CHAPTER 12

Implementing the TIMSS 2019 Scaling Methodology

Pierre Foy
Bethany Fishbein
Matthias von Davier
Liqun Yin

Introduction

The TIMSS assessments cover a wide range of topics in mathematics and science at two grade levels. Given this broad coverage, a matrix-sampling booklet design was used such that each student was administered only a subset of the entire TIMSS mathematics and science item pools. Given the complexities of the data collection and the need to describe student achievement on a scale that represents the entirety of the assessment framework, TIMSS relied on Item Response Theory (IRT) scaling to provide accurate measures of student proficiency distributions and trends. In order to provide unbiased estimates of student achievement and its relationship to contextual variables, the TIMSS scaling approach used a latent regression population model (also called a conditioning model) with subsequent multiple imputation to obtain plausible values representing proficiency in mathematics and science for all students. To enhance the reliability of the imputed student scores, the TIMSS latent regression scaling approach used the available student context data in the process. A detailed description of the TIMSS scaling methodology can be found in Chapter 11.

The TIMSS & PIRLS International Study Center, responsible for the development and management of the TIMSS assessments, undertook the psychometric scaling and population modeling of the TIMSS achievement data. The scaling was based largely on a concurrent calibration of the TIMSS 2019 data together with data from the previous TIMSS 2015 cycle for measuring trends from cycle to cycle, which has been implemented successfully in the past. However, with the dual administration mode—paperTIMSS and eTIMSS, the TIMSS scaling approach for 2019 involved additional psychometric analyses so that the 2019 computer-based data were linked to be reported on the same scales as the 2019 paper-based results and trend measurements were maintained from past assessments.

In 2019, TIMSS began the transition to computer-based assessment by introducing a computerized version known as eTIMSS. Half the participating countries in 2019 chose to administer the eTIMSS version, with the other half retaining the traditional paper-based administration—referred to as paperTIMSS. The major challenge in scaling the 2019 data was linking both the eTIMSS and paperTIMSS data on the same scale while maintaining comparability to the previously established TIMSS achievement trend scales.

In 2017, the TIMSS & PIRLS International Study Center conducted an item equivalence study, using a counterbalanced experimental design, to examine whether switching from paper and pencil to computer based administration would likely affect the psychometric properties of the TIMSS mathematics and science achievement items at the fourth and eighth grades (Fishbein, Martin, Mullis, & Foy, 2018). The study showed that, on average, performance was higher on paperTIMSS than on eTIMSS items at both grades, especially for mathematics. Consequently, in expectation of this mode of administration effect in the 2019 main data collection, it was considered prudent to include a bridge component in the data collection plan. This involved eTIMSS countries administering a version of the paperTIMSS assessment (a subset of the achievement items—the "trend" items previously administered in 2015) in addition to the main eTIMSS assessment to randomly selected, equivalent groups of students. This bridge allowed to directly compare and link the psychometric properties of items available in both modes on the basis of equivalent student samples in countries that chose eTIMSS.

Altogether, 64 countries and 8 benchmarking entities participated in TIMSS 2019. Countries participating in either paperTIMSS or eTIMSS had national samples of approximately 150 schools and 4,000 students per grade. To provide bridging data between the paperTIMSS and eTIMSS assessments, eTIMSS trend countries—eTIMSS 2019 countries that also participated in 2015—administered paperTIMSS booklets consisting of trend items to an additional sample of 1,500 students, sampling from the same schools as the full eTIMSS samples to the extent possible. Selected results on country level comparisons of the bridge and the eTIMSS samples are provided in Chapter 13 of this volume.

As an additional option, countries participating at the fourth grade in paperTIMSS that were concerned the regular TIMSS mathematics assessment would be too difficult for their students could choose to administer a "less difficult" mathematics assessment.

Developing eTIMSS and paperTIMSS

As described in the TIMSS 2019 assessment design (Martin, Mullis, & Foy, 2017), each of the four TIMSS 2019 assessments (mathematics and science at fourth and eighth grades) consisted of 14 blocks of achievement items, six of which were developed for first time use in 2019 and eight of which were administered previously in 2015 and re-administered in 2019 (the trend items). Of the eight trend blocks administered in 2015, three also were administered as part of the 2011 assessment.

The development of the six blocks of new items for each TIMSS 2019 assessment followed the content and cognitive domain specifications described in the *TIMSS 2019 Assessment Frameworks* (Mullis & Martin, 2017). While adhering to the framework specifications, the approach was first to develop an eTIMSS version of the items, capitalizing as much as possible on the eTIMSS computer-based environment by including new item types such as drag-and-drop and drop-down menus, and automated scoring through number pad entry. The eTIMSS version of an item was then adapted to the paper-and-pencil environment for its paperTIMSS version, making the paperTIMSS version as similar as possible to the eTIMSS version. The goal was to maximize the comparability of eTIMSS and paperTIMSS by having the two versions of the assessment measure the same mathematics and science constructs using the same items as much as possible, while also capitalizing on the benefits of the computer based environment for eTIMSS.

The eight blocks of trend items for each assessment were developed at a time when paper and pencil was the only mode of administration, and so these existed only in paper format. An eTIMSS version was developed for each of these items, retaining the look and feel of the paper versions as much as possible. This work was conducted as part of the item equivalence study, where it was estimated that about 87 percent of the items appeared fairly equivalent in both versions (Fishbein et al., 2018).

The less difficult mathematics assessment at the fourth grade also consisted of 14 item blocks, eight of which were trend blocks from 2015 and six newly developed. All the less difficult item blocks existed only in paper format. Four of the regular fourth grade mathematics item blocks were shared with the less difficult mathematics assessment, the basis for linking the two assessments. As there was not a less difficult science assessment, countries administering the less difficult mathematics assessment also administered the regular fourth grade science assessment.

Exhibit 12.1 reports the numbers of items from the TIMSS 2019 assessments included for achievement scaling. In addition to newly developed eTIMSS items, the eTIMSS 2019 assessment also included extended mathematics and science assessment tasks called Problem Solving and Inquiry Tasks, or "PSIs," as in Exhibit 12.1. These items were not part of the IRT-based scaling reported here, but will be added to the TIMSS 2019 International Database at a later date. Countries' achievement on the PSIs will be described in a special analysis report to be released in 2021.

Exhibit 12.1: Number of Items in the TIMSS 2019 Assessments

Assessments		Grade 4		Grade 8	
		Mathematics	Science	Mathematics	Science
paperTIMSS		169	168	206	211
Less Difficult TIMSS Mathematics*		177	168	—	—
Bridge		92	95	114	118
eTIMSS	Regular Items	171	169	206	211
	PSI Items	29	19	25	27

* The less difficult TIMSS mathematics assessment shared 46 mathematics items and all 168 science items with paperTIMSS.

Exhibit 12.2 shows the number of participating countries and benchmarking participants in TIMSS 2019, across the various assessments offered. It also indicates the number of trend countries (countries that also participated in 2015) for the concurrent calibration models.

Exhibit 12.2: Number of Countries Participating in TIMSS 2019

		All Countries	Trend Countries	Benchmarking Participants
Grade 4				
paperTIMSS		17	14	0
Less Difficult TIMSS Mathematics		11	3	0
eTIMSS	with Bridge*	28	27	0
	without Bridge	2	0	6
Total		**58**	**44**	**6**
Grade 8				
paperTIMSS		17	14	2
eTIMSS	with Bridge	19	19	0
	without Bridge	3	0	5
Total		**39**	**33**	**7**

* Austria, although not a trend country, opted to administer the Bridge booklets.

The paperTIMSS Assessment

At the eighth grade and for most countries at the fourth grade, the paperTIMSS assessment design replicated the assessment design from the more recent previous TIMSS assessment cycles. The 14 mathematics and 14 science item blocks at each grade were assembled into 14 assessment booklets, with each booklet having two mathematics and two science item blocks and each item block appearing in two booklets.

Countries participating at the fourth grade had the option of administering the less difficult mathematics assessment instead of the regular fourth grade mathematics assessment. The less difficult assessment consisted of four mathematics item blocks shared with regular TIMSS and 10 mathematics item blocks that were developed to be less difficult than the regular TIMSS fourth grade mathematics assessment. These were combined with the regular fourth grade science item blocks, with booklets mimicking the regular paperTIMSS booklets, having two blocks of mathematics items (either less difficult or regular) and two blocks of science items.

At the fourth grade, 17 countries participated in paperTIMSS, with 14 of them having participated in the TIMSS 2015 assessment and considered as trend countries for the concurrent calibration. Additionally, 11 countries participated in the less difficult mathematics assessment, three of which were trend countries. At the eighth grade, 17 countries and two benchmarking participants participated in paperTIMSS, with 14 countries being trend.

The eTIMSS Assessment

The eTIMSS assessment design emulated the paperTIMSS design in the way the item blocks were assembled into student booklets ("block combinations" in eTIMSS parlance) and spiraled across computer-based assessment sessions. There was, however, no less difficult fourth grade mathematics option in eTIMSS. A further difference was that eTIMSS included two blocks of Problem Solving and Inquiry (PSI) tasks and items in both mathematics and science at each grade, with one or two tasks in each block. The PSIs were a new initiative, introduced for the first time in 2019. For data collection, the PSI blocks were assembled in two extra block combinations for each assessment, with two mathematics and two science PSI blocks in each block combination. The two PSI block combinations were included in the normal rotation of eTIMSS block combinations and, while there was no overlap between regular eTIMSS and PSI items (i.e., no student got both eTIMSS and PSI items), the PSI blocks were administered to a randomly equivalent sub-sample of students within selected classes and schools.

Although the newly developed PSI tasks were designed to form an integral part of the mathematics and science assessments, they had no counterpart in paperTIMSS and were not included in the main reporting scales for 2019. Rather, they were included with the eTIMSS 2019 items in a second, separate scaling model and the results reported separately. This allowed for examining how the PSI items fit in

with the regular items in psychometric terms and prepared for their full inclusion in TIMSS in the 2023 assessment cycle.

Thirty countries and six benchmarking participants participated in eTIMSS at the fourth grade, and 22 countries and five benchmarking participants at the eighth grade.

The eTIMSS Bridge Booklets

Trend countries participating in eTIMSS 2019—countries that also participated in TIMSS 2015—were required to administer a set of eight assessment booklets consisting entirely of the eight mathematics and eight science paperTIMSS trend blocks at each grade. Six of these booklets were exactly the same as those administered in 2015 and two contained blocks also administered in 2015 but in a different combination. The data from these paper bridge booklets were used to link the eTIMSS assessment to the paperTIMSS assessment and the TIMSS trend scales, relying on equivalent populations between the eTIMSS and bridge samples. They also served to provide countries with valuable data on the behavior of mode effects in their countries (see Chapter 13).

The paper bridge booklets were administered to national samples of 1,500 students drawn to be randomly equivalent to the national eTIMSS samples. Of the 30 eTIMSS countries participating at the fourth grade, 27 trend countries administered the paper bridge booklets. In addition, one non-trend country (Austria) administered bridge booklets to fourth grade students for their own research purposes. At the eighth grade, 19 of the 22 eTIMSS countries administered the paper bridge booklets.

Overview of Scaling the TIMSS 2019 Achievement Data

Scaling and linking the TIMSS 2019 data needed to address two major objectives. First, 2019 results from either paperTIMSS or eTIMSS should measure the same mathematics and science constructs and be reported on the same scales. Second, these 2019 results should maintain trends with past TIMSS assessments. With these two goals in mind, the scaling for each subject and grade was conducted in four major phases.

