b</sup>	
Physical science											
	(a)	States of matter (solid, liquid, gas) and their properties (volume, shape)	Not included in the curriculum through Grade 4	50	525	All or almost all the students	85	525	All or almost all the students	85	525
	(b)	Classifying materials based on physical properties (e.g., weight/mass, volume, state of matter, conductivity of heat or electricity)	Not included in the curriculum through Grade 4	21		All or almost all the students	43		All or almost all the students	43	
	(c)	Mixtures, including methods for separating a mixture into its components (e.g., sifting, filtering, evaporation, using a magnet)	Not included in the curriculum through Grade 4	36		All or almost all the students	46		All or almost all the students	46	
	(d)	Properties of magnets (e.g., like poles repel and opposite poles attract, magnets can attract some objects)	Not included in the curriculum through Grade 4	66		All or almost all the students	20		All or almost all the students	20	

(continued)

(continued)

	Norway		Sweden	
	Topic inclusion in curriculum <sup>a</sup>	Proportion of students with teacher reporting topic taught in or before G4 (%)	Topic inclusion in curriculum <sup>a</sup>	Proportion of students with teacher reporting topic taught in or before G4 (%)
2019				
(e) Physical changes in everyday life (e.g., changes of state, dissolving)	All or almost all the students	46	All or almost all the students	51
(f) Chemical changes in everyday life (e.g., decaying, burning, rusting, cooking)	Not included in the curriculum through Grade 4	43	All or almost all the students	43
(g) Common sources of energy (e.g., the Sun, wind, oil) and uses of energy (heating and cooling homes, providing light)	Not included in the curriculum through Grade 4	57	All or almost all the students	48
(h) Light and sound in everyday life (e.g., shadows and reflections, vibrating objects make sound)	All or almost all the students	27	All or almost all the students	17
(i) Heat transfer (e.g., energy flows from a hot object to a colder object)	Not included in the curriculum through Grade 4	19	All or almost all the students	38

(continued)

		Norway			Sweden		
		Topic inclusion in curriculum <sup>a</sup>	Proportion of students with teacher reporting topic taught in or before G4 (%)	Average achievement by content domain <sup>b</sup>	Topic inclusion in curriculum <sup>a</sup>	Proportion of students with teacher reporting topic taught in or before G4 (%)	Average achievement by content domain <sup>b</sup>
Earth Science	2019						
	(j) Electricity and simple electrical circuits (e.g., a circuit must be complete to work correctly)	Not included in the curriculum through Grade 4	18		All or almost all the students	24	
	(k) Forces that cause objects to move (e.g., gravity, pushing/pulling) or change their motion (e.g., friction)	Not included in the curriculum through Grade 4	39		All or almost all the students	26	
	(l) Simple machines (e.g., levers, pulleys, wheels, ramps) that help make motion easier	Not included in the curriculum through Grade 4	19		All or almost all the students	42	
		(a) Physical makeup of Earth's surface (e.g., land and water in unequal proportions, sources of fresh and salt water)	Not included in the curriculum through Grade 4	47	547	59	547

(continued)

	2019			Sweden		
	Norway	Average achievement by content domain <sup>b</sup>	Topic inclusion in curriculum <sup>a</sup>	Norway	Average achievement by content domain <sup>b</sup>	Topic inclusion in curriculum <sup>a</sup>
(continued)						
	(b) Earth's resources used in everyday life (e.g., water, wind, soil, forests, oil, natural gas, minerals)		Not included in the curriculum through Grade 4	59		All or almost all the students
	(c) Changes in Earth's surface over time (e.g., mountain building, weathering, erosion)		Not included in the curriculum through Grade 4	51		All or almost all the students
	(d) Fossils and what they can tell us about past conditions on Earth		All or almost all the students	63		All or almost all the students
	(e) Weather and climate (e.g., daily, seasonal, and locational variations versus long term trends)		All or almost all the students	73		Not included in the curriculum through Grade 4
	(f) Objects in the Solar System (the Sun, the Earth, the Moon, and other planets) and their movements		All or almost all the students	84		All or almost all the students

(continued)



(continued)

		Norway		Sweden			
2019		Topic inclusion in curriculum <sup>a</sup>	Proportion of students with teacher reporting topic taught in or before G4 (%)	Average achievement by content domain <sup>b</sup>	Topic inclusion in curriculum <sup>a</sup>	Proportion of students with teacher reporting topic taught in or before G4 (%)	Average achievement by content domain <sup>b</sup>
	(g) Earth's motion and related patterns observed on Earth (e.g., day and night, seasons)	Not included in the curriculum through Grade 4	83		All or almost all the students	74	

*NB* <sup>a</sup> The Curriculum questionnaire for TIMSS 2019 asked NRCs: “According to the national mathematics curriculum, what proportion of grade 4 students should have been taught each of the following topics or skills by the end of grade 4?” and “According to the national science curriculum, what proportion of grade 4 students should have been taught each of the following topics or skills by the end of grade 4?”