1. **Scaling the paperTIMSS and Bridge Data**: Relying on the usual TIMSS concurrent calibration approach, data from the paperTIMSS trend countries and bridge data from the eTIMSS trend countries were scaled together with their data from TIMSS 2015 to estimate item parameters for the paperTIMSS and bridge data and to establish the scale transformation required to place these results on the TIMSS trend scales.
2. **Scaling the Fourth Grade Less Difficult Mathematics Data**: Special scale linking approaches were implemented to scale the fourth grade mathematics and science data from the 11 countries that opted to administer this assessment. These methods relied on linkages with the TIMSS 2019 fourth grade assessment and the TIMSS Numeracy 2015 assessment to place these results on the TIMSS trend scales.

3. **Scaling the eTIMSS Data**: Scaling the eTIMSS data was based in large part on its linkage to the bridge data that were collected from equivalent samples. The random assignment of equivalent student groups to the bridge and the eTIMSS assessment was utilized in linking by using an anchor test design. The common set of items was based on a substantial subset of eTIMSS items found to be psychometrically equivalent to their paperTIMSS counterparts.
4. **Scaling the PSI Items**: Although the main reporting results were based on the paperTIMSS and eTIMSS items, it was of great interest to evaluate the introduction of items from the Problem Solving and Inquiry tasks into the TIMSS assessments. This item calibration relied on scaling the PSI items along with the eTIMSS items. This last phase of the TIMSS 2019 achievement scaling will be described in a forthcoming publication to be released in 2021, along with the results.

Each of these phases involved four major tasks: calibrating the achievement items (estimating model parameters for each item), creating principal components from the student questionnaire data for use in conditioning, generating plausible values (proficiency estimates) for mathematics and science, and placing these plausible values on the metrics used to report trend results from previous assessments. The scaling procedures produced plausible values for the mathematics and science scales at both the fourth and eighth grades. In addition, plausible values were produced for the content and cognitive domains of mathematics and science. The IRT models and population models used are described in Chapter 11 of this volume.

Before scaling the achievement data, TIMSS conducted an extensive item-by-item review of descriptive item statistics for all countries to evaluate the quality of the assessment items and to identify any unexpected or problematic item properties based on a review of classical test theory item statistics. This review included analyses of change over time with respect to percent correct and partial credit proportions, omit rates, item discrimination and other classical item statistics for trend items from the 2015 assessment, as well as differences between items common to eTIMSS and the paper bridge booklets. These item review activities are described in Chapter 10.

Treatment of Omitted and Not-Reached Responses

Given the matrix-sampling design used by TIMSS, whereby a student is administered only a sample of the 14 assessment blocks (two mathematics and two science blocks), most item responses are missing by design for each student. However, missing data can also result from a student not answering an item, which can occur when the student does not know the answer, omits the item by mistake, or does not have sufficient time to attempt the item. An item is considered "not reached" when—within part 1 or part 2 of a booklet[1]—the item itself and the item immediately preceding it are not answered, and there are no other items completed in the remainder of that part of the booklet.

1 The TIMSS 2019 assessment booklets, including paperTIMSS, eTIMSS, and bridge, consisted of two parts with a break in between.

Not-reached items were treated differently in estimating item parameters and in generating student plausible values. In estimating the item parameters, items in the assessment booklets that were considered not to have been reached by students were treated as if they were not administered. However, not-reached items always were recoded and treated as incorrect when student plausible values were generated.

This treatment of not-reached items was applied to all scaling procedures. Omitted responses always were treated as incorrect.

Scaling the paperTIMSS and Bridge Data

This first phase of scaling constituted a first and fundamental step in the TIMSS 2019 concurrent calibration with TIMSS 2015 trend data to estimate the item parameters for all paperTIMSS items and determined the scale transformations that placed the TIMSS 2019 paperTIMSS achievement results on the TIMSS trend scales. These same scale transformations also were used when transforming the eTIMSS data based on subsequent calibrations.

The metric of the TIMSS reporting scales for overall mathematics and science at each grade level were originally established in TIMSS 1995 by setting the mean of the national average scores for all countries that participated in TIMSS 1995 to 500 and the standard deviation to 100. To enable measurement of trends over time, achievement data from successive TIMSS assessments were transformed to these same metrics. This was done by concurrently scaling the data from each successive assessment with the data from the previous assessment—a process known as concurrent calibration—and applying linear transformations to place the results from each successive assessment on the same scale as the results from the previous assessment. This procedure enabled TIMSS to measure trends across all seven assessment cycles: 1995, 1999, 2003, 2007, 2011, 2015, and 2019.

The first step in linking the assessments for trend scaling is to estimate (calibrate) the item parameters for the items in the current assessment through a concurrent calibration of the data from the current and previous assessments. In 2019, the TIMSS concurrent calibration consisted of combining TIMSS 2015 and TIMSS 2019 data from the trend countries; the 2019 data included the paperTIMSS data of the paperTIMSS trend countries and the bridge data of the eTIMSS trend countries.

In linking successive assessments, concurrent calibration relies on having a large proportion of trend items—items that are retained from one assessment to the next. The TIMSS assessment consists of 14 mathematics item blocks and 14 science item blocks at each grade. In TIMSS 2019, 6 of the mathematics blocks and 6 of the science blocks consisted of newly developed items. The remaining 8 mathematics blocks and 8 science blocks were carried forward from the TIMSS 2015 assessment and are the basis for linking TIMSS 2019 to the TIMSS achievement scales and maintaining trends over time. Exhibits 12.3 through 12.6 show the number of items present for the paperTIMSS 2019 concurrent calibration by item type and content and cognitive domain for both grades and subjects, respectively.

Exhibit 12.3: Mathematics Items for the paperTIMSS 2019 Concurrent Calibration—Grade 4

Item Type	Points	Items Released in 2015		Items Common in 2015 and 2019		Items Introduced in 2019		Total	
		Items	Points	Items	Points	Items	Points	Items	Points
Multiple Choice	1	45	45	42	42	25	25	112	112
Constructed Response	1	28	28	45	45	45	45	118	118
	2	4	8	5	10	7	14	16	32
Total		**77**	**81**	**92**	**97**	**77**	**84**	**246**	**262**

Items by Content and Cognitive Domains

Mathematics Content Domains	Items Released in 2015		Items Common in 2015 and 2019		Items Introduced in 2019		Total	
	Items	Points	Items	Points	Items	Points	Items	Points
Number	36	38	55	59	28	29	119	126
Measurement and Geometry	28	29	26	27	24	27	78	83
Data	13	14	11	11	25	28	49	53

Mathematics Cognitive Domains	Items Released in 2015		Items Common in 2015 and 2019		Items Introduced in 2019		Total	
	Items	Points	Items	Points	Items	Points	Items	Points
Knowing	30	31	34	34	24	24	88	89
Applying	32	34	40	42	33	37	105	113
Reasoning	15	16	18	21	20	23	53	60
Total	**77**	**81**	**92**	**97**	**77**	**84**	**246**	**262**

Exhibit 12.4: Science Items for the paperTIMSS 2019 Concurrent Calibration—Grade 4

Item Type	Points	Items Released in 2015		Items Common in 2015 and 2019		Items Introduced in 2019		Total	
		Items	Points	Items	Points	Items	Points	Items	Points
Multiple Choice	1	35	35	47	47	40	40	122	122
Constructed Response	1	30	30	45	45	31	31	106	106
	2	8	16	3	6	2	4	13	26
Total		**73**	**81**	**95**	**98**	**73**	**75**	**241**	**254**

Items by Content and Cognitive Domains

Science Content Domains	Items Released in 2015		Items Common in 2015 and 2019		Items Introduced in 2019		Total	
	Items	Points	Items	Points	Items	Points	Items	Points
Life Science	33	38	41	43	32	34	106	115
Physical Science	26	26	36	37	25	25	87	88
Earth Science	14	17	18	18	16	16	48	51

Science Cognitive Domains	Items Released in 2015		Items Common in 2015 and 2019		Items Introduced in 2019		Total	
	Items	Points	Items	Points	Items	Points	Items	Points
Knowing	31	34	40	43	29	30	100	107
Applying	28	31	34	34	30	30	92	95
Reasoning	14	16	21	21	14	15	49	52
Total	**73**	**81**	**95**	**98**	**73**	**75**	**241**	**254**

Exhibit 12.5: Mathematics Items for the paperTIMSS 2019 Concurrent Calibration—Grade 8

Item Type	Points	Items Released in 2015		Items Common in 2015 and 2019		Items Introduced in 2019		Total	
		Items	Points	Items	Points	Items	Points	Items	Points
Multiple Choice	1	49	49	62	62	28	28	139	139
Constructed Response	1	40	40	46	46	59	59	145	145
	2	6	12	6	12	5	10	17	34
Total		**95**	**101**	**114**	**120**	**92**	**97**	**301**	**318**

Items by Content and Cognitive Domains

Mathematics Content Domains	Items Released in 2015		Items Common in 2015 and 2019		Items Introduced in 2019		Total	
	Items	Points	Items	Points	Items	Points	Items	Points
Number	28	32	36	37	27	29	91	98
Algebra	31	32	30	31	31	31	92	94
Geometry	18	19	25	28	18	21	61	68
Data and Probability	18	18	23	24	16	16	57	58

Mathematics Cognitive Domains	Items Released in 2015		Items Common in 2015 and 2019		Items Introduced in 2019		Total	
	Items	Points	Items	Points	Items	Points	Items	Points
Knowing	34	34	35	35	29	31	98	100
Applying	37	41	57	60	39	39	133	140
Reasoning	24	26	22	25	24	27	70	78
Total	**95**	**101**	**114**	**120**	**92**	**97**	**301**	**318**

Exhibit 12.6: Science Items for the paperTIMSS 2019 Concurrent Calibration—Grade 8

Item Type	Points	Items Released in 2015		Items Common in 2015 and 2019		Items Introduced in 2019		Total	
		Items	Points	Items	Points	Items	Points	Items	Points
Multiple Choice	1	47	47	59	59	49	49	155	155
Constructed Response	1	43	43	48	48	33	33	124	124
	2	7	14	11	22	11	22	29	58
Total		**97**	**104**	**118**	**129**	**93**	**104**	**308**	**337**

Items by Content and Cognitive Domains

Science Content Domains	Items Released in 2015		Items Common in 2015 and 2019		Items Introduced in 2019		Total	
	Items	Points	Items	Points	Items	Points	Items	Points
Biology	35	38	39	48	35	40	109	126
Chemistry	18	19	22	23	21	24	61	66
Physics	26	26	30	30	22	24	78	80
Earth Science	18	21	27	28	15	16	60	65

Science Cognitive Domains	Items Released in 2015		Items Common in 2015 and 2019		Items Introduced in 2019		Total	
	Items	Points	Items	Points	Items	Points	Items	Points
Knowing	31	34	43	48	32	33	106	115
Applying	45	47	44	48	36	44	125	139
Reasoning	21	23	31	33	25	27	77	83
Total	**97**	**104**	**118**	**129**	**93**	**104**	**308**	**337**

In concurrent calibration, item parameters for the current assessment are estimated based on the data from both the current and previous assessments, recognizing that some items (the trend items) are common to both. It is then possible to estimate the latent ability distributions of students in both assessments using the item parameters from the concurrent calibration. The difference between these two distributions is the trend measure between the previous and current assessments, although not yet on the TIMSS scale metric.

After the item calibration and estimation of student proficiency, the next step is to find the linear transformation that transforms the student ability distribution of the previous assessment data under the concurrent calibration to match the student ability distribution of these same data under the calibration that was done in the previous assessment. The final step entails applying this linear transformation to the current assessment data scaled using the concurrent calibration. This places the current assessment data on the TIMSS trend scale.

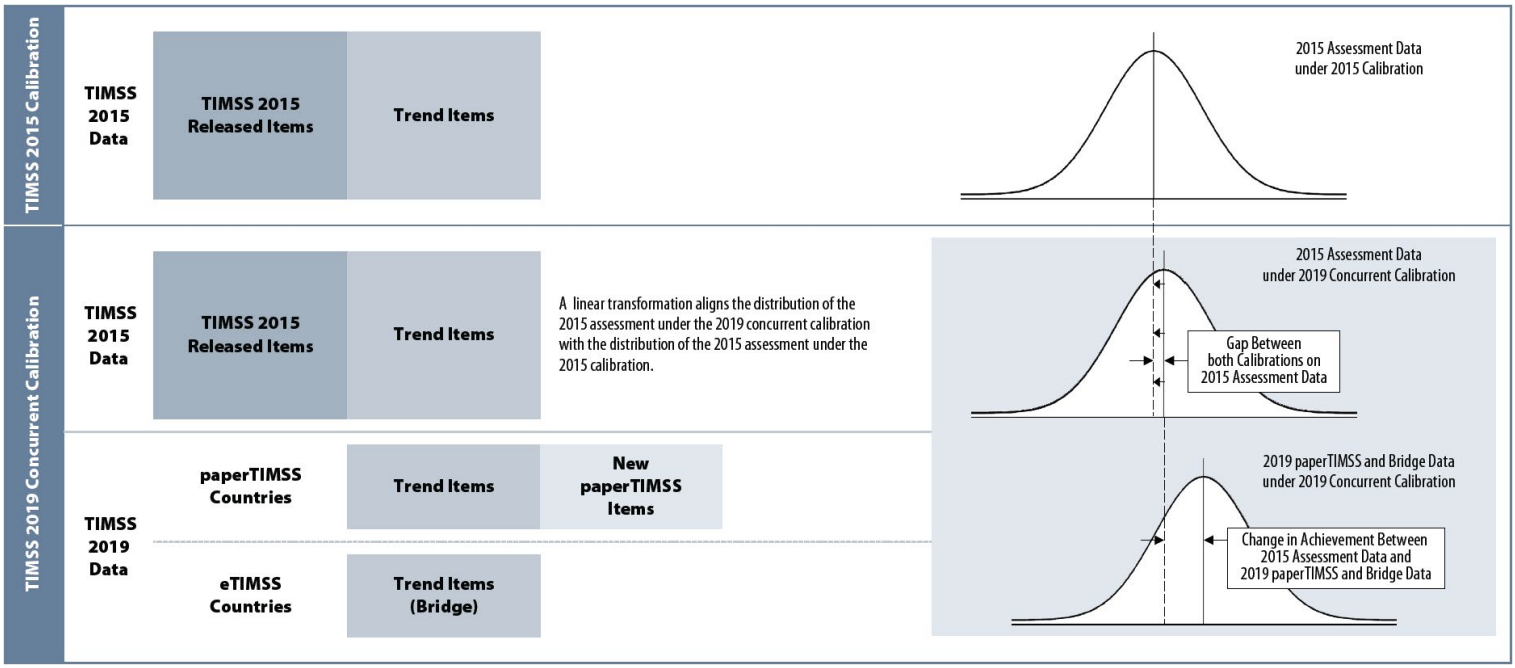
The paperTIMSS 2019 concurrent calibration model provided item parameter estimates for all paperTIMSS items. Using these 2019 item parameters, the TIMSS 2015 ability distribution was re-estimated across all trend countries to find the linear transformation that aligns that re-estimated 2015 student ability distribution with the original student ability distribution that was estimated in 2015. This linear transformation, applied to the 2019 paperTIMSS data and the bridge data, produced achievement results on the TIMSS trend scales. For the paperTIMSS countries, the resulting TIMSS 2019 achievement scores were used for reporting and publishing. The eTIMSS countries with bridge data obtained TIMSS 2019 achievement scores based on their bridge data, which served as a baseline for comparisons with their TIMSS 2019 results based on their eTIMSS data (see Chapter 13).

Calibrating the paperTIMSS and Bridge Data

Item calibration was conducted by the TIMSS & PIRLS International Study Center using the commercially available Parscale software (Muraki & Bock, 1997) and included data from the TIMSS 2015 assessment and data from the TIMSS 2019 assessment, including bridge data, for countries that participated in both assessment cycles. The calibration used all available item response data from each country's student samples and from both the 2019 assessment and the 2015 assessment.

Exhibit 12.7 illustrates the general structure of the paperTIMSS 2019 concurrent calibration model to estimate the paperTIMSS item parameters. The upper panel of the exhibit, labelled "TIMSS 2015 calibration," represents the TIMSS 2015 data from the TIMSS 2019 trend countries and the student ability distribution, shown on the right, which was estimated for this population in the TIMSS 2015 scaling. The lower panel of Exhibit 12.7 is labelled "TIMSS 2019 Concurrent Calibration" and illustrates the full array of paperTIMSS data included in the TIMSS 2019 concurrent calibration model. This included the TIMSS 2015 data from all the TIMSS 2019 trend countries, as well as all 2019 data from paperTIMSS trend countries and bridge data from eTIMSS trend countries.

Exhibit 12.7: The paperTIMSS 2019 Concurrent Calibration Model



The 2019 concurrent calibration model included data from three trend countries that participated in the TIMSS 2019 fourth grade less difficult mathematics assessment. Their data contributed to the item parameter estimation for all fourth grade science items, as well as the 46 fourth grade mathematics items shared with the regular fourth grade mathematics assessment.

Exhibits 12.8 and 12.9 show the sample sizes for scaling the paperTIMSS 2019 data, both for item calibration and for proficiency estimation. Countries are shown as being either paperTIMSS (pT), eTIMSS bridge (Br), or less difficult (LD). All student samples were weighted so that each country contributed equally to the item calibration. This was particularly important for the smaller bridge samples of eTIMSS trend countries to ensure their equal contribution in the item calibration.

Exhibit 12.8: Sample Sizes for Scaling the paperTIMSS 2019 Grade 4 Data

Country	Item Calibration		Proficiency Estimation	
	2019	2015	2019	2015
Armenia - pT	5,399	5,384	5,399	5,384
Australia - pT	5,890	6,057	5,890	6,057
Austria - Br	—	—	1,964	—
Azerbaijan - pT	—	—	5,245	—
Bahrain - pT	5,762	4,146	5,762	4,146
Belgium (Flemish) - pT	4,655	5,404	4,655	5,404
Bulgaria - pT	4,268	4,228	4,268	4,228
Canada - Br	1,604	12,283	1,604	12,283
Chile - Br	1,612	4,756	1,612	4,756
Chinese Taipei - Br	1,663	4,291	1,663	4,291
Croatia - Br	1,472	3,985	1,472	3,985
Cyprus - pT	4,062	4,125	4,062	4,125
Czech Republic - Br	2,030	5,202	2,030	5,202
Denmark - Br	1,432	3,710	1,432	3,710
England - Br	1,242	4,006	1,242	4,006
Finland - Br	1,983	5,015	1,983	5,015
France - Br	1,948	4,873	1,948	4,873
Georgia - Br	1,632	3,919	1,632	3,919
Germany - Br	1,505	3,948	1,505	3,948
Hong Kong SAR - Br	1,329	3,600	1,329	3,600
Hungary - Br	1,778	5,036	1,778	5,036
Iran, Islamic Rep. of - pT	6,010	3,823	6,010	3,823
Ireland - pT	4,582	4,344	4,582	4,344
Italy - Br	1,921	4,373	1,921	4,373
Japan - pT	4,196	4,383	4,196	4,383
Kazakhstan - pT	—	—	4,791	—
Korea, Rep. of - Br	1,541	4,669	1,541	4,669
Kuwait - LD	4,437	3,593	—	3,593
Latvia - pT	—	—	4,481	—
Lithuania - Br	1,587	4,529	1,587	4,529
Morocco - LD	7,723	5,068	—	5,068
Netherlands - Br	1,295	4,515	1,295	4,515
New Zealand - pT	5,019	6,322	5,019	6,322
Northern Ireland - pT	3,497	3,116	3,497	3,116
Norway (5) - Br	1,899	4,329	1,899	4,329
Oman - pT	6,814	9,105	6,814	9,105
Poland - pT	4,882	4,747	4,882	4,747
Portugal - Br	1,612	4,693	1,612	4,693
Qatar - Br	1,486	5,194	1,486	5,194
Russian Federation - Br	2,128	4,921	2,128	4,921

Countries are shown as being either paperTIMSS (pT), eTIMSS bridge (Br), or less difficult (LD).

Exhibit 12.8: Sample Sizes for Scaling the paperTIMSS 2019 Grade 4 Data (continued)

Country	Item Calibration		Proficiency Estimation	
	2019	2015	2019	2015
Saudi Arabia - LD	5,453	4,337	—	4,337
Serbia - pT	4,380	4,036	4,380	4,036
Singapore - Br	1,881	6,517	1,881	6,517
Slovak Republic - Br	1,610	5,773	1,610	5,773
Spain - Br	1,670	7,764	1,670	7,764
Sweden - Br	1,697	4,142	1,697	4,142
United Arab Emirates - Br	2,243	21,177	2,243	21,177
United States - Br	1,652	10,029	1,652	10,029
TOTAL	**132,481**	**239,467**	**131,349**	**239,467**

Countries are shown as being either paperTIMSS (pT), eTIMSS bridge (Br), or less difficult (LD).

Exhibit 12.9: Sample Sizes for Scaling the paperTIMSS 2019 Grade 8 Data

Country	Item Calibration		Proficiency Estimation	
	2019	2015	2019	2015
Australia - pT	9,060	10,338	9,060	10,338
Bahrain - pT	5,725	4,918	5,725	4,918
Chile - Br	1,526	4,849	1,526	4,849
Chinese Taipei - Br	1,578	5,711	1,578	5,711
Cyprus - pT	—	—	3,521	—
Egypt - pT	7,210	7,822	7,210	7,822
England - Br	1,592	4,814	1,592	4,814
Georgia - Br	1,314	4,035	1,314	4,035
Hong Kong SAR - Br	1,423	4,155	1,423	4,155
Hungary - Br	1,751	4,893	1,751	4,893
Iran, Islamic Rep. of - pT	5,980	6,130	5,980	6,130
Ireland - pT	4,118	4,704	4,118	4,704
Israel - Br	1,863	5,512	1,863	5,512
Italy - Br	2,032	4,481	2,032	4,481
Japan - pT	4,446	4,745	4,446	4,745
Jordan - pT	7,176	7,865	7,176	7,865
Kazakhstan - pT	—	—	4,453	—
Korea, Rep. of - Br	1,693	5,309	1,693	5,309
Kuwait - pT	4,574	4,503	4,574	4,503
Lebanon - pT	4,730	3,873	4,730	3,873
Lithuania - Br	1,687	4,347	1,687	4,347
Malaysia - Br	1,560	9,726	1,560	9,726
Morocco - pT	8,458	13,035	8,458	13,035
New Zealand - pT	6,051	8,142	6,051	8,142
Norway (9) - Br	2,018	4,697	2,018	4,697
Oman - pT	6,751	8,883	6,751	8,883
Qatar - Br	1,490	5,403	1,490	5,403
Romania - pT	—	—	4,494	—
Russian Federation - Br	2,083	4,780	2,083	4,780
Saudi Arabia - pT	5,680	3,759	5,680	3,759
Singapore - Br	1,871	6,116	1,871	6,116
South Africa (9) - pT	20,829	12,514	20,829	12,514
Sweden - Br	1,582	4,090	1,582	4,090
Turkey - Br	1,819	6,079	1,819	6,079
United Arab Emirates - Br	2,089	18,012	2,089	18,012
United States - Br	1,484	10,221	1,484	10,221
Benchmarking Participants				
Gauteng, RSA (9) - pT	—	—	5,633	—
Western Cape, RSA (9) - pT	—	—	5,351	—
TOTAL	**133,243**	**218,461**	**156,695**	**218,461**

Countries are shown as being either paperTIMSS (pT) or eTIMSS bridge (Br).