<sup>b</sup> (Mullis et al., 2020)

## **Appendix 2 Mean Differences in Student Achievement**

	Ach: Math	Ach: Number	Ach: Geometry	Ach: Data	Content coverage: Number	Content coverage: Geometry	Content coverage: Data
Mathematics specialists	Denmark 2011	539.666	536.640	551.680	534.931	75.020	53.330
	Denmark 2015	531.438	528.070	546.555	518.626	78.492	56.707
	Denmark 2019	533.003	517.075	536.250	525.878	83.698	62.103
	Difference 2015–2011	– 8.228	– 8.570	– 5.125	– 16.305	3.472	0.972
Non-mathematics specialists	Difference 2019–2015	1.565	– 10.995	– 10.305	7.252	5.206	5.396
	Denmark 2011	536.753	533.826	547.231	530.816	75.633	50.508
	Denmark 2015	537.925	533.944	554.374	525.000	81.044	66.727
	Denmark 2019	527.124	519.957	539.076	527.427	86.105	61.445
Mathematics specialists	Difference 2015–2011	1.172	0.118	7.143	– 5.816	5.411	16.219
	Difference 2019–2015	– 10.801	– 13.987	– 15.298	2.427	5.061	– 5.282
	Finland 2011	553.171	553.695	551.633	555.398	78.611	78.056
	Finland 2015	524.652	519.145	528.660	529.106	88.381	89.545
Non-mathematics specialists	Finland 2019	539.645	536.386	545.373	542.756	96.040	57.717
	Difference 2015–2011	– 28.519	– 34.550	– 22.973	– 26.292	9.770	11.489
	Difference 2019–2015	14.993	17.241	16.713	13.650	7.659	– 31.828
	Finland 2011	545.847	545.740	543.955	551.398	89.555	83.732
Finland 2015	532.015	528.376	535.967	538.436	90.845	86.052	

(continued)

(continued)		Ach: Math	Ach: Number	Ach: Geometry	Ach: Data	Content coverage: Number	Content coverage: Geometry	Content coverage: Data
	Finland 2019	526.688	522.597	533.174	527.969	92.708	70.914	58.460
	Difference 2015–2011	– 13.832	– 17.364	– 7.988	– 12.962	1.290	3.365	2.320
	Difference 2019–2015	– 5.327	– 5.779	– 2.793	– 10.467	1.863	14.711	– 27.592
Mathematics specialists	Norway 2011	496.334	490.566	507.609	495.047	64.139	68.142	70.201
	Norway 2015	552.684	544.794	562.503	570.392	77.950	71.078	76.681
	Norway 2019	546.358	543.305	552.131	552.100	77.590	61.839	77.705
	Difference 2015–2011	56.350	54.228	54.894	75.345	13.811	2.936	6.480
Non-mathematics specialists	Difference 2019–2015	– 6.326	– 1.489	– 10.372	– 18.292	– 0.360	– 9.239	1.024
	Norway 2011	490.421	483.538	483.538	490.356	62.817	73.275	62.904
	Norway 2015	548.927	542.014	558.957	564.939	78.036	70.540	69.900
	Norway 2019	543.070	540.337	545.129	546.239	75.259	56.553	78.300
	Difference 2015–2011	58.506	58.476	75.419	74.583	15.219	– 2.735	6.996
Mathematics specialists	Difference 2019–2015	– 5.857	– 1.677	– 13.828	– 18.700	– 2.777	– 13.987	8.400
	Sweden 2011	501.306	498.133	497.871	522.152	62.050	36.894	66.454
	Sweden 2015	519.396	514.004	523.989	528.909	65.715	42.712	66.355
	Sweden 2019	524.426	520.508	524.799	530.143	74.583	58.849	69.258

(continued)