At the fourth grade, 44 countries contributed to the concurrent calibration, including three countries that participated in the fourth grade less difficult mathematics assessment. These 44 trend countries provided 239,467 students from the 2015 assessment and 132,481 students from the 2019 assessment, including bridge data from eTIMSS trend countries. At the eighth grade, 33 countries contributed to the concurrent calibration, 218,461 students from the 2015 assessment and 133,243 students from the 2019 assessment, including bridge data from eTIMSS trend countries.

The item parameters estimated from these concurrent calibrations, based on the countries that participated in both the previous and current assessments, were used to estimate student proficiency for all countries and benchmarking entities participating in the paperTIMSS 2019 and bridge assessments. These item parameters also were used to estimate student proficiency in the mathematics and science content and cognitive domains. Estimating student proficiency for all eTIMSS countries and benchmarking participants based on their eTIMSS data also relied, to a large extent, on these estimated paperTIMSS item parameters.

At the fourth grade, paperTIMSS and bridge student proficiency was estimated for a total of 45 countries, as shown in Exhibit 12.8. At the eighth grade, student proficiency was estimated for 36 countries and 2 benchmarking participants, as shown in Exhibit 12.9. The item parameters estimated from the paperTIMSS concurrent calibration at the fourth and eighth grades and for mathematics and science are presented in Appendices 12A through 12D.

Variables for Conditioning the paperTIMSS and Bridge Data

Conditioning refers to utilizing a latent regression model that involves all available students' contextual information to improve statistical properties of the estimated student proficiency values. Ideally, all student-level contextual data would be included in the conditioning model, but because TIMSS has so many student context variables that could be used in conditioning, the TIMSS & PIRLS International Study Center follows the practice established by NAEP and followed by other large-scale studies of using principal component analysis to reduce the number of variables while explaining most of their common variance. Principal components for the TIMSS student context variables (including parent context variables at the fourth grade) were constructed as follows:

- For categorical variables (questions with a small number of fixed response options), a dummy coded variable was created for each response option, with a value of one if the option is chosen and zero otherwise. If a student omitted or was not administered a particular question, all dummy coded variables associated with that question were assigned the value zero.
- Context variables with numerous response options (such as year of birth) were recoded using criterion scaling.[2] This was done by replacing the response option with the mean interim achievement score of all students choosing that option. Criterion scaling maximizes

2 The process of generating criterion-scaled variables is described in Beaton (1969).

the correlation between the scaled variable and achievement. For TIMSS, the interim achievement score was the student-level average of the mathematics and science EAP scores produced from the item calibrations.

- Separately for each country, all the dummy-coded and criterion-scaled variables were included in a principal component analysis. Those principal components accounting for 90 percent of the variance of all context variables were retained for use as conditioning variables.[3] Because the principal component analysis was performed separately for each country and benchmarking participant, different numbers of principal components were required to account for 90 percent of the common variance in each country's context variables.

In addition to the principal components, students' gender (dummy coded), the language of the test (dummy coded), an indicator of the classroom in the school to which a student belongs (criterion scaled), and an optional country-specific variable (dummy coded) were included as primary conditioning variables, thereby accounting for most of the variance between students and preserving the between-classroom and within-classroom variance structure in the latent regression conditioning model. Exhibits 12.10 and 12.11 provide details on the conditioning models used for proficiency estimation of the paperTIMSS and bridge data at the fourth and eighth grades, respectively.

3 The number of principal components retained is limited to no more than 5% of a country's student sample size, thereby possibly reducing the percentage of variance accounted for to avoid over-specification of the conditioning model. This constraint played a major role with the eTIMSS bridge samples due to their smaller size.

Exhibit 12.10: Conditioning Models for the paperTIMSS 2019 Grade 4 Data

Country	2019				2015			
	Number of Primary Conditioning Variables	Number of Principal Components Available	Number of Principal Components Retained	Percentage of Variance Explained	Number of Primary Conditioning Variables	Number of Principal Components Available	Number of Principal Components Retained	Percentage of Variance Explained
Armenia - pT	2	532	269	88	2	615	269	84
Australia - pT	2	323	176	90	2	633	302	89
Austria - Br	2	558	98	61	—	—	—	—
Azerbaijan - pT	3	563	262	85	—	—	—	—
Bahrain - pT	3	562	288	89	3	637	207	75
Belgium (Flemish) - pT	2	557	232	83	2	629	270	84
Bulgaria - pT	2	545	213	82	2	617	211	78
Canada - Br	5	544	80	59	5	619	321	90
Chile - Br	2	538	80	55	2	610	237	80
Chinese Taipei - Br	2	562	83	56	2	636	214	78
Croatia - Br	2	557	73	56	3	637	199	76
Cyprus - pT	3	563	203	78	2	637	206	74
Czech Republic - Br	2	558	101	65	2	636	260	84
Denmark - Br	2	555	71	56	2	628	185	73
England - Br	2	329	62	59	2	336	179	90
Finland - Br	3	560	99	63	3	634	250	83
France - Br	2	562	97	60	2	637	243	81
Georgia - Br	2	559	81	56	2	637	195	74
Germany - Br	2	563	75	59	2	637	197	76
Hong Kong SAR - Br	3	563	66	54	3	637	180	73
Hungary - Br	2	538	88	58	2	613	251	82
Iran, Islamic Rep. of - pT	2	563	299	90	2	637	191	73
Ireland - pT	3	563	229	83	3	637	217	78
Italy - Br	2	556	96	59	2	631	218	77
Japan - pT	2	552	209	82	2	635	219	79
Kazakhstan - pT	3	562	239	84	—	—	—	—
Korea, Rep. of - Br	2	549	77	57	2	636	233	81
Latvia - pT	3	561	224	82	—	—	—	—
Lithuania - Br	4	548	79	57	4	630	226	79
Netherlands - Br	2	323	64	61	2	619	225	82
New Zealand - pT	6	563	250	87	8	633	314	90
Northern Ireland - pT	2	503	174	79	3	589	155	71
Norway (5) - Br	3	483	94	64	3	636	216	80
Oman - pT	3	563	306	90	3	637	353	90
Poland - pT	2	558	244	85	2	616	237	81
Portugal - Br	2	561	80	54	2	636	234	79
Qatar - Br	3	562	74	56	3	632	259	83
Russian Federation - Br	2	537	106	62	2	613	246	81
Serbia - pT	2	562	219	83	2	628	201	76
Singapore - Br	2	539	94	62	2	637	322	90

Countries are shown as being either paperTIMSS (pT) or eTIMSS bridge (Br).

Exhibit 12.10: Conditioning Models for the paperTIMSS 2019 Grade 4 Data (Continued)

Country	2019				2015			
	Number of Primary Conditioning Variables	Number of Principal Components Available	Number of Principal Components Retained	Percentage of Variance Explained	Number of Primary Conditioning Variables	Number of Principal Components Available	Number of Principal Components Retained	Percentage of Variance Explained
Slovak Republic - Br	3	563	80	55	3	633	288	86
Spain - Br	6	555	83	57	5	628	319	90
Sweden - Br	2	537	84	60	2	611	207	78
United Arab Emirates - Br	5	563	112	68	5	637	346	90
United States - Br	10	327	82	65	10	330	184	90

Countries are shown as being either paperTIMSS (pT) or eTIMSS bridge (Br).

Exhibit 12.11: Conditioning Models for the paperTIMSS 2019 Grade 8 Data

Country	2019				2015			
	Number of Primary Conditioning Variables	Number of Principal Components Available	Number of Principal Components Retained	Percentage of Variance Explained	Number of Primary Conditioning Variables	Number of Principal Components Available	Number of Principal Components Retained	Percentage of Variance Explained
Australia - pT	2	539	241	90	2	478	245	90
Bahrain - pT	3	546	255	90	3	482	245	89
Chile - Br	2	545	76	59	2	481	242	89
Chinese Taipei - Br	2	532	78	63	2	481	231	90
Cyprus - pT	3	888	176	67	—	—	—	—
Egypt - pT	3	547	273	90	2	482	276	90
England - Br	2	545	79	61	2	482	240	89
Georgia - Br	2	886	65	49	2	850	201	72
Hong Kong SAR - Br	3	545	71	64	2	482	207	87
Hungary - Br	2	887	87	53	2	850	244	75
Iran, Islamic Rep. of - pT	2	547	257	90	2	482	261	90
Ireland - pT	3	547	205	84	3	482	235	88
Israel - Br	3	481	93	66	3	436	230	90
Italy - Br	2	546	101	65	2	482	224	87
Japan - pT	2	547	222	89	2	480	234	90
Jordan - pT	2	547	259	90	2	482	263	90
Kazakhstan - pT	3	887	222	77	—	—	—	—
Korea, Rep. of - Br	2	533	84	66	2	481	227	90
Kuwait - pT	3	541	228	86	3	474	225	85
Lebanon - pT	3	769	236	78	3	724	193	71
Lithuania - Br	4	881	84	54	4	845	217	73
Malaysia - Br	3	541	78	59	2	473	248	90
Morocco - pT	3	888	422	90	2	850	463	90
New Zealand - pT	7	547	246	90	8	478	245	90
Norway (9) - Br	3	503	100	67	3	482	234	89
Oman - pT	3	547	268	90	3	482	271	90
Qatar - Br	3	547	74	59	3	477	244	90
Romania - pT	2	888	224	74	—	—	—	—
Russian Federation - Br	2	888	104	57	2	849	239	76
Saudi Arabia - pT	3	541	266	90	3	482	187	79
Singapore - Br	2	523	93	65	2	482	246	90
South Africa (9) - pT	5	547	277	90	3	482	276	90
Sweden - Br	2	773	79	58	2	726	204	77
Turkey - Br	2	547	90	61	2	481	257	90
United Arab Emirates - Br	5	547	104	67	5	482	258	90
United States - Br	10	542	74	59	10	475	248	90
Benchmarking Participants								
Gauteng, RSA (9) - pT	3	547	265	90	—	—	—	—
Western Cape, RSA (9) - pT	3	547	262	90	—	—	—	—

Countries are shown as being either paperTIMSS (pT) or eTIMSS bridge (Br).

Generating Plausible values for the paperTIMSS and Bridge Data

Educational Testing Service's MGROUP program (Sheehan, 1985) was used to estimate the latent regression model and generate plausible values. This program takes as input the students' responses to the items they were given, the item parameters estimated at the calibration stage, and the conditioning variables, and generates as output the estimated regression effects and residual variance covariance, as well as plausible values that represent the posterior distribution of student proficiency given achievement and contextual data. A useful feature of MGROUP is its ability to estimate multi-dimensional latent regression models using the responses to all items across the proficiency scales and the correlations among the scales to improve the reliability of each individual scale. TIMSS capitalizes on this feature to estimate simultaneously overall mathematics proficiency and overall science proficiency at each grade using a two-dimensional MGROUP model. More details on the latent regression model are available in Chapter 11 of this volume.

The multi-dimensional scaling feature of MGROUP also was used to generate plausible values for the TIMSS 2019 content and cognitive domains. The estimation of plausible values for the mathematics and science content and cognitive domains relied on multidimensional IRT models using the item parameters estimated for the overall mathematics and overall science scales as well as the same set of conditioning variables. At the fourth grade, the content domain scaling used two four-dimensional models, one to estimate plausible values for the three content domains in mathematics with overall science and a second for the three science content domains with overall mathematics. At the eighth grade, the content domain scaling required two five-dimensional models because of the four content domains in each subject along with the other overall subject. The cognitive domain scaling relied on four four-dimensional models to estimate the three cognitive domains in mathematics and science, along with the other overall subject, at both fourth and eighth grades. All of these models were applied to each paperTIMSS country and benchmarking participant.

In addition to generating plausible values on the overall mathematics and science scales for the 2019 paperTIMSS and bridge data, the item parameters estimated at the calibration stage also were used to generate plausible values for the TIMSS 2015 assessment data for the countries included in the concurrent calibration at the fourth and eighth grades. These additional plausible values were used to establish the linear transformation necessary to place the paperTIMSS and bridge 2019 data on the appropriate TIMSS trend scales.

Transforming the Overall Scores to Measure Trends

To provide results for the TIMSS 2019 assessments on the existing TIMSS achievement scales, the 2019 plausible values for overall mathematics and overall science had to be transformed to the TIMSS reporting metric. This was accomplished through a set of linear transformations as part of the concurrent calibration approach. These linear transformations were given by:

$$PV_{ik}^{*} = A_{ik} + B_{ik} \times PV_{ik} \tag{12.1}$$

where

PV_{ik} is the TIMSS 2019 plausible value i of scale k prior to transformation;

PV_{ik}^{*} is the TIMSS 2019 plausible value i of scale k after transformation; and

A_{ik} and B_{ik} are the linear transformation constants.

The linear transformation constants were obtained by first computing the international means and standard deviations of the plausible values for the overall mathematics and science scales using the plausible values produced in 2015 based on the 2015 item calibrations for the trend countries. These were the plausible values published in 2015. Next, the same calculations were done using the plausible values from the re-scaled TIMSS 2015 assessment data based on the 2019 paperTIMSS and bridge concurrent item calibrations for the same set of trend countries. From these calculations, the linear transformation constants were defined as:

$$B_{ik} = \sigma_{ik} \,/\, \sigma_{ik}^{*} \tag{12.2}$$

$$A_{ik} = \mu_{ik} - B_{ik} \cdot \mu_{ik}^{*} \tag{12.3}$$

where

μ_{ik} is the international mean of scale k based on plausible value i published in 2015;

μ_{ik}^{*} is the international mean of scale k based on plausible value i from the 2015 assessment based on the 2019 concurrent calibration;

σ_{ik} is the international standard deviation of scale k based on plausible value i published in 2015;

σ_{ik}^{*} is the international standard deviation of scale k based on plausible value i from the 2015 assessment based on the 2019 concurrent calibration.

There are five sets of transformation constants for each scale, one for each plausible value. The trend countries contributed equally to the calculation of these transformation constants. Exhibits 12.12 and 12.13 show the TIMSS 2019 transformation constants for both subjects at the fourth grade and eighth grade, respectively. These transformation constants were applied to overall mathematics, overall science, and their respective content and cognitive domains. They also were applied across all TIMSS 2019 assessments: paperTIMSS, eTIMSS, bridge, and science for the countries participating in the less difficult assessment.

Exhibit 12.12: Transformation Constants for the TIMSS 2019 Grade 4 Data

Overall Mathematics	TIMSS 2015 Published Scores		TIMSS 2015 Re-Scaled Scores		A_{ik}	B_{ik}
	Mean	Standard Deviation	Mean	Standard Deviation		
PV1	511.25828	99.44908	-0.05863	1.03038	516.91736	96.51715
PV2	511.32879	99.96828	-0.05780	1.03165	516.92943	96.90131
PV3	511.72035	98.57866	-0.05873	1.02959	517.34333	95.74545
PV4	511.07161	99.70953	-0.05635	1.03198	516.51649	96.61951
PV5	510.86364	99.52263	-0.05629	1.02952	516.30491	96.66892

Overall Science	TIMSS 2015 Published Scores		TIMSS 2015 Re-Scaled Scores		A_{ik}	B_{ik}
	Mean	Standard Deviation	Mean	Standard Deviation		
PV1	506.83611	99.28332	-0.01640	0.98759	508.48461	100.53116
PV2	505.33314	99.77459	-0.01691	0.98878	507.03961	100.90681
PV3	505.66704	99.87928	-0.01688	0.98785	507.37344	101.10788
PV4	504.63307	100.51279	-0.01857	0.98947	506.51953	101.58220
PV5	506.56374	99.60458	-0.01817	0.98877	508.39371	100.73569

Exhibit 12.13: Transformation Constants for the TIMSS 2019 Grade 8 Data

Overall Mathematics	TIMSS 2015 Published Scores		TIMSS 2015 Re-Scaled Scores		A_{ik}	B_{ik}
	Mean	Standard Deviation	Mean	Standard Deviation		
PV1	481.22701	110.64947	-0.03701	0.99368	485.34848	111.35346
PV2	481.67630	111.33530	-0.03596	0.99442	485.70283	111.95996
PV3	481.41115	112.03210	-0.03787	0.99406	485.67858	112.70101
PV4	480.58759	112.61280	-0.03757	0.99614	484.83512	113.04950
PV5	481.40015	111.97331	-0.03629	0.99284	485.49337	112.78062

Overall Science	TIMSS 2015 Published Scores		TIMSS 2015 Re-Scaled Scores		A_{ik}	B_{ik}
	Mean	Standard Deviation	Mean	Standard Deviation		
PV1	484.92745	109.68547	-0.00066	0.94325	485.00413	116.28414
PV2	484.89171	109.07120	-0.00075	0.94167	484.97803	115.82786
PV3	486.02108	108.36916	-0.00139	0.94144	486.18070	115.10991
PV4	484.61364	110.12633	0.00005	0.94190	484.60824	116.91939
PV5	485.54639	109.34609	0.00021	0.94104	485.52214	116.19689

Evaluating Model Fit to the TIMSS Assessment Data

After scaling the TIMSS 2019 paperTIMSS and bridge data, extensive checks were performed to verify the fit of the IRT models applied to these data, in terms of item calibration, proficiency estimation, and link to the TIMSS trend reporting scales. One key method consisted of evaluating the fit of the estimated item characteristic curves to the empirical response data. A second critical method consisted of measuring the accuracy in re-estimating the TIMSS 2015 achievement results across the pool of trend countries, a crucial component in accurately reporting TIMSS 2019 results on the TIMSS trend scales. This involved quantifying the linking error between the 2015 and 2019 assessments.

Item Characteristic Curves

Model fit was assessed by visually comparing the item response function curves generated using the item parameters estimated from the data with the empirical item response function curves calculated from the latent abilities estimated for each student that responded to an item. The empirical functions are

themselves based on an estimated latent ability distribution that uses the IRT model and are therefore also referred to item functions based on *pseudo counts*. When the empirical results for an item fall near the fitted curves, the IRT model for that item fits the data well and provides an accurate and reliable measurement of the underlying proficiency scale.

Plots of these response function curves are called item characteristic curves (ICC). The plots in Exhibits 12.14 and 12.15 show examples of the empirical and fitted item response functions for dichotomously scored (right/wrong) multiple-choice and constructed response items, respectively. In each plot, the horizontal axis represents the proficiency scale on the logit metric, and the vertical axis represents the probability of a correct response. The fitted curve based on the estimated item parameters is shown as a solid line, with the item slope parameter represented by the slope of the curve between the two inflexion points, the difficulty or location parameter represented by the point on the horizontal axis where the probability of a correct response is 50 percent, and, for multiple-choice items, a lower asymptote corresponding to the guessing parameter.

Empirical results based on *pseudo counts* are represented by circles. The empirical results are obtained by first dividing the logit proficiency scale into intervals of equal size and then counting the number of students responding to the item whose *estimated* latent abilities (EAP scores estimated by Parscale) fall in each interval. Then the proportion of students in each interval that responded correctly to the item is calculated. In the exhibits, the center of each circle represents this empirical proportion of correct responses. The size of each circle is proportional to the estimated number of students contributing to the empirical proportion correct in its corresponding interval.

Exhibit 12.14: Example Item Response Function for a Dichotomous Multiple-Choice Item from paperTIMSS 2019 Grade 8 Mathematics