(continued)		Ach: Math	Ach: Number	Ach: Geometry	Ach: Data	Content coverage: Number	Content coverage: Geometry	Content coverage: Data
Non-mathematics specialists	Difference 2015–2011	18.090	15.871	26.118	6.757	3.665	5.818	– 0.099
	Difference 2019–2015	5.030	6.504	0.810	1.234	8.868	16.137	2.903
	Sweden 2011	510.193	505.495	504.855	527.156	57.967	40.568	75.621
	Sweden 2015	514.251	510.542	515.655	528.863	66.172	54.498	51.228
	Sweden 2019	515.257	508.482	514.203	518.962	71.984	53.945	82.466
Science specialists	Difference 2015–2011	4.058	5.047	10.800	1.707	8.205	13.930	– 24.393
	Difference 2019–2015	1.006	– 2.060	– 1.452	– 9.901	5.812	– 0.553	31.238
	Denmark 2011	536.579	533.876	546.881	528.920	69.614	76.920	45.712
	Denmark 2015	525.996	522.180	537.839	512.386	76.009	74.488	52.126
	Denmark 2019	521.490	515.222	533.757	520.979	83.797	70.912	57.880
Non-science specialists	Difference 2015–2011	– 10.583	– 11.696	– 9.042	– 16.534	6.395	– 2.432	6.414
	Difference 2019–2015	– 4.506	– 6.958	– 4.082	8.593	7.788	– 3.576	5.754
	Denmark 2011	538.387	535.349	549.792	533.382	75.944	78.580	53.677
	Denmark 2015	536.499	532.912	553.149	523.639	80.639	81.094	63.168
	Denmark 2019	526.712	519.301	538.635	528.096	85.190	77.122	62.542
Difference 2015–2011	– 1.888	– 2.437	3.357	– 9.743	4.695	2.514	9.491	

(continued)

(continued)		Ach: Math	Ach: Number	Ach: Geometry	Ach: Data	Content coverage: Number	Content coverage: Geometry	Content coverage: Data
	Difference 2019–2015	– 9.787	– 13.611	– 14.514	4.457	4.551	– 3.972	– 0.626
Science specialists	Finland 2011	553.587	552.031	551.482	557.107	85.404	50.733	81.624
	Finland 2015	539.813	534.768	541.004	547.842	89.717	50.780	93.970
	Finland 2019	518.167	517.041	523.828	521.694	95.113	73.035	60.274
	Difference 2015–2011	– 13.774	– 17.263	– 10.478	– 9.265	4.313	0.047	12.346
	Difference 2019–2015	– 21.646	– 17.727	– 17.176	– 26.148	5.396	22.255	– 33.696
Non-science specialists	Finland 2011	545.728	545.844	544.064	551.093	88.399	54.036	83.127
	Finland 2015	530.605	526.999	534.913	536.753	90.587	57.166	85.574
	Finland 2019	528.618	524.264	535.202	529.879	92.849	70.453	58.676
	Difference 2015–2011	– 15.123	– 18.845	– 9.151	– 14.340	2.188	3.130	2.447
	Difference 2019–2015	– 1.987	– 2.735	0.289	– 6.874	2.262	13.287	– 26.898
Science Specialists	Norway 2011	484.077	477.362	496.935	483.243	64.655	73.688	82.157
	Norway 2015	553.976	547.298	565.106	570.937	78.262	72.462	82.069
	Norway 2019	552.408	549.394	556.811	558.320	79.336	61.963	81.326
	Difference 2015–2011	69.899	69.936	68.171	87.694	13.607	– 1.226	– 0.088
	Difference 2019–2015	– 1.568	2.096	– 8.295	– 12.617	1.074	– 10.499	– 0.743

(continued)

(continued)		Ach: Math	Ach: Number	Ach: Geometry	Ach: Data	Content coverage: Number	Content coverage: Geometry	Content coverage: Data
Non-science specialists	Norway 2011	493.742	487.163	505.330	493.470	63.490	72.013	61.066
	Norway 2015	549.312	541.847	559.013	565.682	78.188	70.391	68.919
	Norway 2019	541.859	538.972	545.782	546.013	75.345	58.078	76.467
Non-science specialists	Difference 2015–2011	55.570	54.684	53.683	72.212	14.698	– 1.622	7.853
	Difference 2019–2015	– 7.453	– 2.875	– 13.231	– 19.669	– 2.843	– 12.313	7.548
	Sweden 2011	502.305	498.864	498.438	523.077	60.995	37.017	66.067
Science specialists	Sweden 2015	520.707	514.856	525.587	531.049	64.449	42.309	67.624
	Sweden 2019	527.761	524.142	528.984	533.903	74.920	57.029	68.645
	Difference 2015–2011	18.402	15.992	27.149	7.972	3.454	5.292	1.557
Non-science specialists	Difference 2019–2015	7.054	9.286	3.397	2.854	10.471	14.720	1.021
	Sweden 2011	506.768	502.574	502.367	524.687	60.267	40.019	73.727
	Sweden 2015	514.586	511.049	517.301	525.041	68.118	48.553	57.348
Non-science specialists	Sweden 2019	513.959	508.039	511.956	518.023	72.555	60.409	76.062
	Difference 2015–2011	7.818	8.475	14.934	0.354	7.851	8.534	– 16.379
	Difference 2019–2015	– 0.627	– 3.010	– 5.345	– 7.018	4.437	11.856	18.714