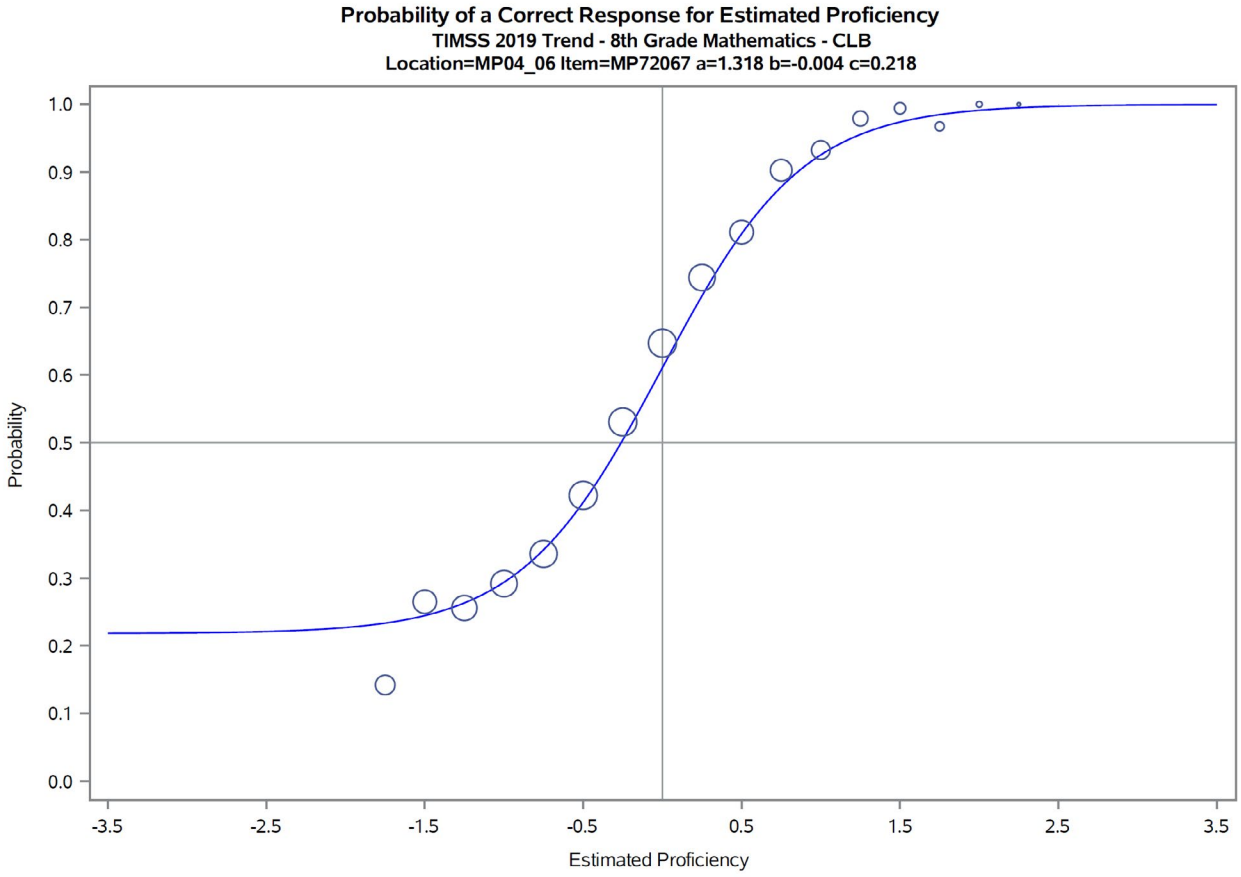
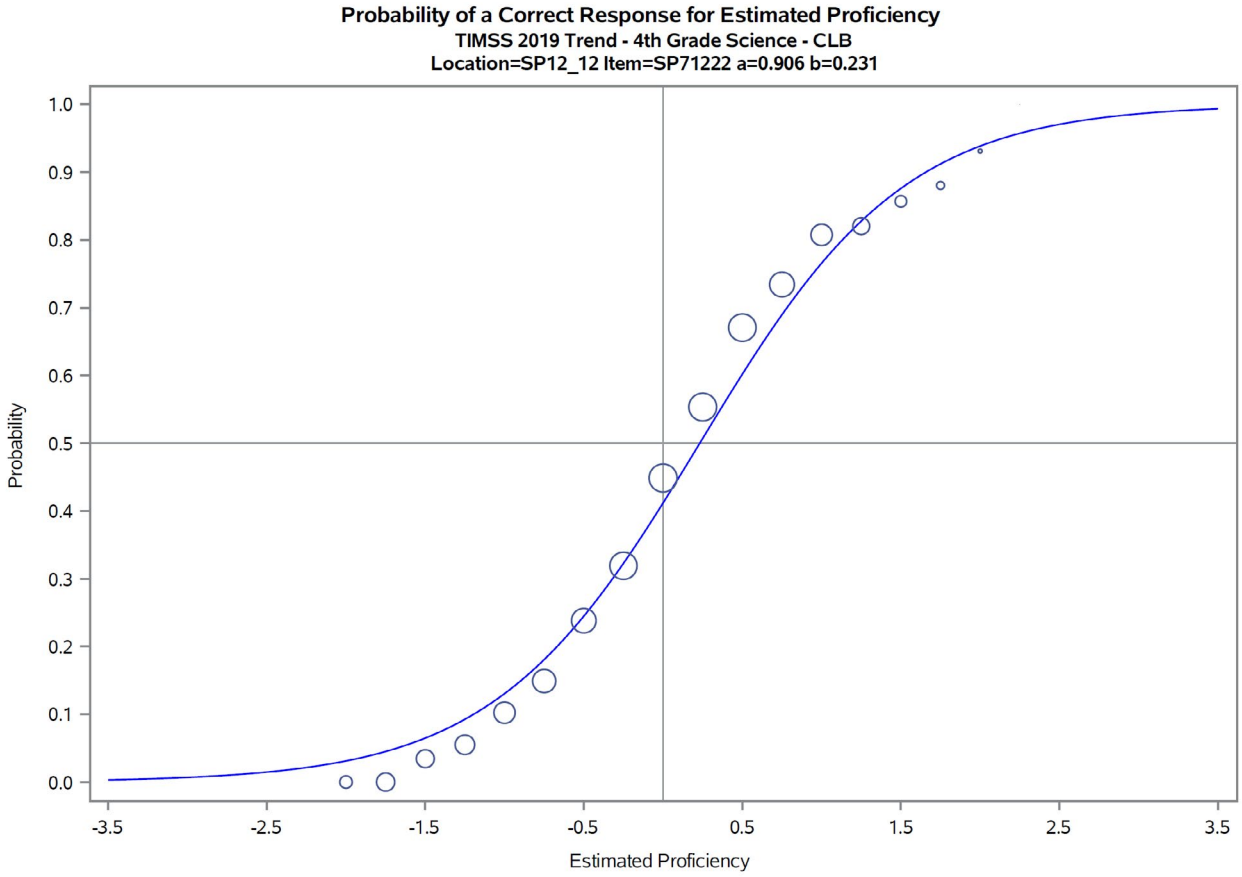


Exhibit 12.15: Example Item Response Function for a Dichotomous Constructed-Response Item from paperTIMSS 2019 Grade 4 Science

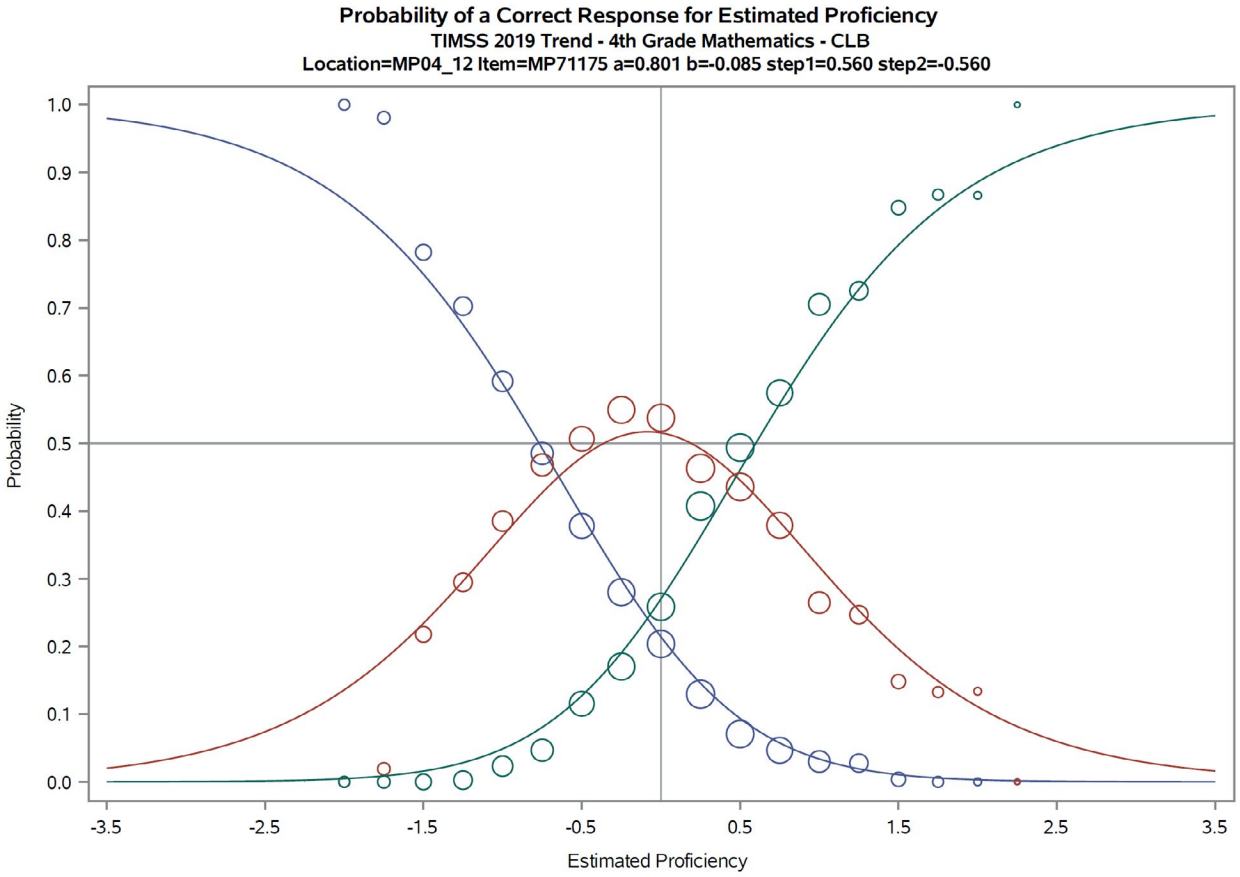


In addition to graphical model fit assessment, the fit of an item to the IRT model is quantified by the root mean square difference (RMSD) statistic. The RMSD is the square root of the average of squared differences (i.e., the area) between the empirical curve, shown as bubbles, and the fitted curve, shown as the straight line, weighted by the size of the empirical bubbles. The RMSD statistics for the items shown in exhibits 12.14 and 12.15 are 0.028 and 0.038, respectively. RMSD values less than 0.1 were considered to indicate good fit.

The ICC plot in Exhibit 12.16 shows the empirical and fitted item response functions for a polytomous item (scored 0, 1, or 2). As for the dichotomous item plots above, the horizontal axis represents the proficiency scale in logits, but in this example the vertical axis represents the probability of having a response in a given response category. The fitted curves based on the estimated item parameters are shown as solid lines and the empirical results are represented by circles. The interpretation of the circles is the same as in Exhibits 12.14 and 12.15. The curve starting at the top left of the chart plots the probability of a score of zero on the item. This probability should always decrease as proficiency increases. The

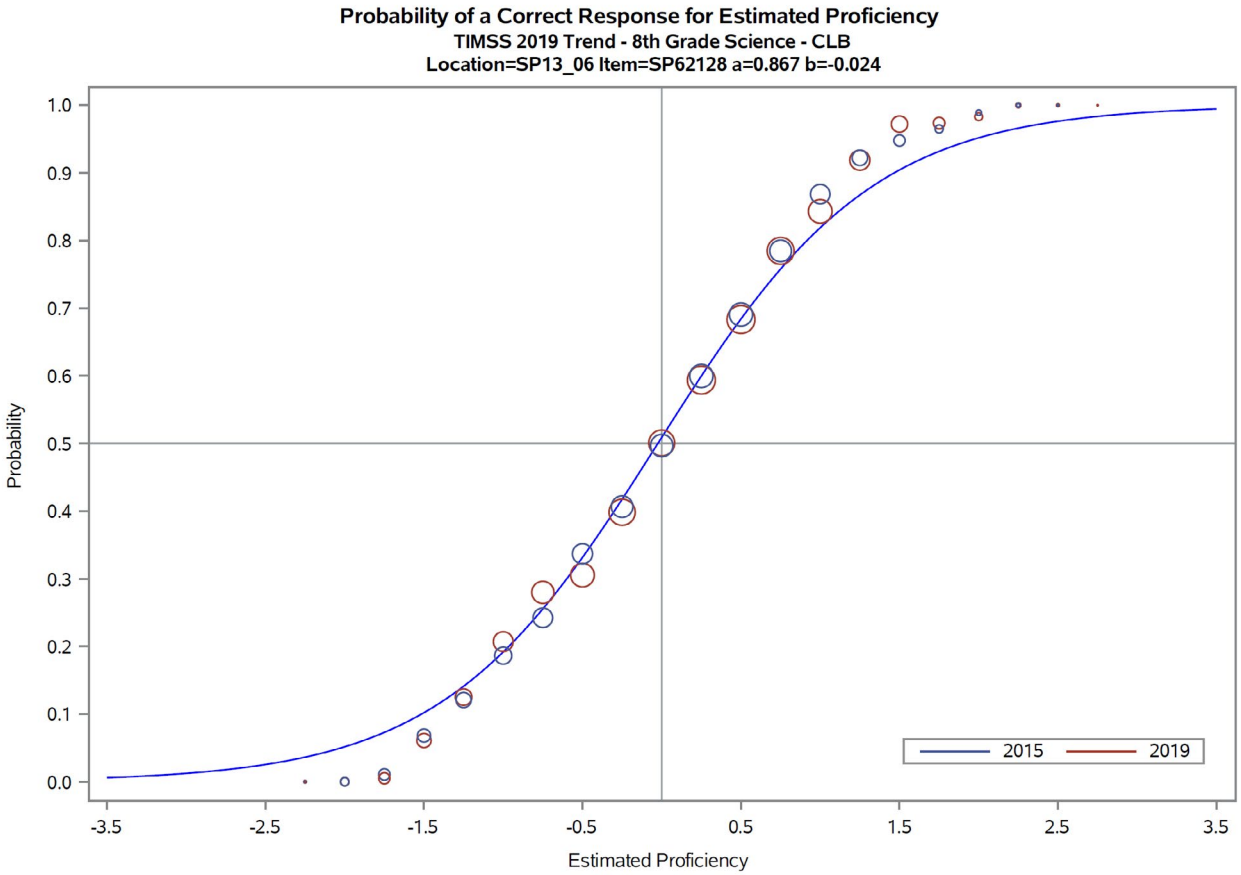
bell-shaped curve shows the probability of a score of one point—partial credit, which should start low approaching zero for low-ability students, reaching a maximum for medium-ability students, and decreasing for high-ability students. The curve ending at the top right corner of the chart shows the probability of a score of two points—full credit, starting low for low-ability students and increasing as proficiency increases. For this particular item, the RMSD value is 0.035, calculated from all three response curves.

Exhibit 12.16: Example Item Response Function for a Polytomous Constructed-Response Item from paperTIMSS 2019 Grade 4 Mathematics



Although a single set of item parameters was estimated for any given item in the concurrent calibration for 2019, trend items have two empirical curves, one for each assessment cycle. Plotting both empirical curves from 2019 and 2015 allowed for a visual inspection of the invariance of the item parameters between cycles; a key aspect of the link to the trend scale. Exhibit 12.17 shows the ICC for a paperTIMSS 2019 trend item, with its single fitted curve and two empirical curves: the blue bubbles represent the empirical curve based on the TIMSS 2015 response data, the red curve the empirical curve based on the TIMSS 2019 response data. Thus, for trend items, there are two RMSD values. The RMSD values for this particular item are 0.027 based on the 2015 data and 0.028 based on the 2019 data.

Exhibit 12.17: Example Item Response Function for a Dichotomous Constructed-Response Trend Item from paperTIMSS 2019 Grade 8 Science



RMSD values were computed for all items included in the paperTIMSS 2019 concurrent calibrations. These values are shown in the item parameter exhibits of Appendices 12A through 12D. They are also presented graphically in Exhibits 12.18 through 12.21 for the fourth and eighth grades and for mathematics and science, respectively. In each exhibit, the items are sorted from smallest to largest RMSD values. For trend items with two RMSD values, the largest of the two determined the order. Across both grades and subjects, the vast majority of paperTIMSS items have RMSD values less than 0.04. All paperTIMSS items have RMSD values less than 0.10.

Exhibit 12.18: RMSD Statistics for Items in the paperTIMSS 2019 Concurrent Calibration—Grade 4 Mathematics

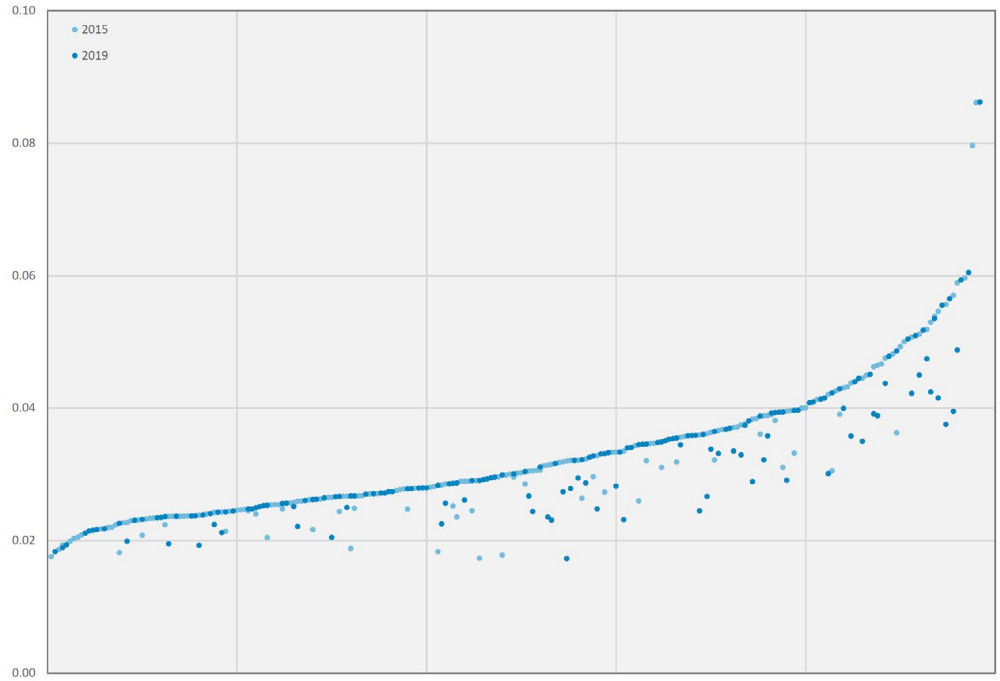


Exhibit 12.19: RMSD Statistics for Items in the paperTIMSS 2019 Concurrent Calibration—Grade 4 Science

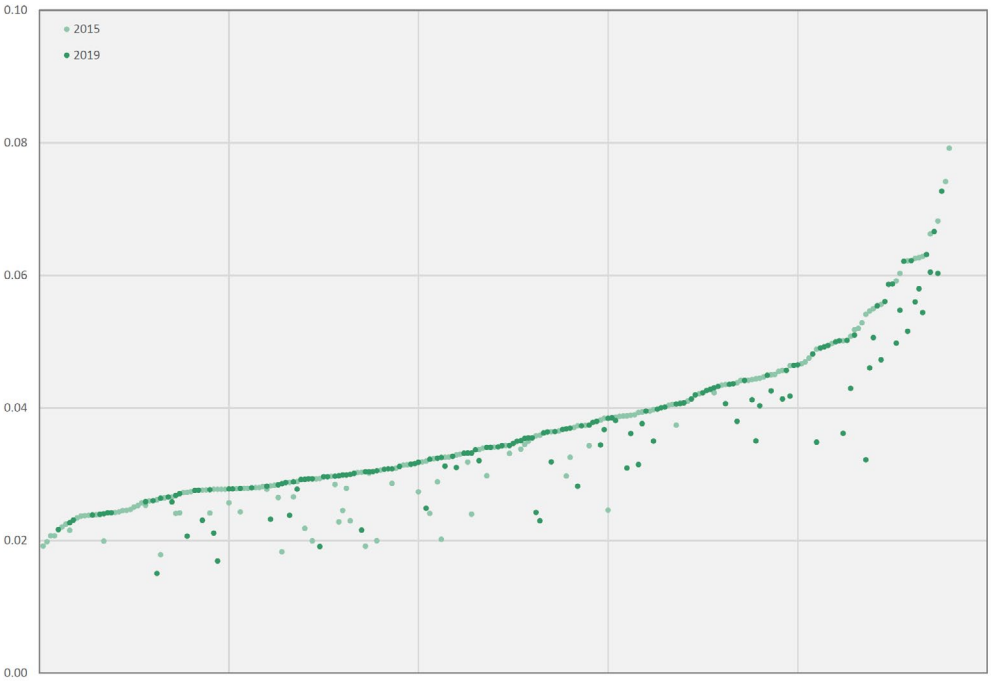


Exhibit 12.20: RMSD Statistics for Items in the paperTIMSS 2019 Concurrent Calibration—Grade 8 Mathematics

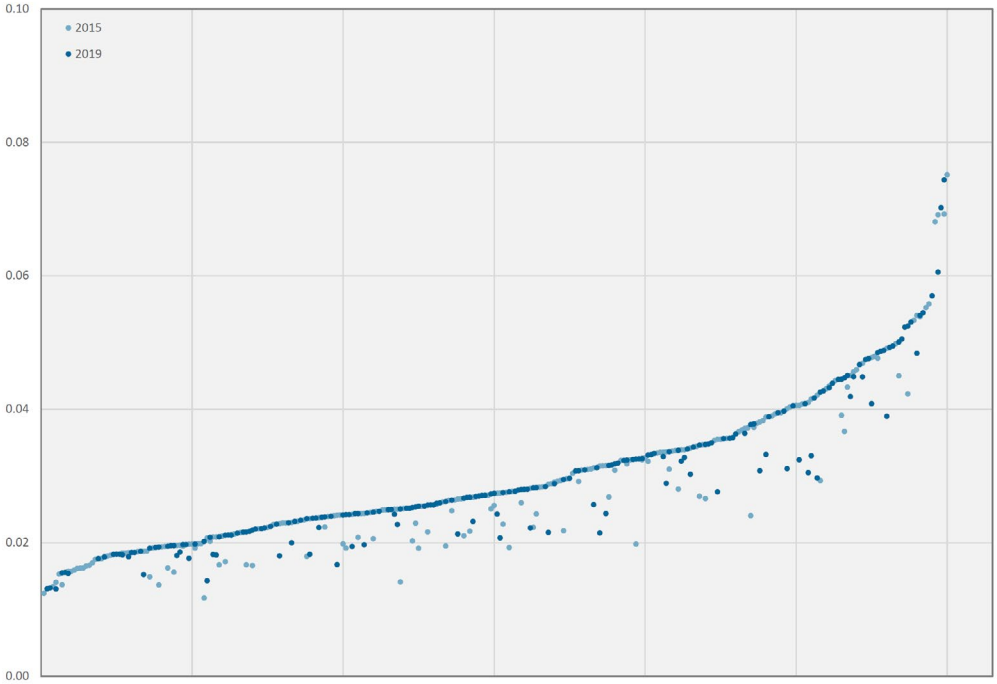
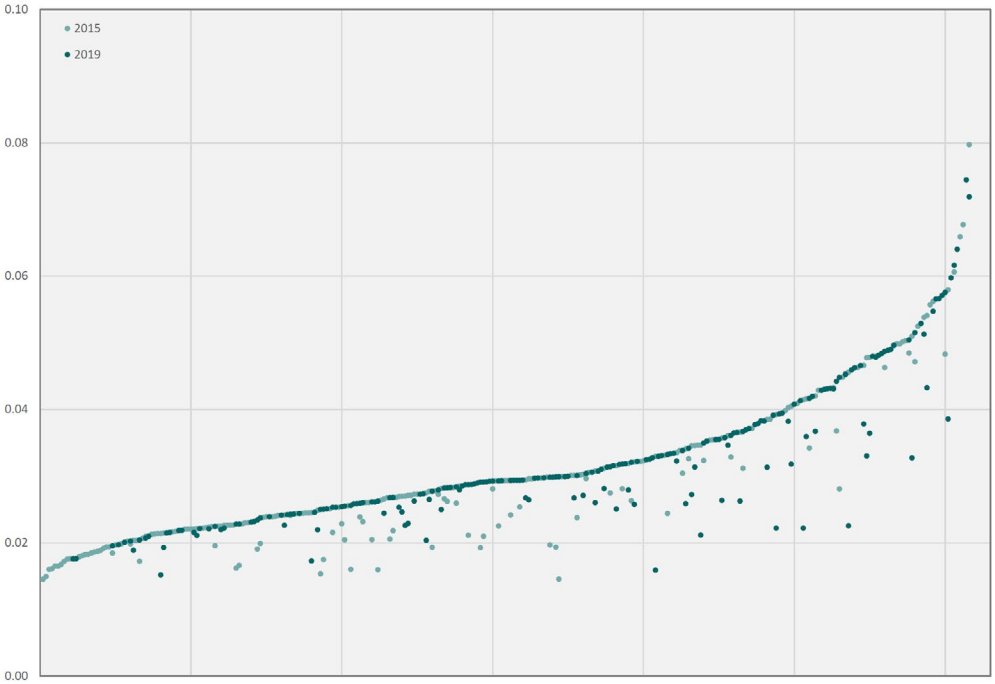