	Ach: Science	Ach: Life Science	Ach: Physical Science	Ach: Earth Science	Content coverage: Life Science	Content coverage: Physical Science	Content coverage: Earth Science
Mathematics specialists	Denmark 2011	533.302	528.896	533.302	75.485	53.559	63.560
	Denmark 2015	521.384	509.614	524.939	56.753	43.259	62.936
	Denmark 2019	520.490	523.827	504.838	536.250	44.685	65.603
	Difference 2015–2011	– 9.637	– 4.178	– 19.282	– 8.363	– 18.732	– 10.300
	Difference 2019–2015	– 0.894	– 5.297	– 4.776	11.311	10.718	2.667
Non-mathematics specialists	Denmark 2011	529.326	527.195	527.427	58.829	45.290	68.896
	Denmark 2015	525.960	533.179	514.243	530.076	49.615	65.776
	Denmark 2019	524.833	529.159	509.750	537.095	71.050	62.986
	Difference 2015–2011	– 3.366	1.664	– 12.952	2.649	6.485	– 3.120
	Difference 2019–2015	– 1.127	– 4.020	– 4.493	7.019	5.736	– 2.790
Mathematics specialists	Finland 2011	576.212	580.262	572.396	567.916	31.287	45.905
	Finland 2015	545.127	543.965	534.754	552.603	67.633	60.875
	Finland 2019	557.806	559.214	549.260	570.306	66.365	55.851
	Difference 2015–2011	– 31.085	– 36.297	– 37.642	– 15.313	– 3.580	14.970
	Difference 2019–2015	12.679	15.249	14.506	17.703	– 1.268	– 5.024

(continued)



(continued)

	Ach: Science	Ach: Life Science	Ach: Physical Science	Ach: Earth Science	Content coverage: Life Science	Content coverage: Physical Science	Content coverage: Earth Science	
Non-mathematics specialists	Finland 2011	570.785	574.620	568.354	566.548	74.785	41.922	54.612
	Finland 2015	549.827	552.288	543.261	556.816	71.932	45.729	64.273
	Finland 2019	549.721	553.675	539.283	557.687	70.218	46.055	53.685
	Difference 2015–2011	– 20.958	– 22.332	– 25.093	– 9.732	– 2.853	3.807	9.661
Mathematics specialists	Difference 2019–2015	– 0.106	1.387	– 3.978	0.871	– 1.714	0.326	– 10.588
	Norway 2011	493.518	495.077	479.741	503.675	62.116	27.221	76.670
	Norway 2015	540.769	549.367	524.299	551.775	60.188	42.882	62.861
	Norway 2019	542.728	549.863	528.162	550.729	63.168	35.292	62.159
Non-mathematics specialists	Difference 2015–2011	47.251	54.290	44.558	48.100	– 1.928	15.661	– 13.809
	Difference 2019–2015	1.959	0.496	3.863	– 1.046	2.980	– 7.590	– 0.702
	Norway 2011	490.253	491.802	478.996	502.307	65.522	32.511	77.687
	Norway 2015	536.142	544.492	521.046	547.911	66.539	41.532	71.107
Non-mathematics specialists	Norway 2019	537.400	546.496	524.447	543.054	58.780	36.186	67.271
	Difference 2015–2011	45.889	52.690	42.050	45.604	1.017	9.021	– 6.580
	Difference 2019–2015	1.258	2.004	3.401	– 4.857	– 7.759	– 5.346	– 3.836

(continued)

(continued)

	Ach: Science	Ach: Life Science	Ach: Physical Science	Ach: Earth Science	Content coverage: Life Science	Content coverage: Physical Science	Content coverage: Earth Science
Mathematics specialists	Sweden 2011	530.713	531.795	525.673	535.163	57.650	68.802
	Sweden 2015	541.605	540.506	535.481	552.930	59.585	70.310
	Sweden 2019	540.823	545.046	528.391	550.573	59.352	53.506
	Difference 2015–2011	10.892	8.711	9.808	17.767	1.935	1.508
Non-mathematics specialists	Difference 2019–2015	-0.782	4.540	-7.090	-2.357	-0.233	-16.804
	Sweden 2011	540.475	539.131	533.227	545.977	58.065	67.100
	Sweden 2015	533.441	533.840	526.746	541.831	57.799	78.632
	Sweden 2019	529.790	534.529	517.861	541.011	60.115	64.072
Science specialists	Difference 2015–2011	-7.034	-5.291	-6.481	-4.146	-0.266	11.532
	Difference 2019–2015	-3.651	0.689	-8.885	-0.820	2.316	-14.560
	Denmark 2011	526.807	528.160	524.539	524.539	74.320	64.634
	Denmark 2015	517.557	526.456	507.180	522.043	50.294	50.938
Science specialists	Denmark 2019	514.578	518.516	498.288	528.822	65.090	63.130
	Difference 2015–2011	-9.250	-1.704	-17.359	-2.496	-24.026	-13.696
	Difference 2019–2015	-2.979	-7.940	-8.892	6.779	14.796	12.192

(continued)

(continued)

	Ach: Science	Ach: Life Science	Ach: Physical Science	Ach: Earth Science	Content coverage: Life Science	Content coverage: Physical Science	Content coverage: Earth Science
Non-science specialists	Denmark 2011	530.780	533.227	528.667	529.431	65.102	64.707
	Denmark 2015	524.948	531.970	512.815	528.682	65.444	66.449
	Denmark 2019	524.741	528.556	509.618	536.591	69.780	64.288
	Difference 2015–2011	-5.832	-1.257	-15.852	-0.749	0.342	-1.477
Science specialists	Difference 2019–2015	-0.207	-3.414	-3.197	7.909	4.336	-2.161
	Finland 2011	579.493	585.257	576.122	576.333	63.146	50.173
	Finland 2015	560.065	564.767	555.846	569.759	66.336	59.372
	Finland 2019	541.578	546.355	531.674	548.432	65.966	48.558
	Difference 2015–2011	-19.428	-20.490	-20.276	-6.574	3.190	9.199
	Difference 2019–2015	-18.487	-18.412	-24.172	-21.327	-0.370	-10.814
Non-science specialists	Finland 2011	570.405	574.066	567.994	565.505	75.876	53.800
	Finland 2015	548.535	550.371	541.329	555.115	72.054	64.725
	Finland 2019	551.414	555.046	541.081	559.890	70.352	54.128
	Difference 2015–2011	-21.870	-23.695	-26.665	-10.390	-3.822	10.925
Difference 2019–2015	2.879	4.675	-0.248	4.775	-1.702	-0.499	-10.597

(continued)

(continued)

	Ach: Science	Ach: Life Science	Ach: Physical Science	Ach: Earth Science	Content coverage: Life Science	Content coverage: Physical Science	Content coverage: Earth Science	
Science specialists	Norway 2011	482.824	483.750	470.683	492.891	70.897	40.715	80.085
	Norway 2015	541.536	549.208	525.497	553.377	67.767	51.522	66.498
	Norway 2019	549.262	556.438	533.914	555.860	65.263	36.326	62.701
	Difference 2015–2011	58.712	65.458	54.814	60.486	– 3.130	10.807	– 13.587
	Difference 2019–2015	7.726	7.230	8.417	2.483	– 2.504	– 15.196	– 3.797
Non-science specialists	Norway 2011	492.976	494.724	481.367	505.104	63.363	29.031	77.824
	Norway 2015	536.898	545.725	521.586	548.562	63.309	37.780	69.476
	Norway 2019	536.456	544.866	523.292	543.512	58.723	35.872	68.040
	Difference 2015–2011	43.922	51.001	40.219	43.458	– 0.054	8.749	– 8.348
	Difference 2019–2015	–0.442	– 0.859	1.706	– 5.050	– 4.586	– 1.908	– 1.436
Science specialists	Sweden 2011	532.212	533.898	527.525	537.554	59.628	31.561	68.593
	Sweden 2015	543.336	542.818	537.599	555.204	60.272	48.241	69.396
	Sweden 2019	544.463	548.268	532.563	555.095	60.122	40.871	54.034
	Difference 2015–2011	11.124	8.920	10.074	17.650	0.644	16.680	0.803
	Difference 2019–2015	1.127	5.450	– 5.036	– 0.109	– 0.150	– 7.370	– 15.362

(continued)

(continued)

	Ach: Science	Ach: Life Science	Ach: Physical Science	Ach: Earth Science	Content coverage: Life Science	Content coverage: Physical Science	Content coverage: Earth Science	
Non-science specialists	Sweden 2011	535.026	529.351	540.781	54.296	33.033	69.778	
	Sweden 2015	533.144	527.625	543.749	56.709	34.604	78.038	
	Sweden 2019	534.276	515.958	537.993	56.992	40.485	60.283	
	Difference 2015–2011	-1.833	-1.882	-1.726	2.968	2.413	1.571	8.260
	Difference 2019–2015	-5.491	1.132	-11.667	-5.756	0.283	5.881	-17.755

### **Appendix 3 The Relationships Between Content Coverage and Student Achievement at the Within/Student and Between/Classroom levels**

		2011					2015				
		Denmark	Finland	Norway	Sweden	Denmark	Finland	Norway	Sweden		
<i>Within level (Student level)</i>											
<i>Achievement—Data on</i>											
SES(Books)		0.231*	0.204*	0.176*	0.210*	0.263*	0.191*	0.291*	0.252*		
<i>Achievement—Geometry on</i>											
SES(Books)		0.263*	0.238*	0.183*	0.261*	0.257*	0.224*	0.282*	0.251*		
<i>Achievement—Number on</i>											
SES(Books)		0.260*	0.234*	0.205*	0.235*	0.274*	0.242*	0.281*	0.256*		
<i>Between level (Class level)</i>											
<i>Achievement—Data on</i>											
SES(Books)		0.660*	0.325*	0.205	0.802*	0.605*	0.680*	0.561*	0.846*		
Content coverage: Number		0.054	0.077	0.051	0.077	-0.074	-0.007	-0.077	0.072		
Content coverage: Geometry		-0.036	0.213*	0.209	0.052	0.160*	0.000	0.126	0.111		
Content coverage: Data		0.163	-0.018	0.036	-0.005	-0.013	0.079	0.306*	0.004		
<i>Achievement—Geometry on</i>											
SES(Books)		0.606*	0.349*	0.273*	0.849*	0.565*	0.674*	0.573*	0.801*		
Content coverage: Number		0.051	0.100	0.081	0.079	-0.084	-0.011	-0.110	0.095		
Content coverage: Geometry		-0.002	0.242*	0.222	0.016	0.138*	0.021	0.165	0.094		

(continued)

	2011					2015					
	Denmark	Finland	Norway	Sweden	Denmark	Finland	Norway	Sweden	Denmark	Finland	Sweden
Content coverage: Data	0.151	0.005	-0.017	-0.028	-0.006	0.047	0.274*	0.048			
<i>Achievement—Number on</i>											
SES(Books)	0.649*	0.385*	0.351*	0.779*	0.528*	0.719*	0.536*	0.838*			
Content coverage: Number	0.067	0.100	0.047	0.152	-0.098	0.034	-0.086	0.095			
Content coverage: Geometry	-0.026	0.217*	0.225*	0.034	0.182*	-0.034	0.153	0.088			
Content coverage: Data	0.146	-0.046	-0.019	0.030	-0.011	0.040	0.328*	0.014			
<i>Model fit</i>											
$\chi^2 = (df, n) = \text{mean}$	(0, 2859) = 0.054	(0, 4323) = 0.003	(0, 2527) = 0.106	(0, 2961) = 12.254	(0, 3171) = 0.089	(0, 4959) = 0.008	(0, 3854) = 0.319	(0, 3843) = 0.224			
RMSEA	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000			
CFI	1.000	1.000	1.000	0.998	1.000	1.000	1.000	1.000			
TLI	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000			
SRMR (within)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000			
SRMR (between)	0.001	0.001	0.001	0.011	0.001	0.001	0.001	0.000			
<i>Within level (Student level)</i>											
<i>Achievement—Life Science on</i>											
SES(Books)	0.262*	0.248*	0.285*	0.304*	0.275*	0.242*	0.269*	0.263*			
<i>Achievement—Physical Science on</i>											
SES(Books)	0.256*	0.259*	0.224*	0.266*	0.270*	0.230*	0.285*	0.272*			
<i>Achievement—Earth Science on</i>											
SES(Books)	0.237*	0.212*	0.292*	0.275*	0.268*	0.265*	0.221*	0.279*			

(continued)



	2011					2015						
	Denmark	Finland	Norway	Sweden	Denmark	Finland	Norway	Sweden	Denmark	Finland	Norway	Sweden
<i>Between level (Class level)</i>												
<i>Achievement—Life Science on</i>												
SES(Books)	0.911*	0.373*	0.332*	0.870*	0.736*	0.794*	0.543*	0.837*				
Content coverage: Life Science	0.357*	0.023	0.118	-0.010	-0.121	0.229*	0.122	-0.034				
Content coverage: Physical Science	-0.072	-0.021	-0.105	0.074	-0.149	-0.144	0.066	-0.016				
Content coverage: Earth Science	0.181	0.125	0.048	0.083	0.157	-0.016	0.107	0.149				
<i>Achievement—Physical Science on</i>												
SES(Books)	0.902*	0.424*	0.340*	0.884*	0.738*	0.693*	0.604*	0.825*				
Content coverage: Life Science	0.326*	0.036	0.084	-0.011	-0.096	0.248*	0.169	-0.080				
Content coverage: Physical Science	-0.072	-0.033	-0.117	0.114	-0.182	-0.092	0.075	0.009				
Content coverage: Earth Science	0.200	0.124	0.049	0.049	0.157	-0.033	0.055	0.150				
<i>Achievement—Earth Science on</i>												
SES(Books)	0.894*	0.383*	0.432*	0.861*	0.700*	0.809*	0.596*	0.826*				
Content coverage: Life Science	0.304*	0.006	0.017	0.007	-0.129	0.186*	0.134	-0.086				
Content coverage: Physical Science	-0.048	-0.062	-0.093	0.058	-0.176	-0.102	0.091	-0.015				

(continued)

	2011			2015										
	Denmark	Finland	Norway	Sweden	Denmark	Finland	Norway	Sweden						
Content coverage: Earth Science	0.189	0.160	0.092	0.062	0.188	0.016	0.073	0.166						
<i>Model fit</i>														
$\chi^2 = (df, n) = \text{mean}$	(0, 1428) = 0.252	(0, 4147) = 0.061	(0, 2022) = 0.265	(0, 2575) = 0.181	(0, 1298) = 0.097	(0, 4864) = 0.013	(0, 2541) = 0.146	(0, 3061) = 0.240						
RMSEA	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000						
CFI	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000						
TLI	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000						
SRMR (within)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000						
SRMR (between)	0.002	0.001	0.005	0.001	0.001	0.001	0.001	0.000						
2019														
			Denmark			Finland			Norway			Sweden		
<i>Within level (Student level)</i>														
<i>Achievement—Data on</i>														
SES(Books)	0.204*			0.272*			0.228*			0.256*				
<i>Achievement—Geometry on</i>														
SES(Books)	0.262*			0.280*			0.267*			0.278*				
<i>Achievement—Number on</i>														
SES(Books)	0.240*			0.273*			0.256*			0.270*				
<i>Between level (Class level)</i>														
<i>Achievement—Data on</i>														
SES(Books)	0.529			0.830*			0.635*			0.734*				
Content coverage: Number	0.209			0.061			0.226			0.013				

(continued)

	2019				
	Denmark	Finland	Norway	Sweden	
Content coverage: Geometry	0.081	0.062	- 0.092	0.144	
Content coverage: Data	0.131	- 0.083	0.167	0.002	
<i>Achievement—Geometry on</i>					
SES(Books)	0.524	0.835*	0.715*	0.816*	
Content coverage: Number	0.172	0.055	0.171	0.057	
Content coverage: Geometry	0.144	0.030	- 0.044	0.185*	
Content coverage: Data	0.154	- 0.123	0.084	- 0.028	
<i>Achievement—Number on</i>					
SES(Books)	0.571	0.841*	0.602*	0.777*	
Content coverage: Number	0.197	0.073	0.264	0.124	
Content coverage: Geometry	0.084	0.025	- 0.030	0.161	
Content coverage: Data	0.139	- 0.104	0.155	- 0.056	
<i>Model fit</i>					
$\chi^2 = (df, n) = \text{mean}$	(0, 2582) = 0.086	(0, 4661) = 0.268	(0, 2808) = 0.238	(0, 3469) = 0.062	
RMSEA	0.000	0.000	0.000	0.000	
CFI	1.000	1.000	1.000	1.000	
TLI	1.000	1.000	1.000	1.000	
SRMR (within)	0.000	0.000	0.000	0.000	
SRMR (between)	0.002	0.001	0.001	0.000	

(continued)

	2019			
	Denmark	Finland	Norway	Sweden
<i>Within level (Student level)</i>				
<i>Achievement—Life Science on</i>				
SES(Books)	0.305*	0.295*	0.320*	0.293*
<i>Achievement—Physical Science on</i>				
SES(Books)	0.301*	0.254*	0.259*	0.281*
<i>Achievement—Earth Science on</i>				
SES(Books)	0.290*	0.312*	0.315*	0.278*
<i>Between level (Class level)</i>				
<i>Achievement—Life Science on</i>				
SES(Books)	0.734*	0.767*	0.705*	0.878*
Content coverage: Life Science	-0.052	0.056	-0.161	0.007
Content coverage: Physical Science	0.016	0.133	0.181	0.181
Content coverage: Earth Science	0.031	-0.112	0.074	-0.096
<i>Achievement—Physical Science on</i>				
SES(Books)	0.746*	0.756*	0.731*	0.860*
Content coverage: Life Science	0.094	0.095	-0.193	0.005
Content coverage: Physical Science	-0.001	0.138	0.158	0.188*
Content coverage: Earth Science	-0.012	-0.168*	0.088	-0.109
<i>Achievement—Earth Science on</i>				
SES(Books)	0.695*	0.796*	0.758*	0.871*

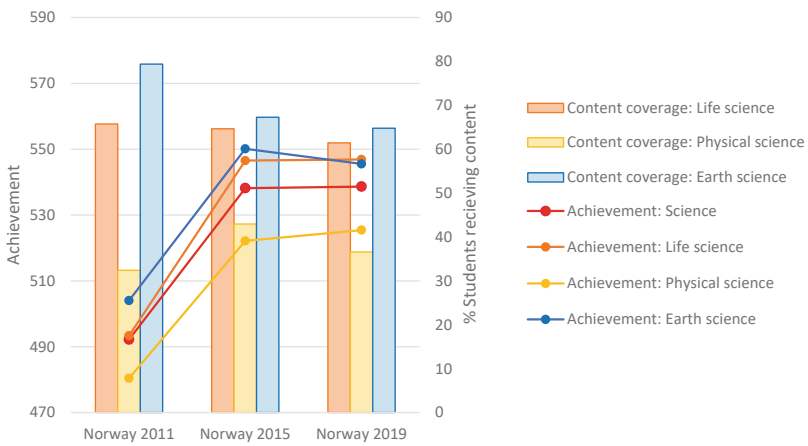
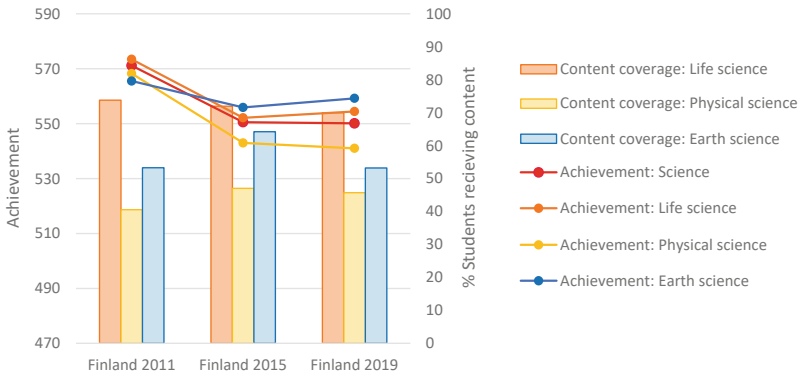
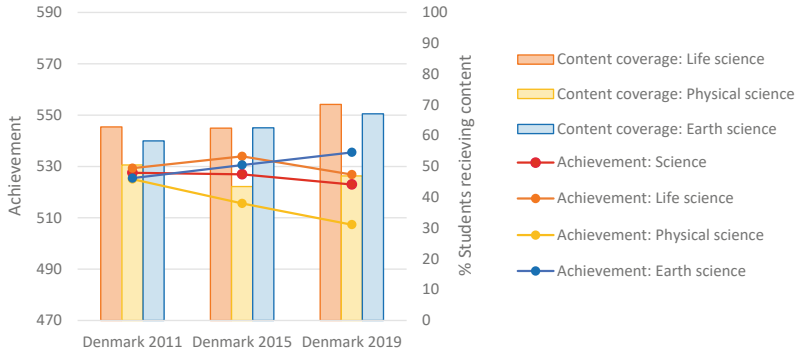
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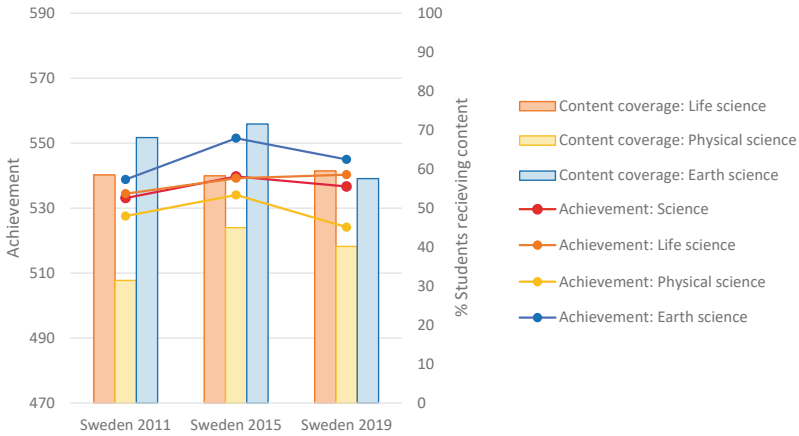
(continued)

	2019			
	Denmark	Finland	Norway	Sweden
Content coverage: Life Science	0.029	0.096	- 0.169	0.030
Content coverage: Physical Science	- 0.035	0.118	0.192	0.198*
Content coverage: Earth Science	- 0.067	- 0.161*	0.078	- 0.116
<i>Model fit</i>				
$\chi^2 = (df, n) = \text{mean}$	(0, 1569) = 0.124	(0, 4518) = 0.074	(0, 2035) = 0.130	(0, 2633) = 0.151
RMSEA	0.000	0.000	0.000	0.000
CFI	1.000	1.000	1.000	1.000
TLI	1.000	1.000	1.000	1.000
SRMR (within)	0.000	0.000	0.000	0.000
SRMR (between)	0.002	0.001	0.001	0.001

NB \*  $P < 0.05$

### Appendix 4 Bar Graphs Showing Achievement in Science Domains for the Years 2011 to 2019 for All Countries





Note One bar graph per country.

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