Exhibit 12.21: RMSD Statistics for Items in the paperTIMSS 2019 Concurrent Calibration—Grade 8 Science



Quantifying the Linking Error between 2015 and 2019

A key aspect of reporting the TIMSS 2019 results on the TIMSS trend scales is the ability to accurately re-estimate the TIMSS 2015 achievement results based on a concurrent calibration of the 2015 and 2019 data across a common set of trend countries. As described earlier, this re-estimation serves to establish the linear transformation that places the TIMSS 2019 results on the TIMSS trend scale. Although this transformation is set globally to match the overall mean and standard deviation across the trend countries, it also should achieve a good alignment of the 2015 results across calibrations for each individual trend country. The difference between a trend country's TIMSS 2015 achievement mean published back in 2015 and re-estimated in 2019 gives a good measure of quality of the link between the two assessments. The linking error is quantified by the standard error of difference, for each country and aggregated over the countries (see Martin, Mullis, Foy, Brossman, & Stanco, 2012).

Exhibits 12.22 through 12.25 provide results on the linking error associated with the paperTIMSS 2019 results for the fourth and eighth grades and for mathematics and science, respectively. Across both grades and subjects, there was good agreement between the countries' published and re-estimated 2015 results. Only one country shows a statistically significant difference for eighth grade science. In the vast majority of cases, the differences are within one point and the standard errors rarely exceed 2 points.

Exhibit 12.22: Trend Linking Error for the paperTIMSS 2019 Grade 4 Mathematics Scale

Country	TIMSS 2015 Published Results		TIMSS 2015 Re-Estimated Results		Difference (Linking Error)
	Mean	Standard Deviation	Mean	Standard Deviation	
Armenia	481 (3.4)	80 (1.5)	481 (3.5)	80 (1.6)	0 (0.9)
Australia	517 (3.1)	83 (1.8)	518 (3.0)	84 (1.6)	0 (0.9)
Bahrain	450 (2.1)	85 (1.8)	451 (2.1)	84 (1.5)	1 (1.6)
Belgium (Flemish)	546 (2.1)	61 (1.2)	545 (2.0)	61 (1.3)	0 (0.6)
Bulgaria	524 (5.3)	83 (2.6)	524 (5.2)	83 (2.7)	0 (1.4)
Canada	511 (2.3)	75 (1.9)	511 (2.5)	75 (2.1)	0 (1.0)
Chile	459 (2.4)	73 (1.5)	459 (2.6)	74 (1.4)	0 (0.8)
Chinese Taipei	597 (1.9)	71 (1.2)	597 (1.8)	71 (1.5)	0 (0.9)
Croatia	502 (1.8)	66 (1.0)	502 (2.0)	66 (1.4)	0 (1.4)
Cyprus	523 (2.7)	81 (1.2)	523 (2.5)	81 (1.2)	0 (0.8)
Czech Republic	528 (2.2)	70 (1.3)	528 (2.3)	70 (1.4)	0 (0.7)
Denmark	539 (2.7)	75 (1.6)	538 (2.7)	75 (1.4)	0 (1.3)
England	546 (2.8)	84 (2.2)	547 (2.9)	84 (2.1)	0 (0.7)
Finland	535 (2.0)	67 (1.2)	535 (1.9)	67 (1.2)	0 (0.8)
France	488 (2.9)	74 (1.3)	488 (2.8)	74 (1.5)	0 (1.2)
Georgia	463 (3.6)	87 (2.4)	463 (3.6)	86 (2.4)	0 (1.5)
Germany	522 (2.0)	65 (1.2)	522 (2.1)	65 (1.2)	0 (0.8)
Hong Kong SAR	615 (2.9)	66 (1.7)	614 (3.0)	66 (1.5)	-1 (0.8)
Hungary	529 (3.2)	88 (2.3)	529 (3.2)	88 (2.3)	0 (0.8)
Iran, Islamic Rep. of	424 (4.1)	101 (3.0)	424 (3.7)	100 (2.5)	1 (1.6)
Ireland	547 (2.1)	73 (1.2)	547 (2.1)	74 (1.4)	0 (0.9)
Italy	507 (2.6)	72 (1.7)	507 (2.5)	72 (1.8)	0 (0.9)
Japan	593 (2.0)	69 (1.0)	593 (1.9)	69 (1.1)	0 (0.8)
Korea, Rep. of	608 (2.2)	67 (1.4)	609 (2.1)	69 (1.7)	1 (0.9)
Kuwait	351 (4.8)	101 (2.4)	352 (4.8)	100 (2.3)	1 (2.0)
Lithuania	535 (2.5)	71 (1.5)	535 (2.5)	72 (1.4)	0 (0.9)
Morocco	379 (3.8)	91 (2.6)	380 (3.7)	91 (2.2)	0 (2.0)
Netherlands	530 (1.7)	56 (1.0)	529 (1.7)	56 (0.9)	0 (0.9)
New Zealand	491 (2.3)	90 (1.5)	491 (2.4)	90 (1.6)	0 (1.2)
Northern Ireland	570 (2.9)	86 (1.7)	570 (3.0)	86 (2.0)	-1 (1.0)
Norway (5)	549 (2.5)	71 (1.4)	549 (2.5)	71 (1.5)	0 (1.0)
Oman	425 (2.5)	101 (1.3)	426 (2.5)	101 (1.6)	0 (0.9)
Poland	535 (2.1)	71 (1.1)	535 (2.3)	72 (1.2)	0 (1.1)
Portugal	541 (2.2)	72 (1.2)	541 (2.3)	73 (1.2)	0 (1.0)
Qatar	439 (3.4)	97 (2.3)	439 (3.4)	96 (2.4)	0 (1.1)
Russian Federation	564 (3.4)	73 (2.4)	564 (3.4)	73 (2.4)	0 (0.9)
Saudi Arabia	383 (4.1)	92 (2.2)	383 (4.1)	92 (2.3)	0 (1.0)
Serbia	518 (3.5)	87 (2.8)	517 (3.5)	88 (2.4)	-1 (1.1)
Singapore	618 (3.8)	86 (2.6)	619 (3.9)	87 (2.6)	1 (0.5)
Slovak Republic	498 (2.5)	80 (1.7)	498 (2.3)	79 (1.8)	0 (0.8)

Linking error is the standard error associated with the difference. Standard errors are shown in parentheses.

Exhibit 12.22: Trend Linking Error for the paperTIMSS 2019 Grade 4 Mathematics Scale (continued)

Country	TIMSS 2015 Published Results		TIMSS 2015 Re-Estimated Results		Difference (Linking Error)
	Mean	Standard Deviation	Mean	Standard Deviation	
Spain	505 (2.5)	69 (1.3)	504 (2.4)	69 (1.3)	-1 (1.0)
Sweden	519 (2.8)	69 (1.7)	519 (2.8)	70 (1.7)	0 (0.8)
United Arab Emirates	452 (2.4)	105 (1.5)	452 (2.5)	105 (1.5)	1 (0.6)
United States	539 (2.3)	81 (1.3)	539 (2.2)	82 (1.3)	0 (0.7)
International Average	**511 (0.5)**	**79 (0.5)**	**511 (0.5)**	**79 (0.5)**	**0 (0.1)**

Exhibit 12.23: Trend Linking Error for the paperTIMSS 2019 Grade 4 Science Scale

Country	TIMSS 2015 Published Results		TIMSS 2015 Re-Estimated Results		Difference (Linking Error)
	Mean	Standard Deviation	Mean	Standard Deviation	
Armenia	444 (4.0)	87 (1.6)	442 (3.9)	87 (1.5)	-1 (1.0)
Australia	524 (2.9)	76 (1.9)	523 (2.8)	77 (1.8)	0 (1.3)
Bahrain	459 (2.6)	105 (1.7)	460 (2.7)	104 (1.5)	2 (1.6)
Belgium (Flemish)	512 (2.3)	62 (1.2)	510 (2.3)	63 (1.2)	-1 (0.8)
Bulgaria	536 (5.9)	95 (3.6)	537 (6.1)	96 (3.8)	1 (1.2)
Canada	525 (2.6)	73 (1.6)	525 (2.6)	74 (1.6)	0 (0.7)
Chile	478 (2.7)	74 (1.4)	477 (2.8)	74 (1.5)	-1 (1.1)
Chinese Taipei	555 (1.8)	68 (1.1)	555 (2.1)	68 (1.2)	0 (1.1)
Croatia	533 (2.1)	62 (1.1)	533 (2.4)	63 (1.2)	0 (1.2)
Cyprus	481 (2.6)	76 (1.4)	481 (2.7)	76 (1.3)	0 (1.3)
Czech Republic	534 (2.4)	70 (1.4)	535 (2.1)	70 (1.2)	1 (1.6)
Denmark	527 (2.1)	69 (1.3)	527 (2.4)	70 (1.6)	0 (1.2)
England	536 (2.4)	70 (1.7)	536 (2.4)	70 (1.6)	0 (1.0)
Finland	554 (2.3)	65 (1.7)	553 (2.2)	65 (1.6)	0 (0.8)
France	487 (2.7)	73 (1.4)	487 (2.7)	73 (1.3)	-1 (1.0)
Georgia	451 (3.7)	87 (2.5)	450 (3.9)	88 (2.5)	-1 (1.4)
Germany	528 (2.4)	70 (1.3)	528 (2.4)	70 (1.2)	-1 (0.9)
Hong Kong SAR	557 (2.9)	70 (1.4)	557 (3.1)	71 (1.6)	1 (1.0)
Hungary	542 (3.3)	83 (2.7)	542 (3.3)	83 (2.7)	0 (1.0)
Iran, Islamic Rep. of	421 (4.0)	103 (3.0)	421 (4.4)	102 (2.8)	0 (2.2)
Ireland	529 (2.4)	70 (2.0)	529 (2.6)	70 (1.5)	0 (1.5)
Italy	516 (2.6)	66 (1.3)	516 (2.6)	68 (1.4)	0 (1.5)
Japan	569 (1.8)	65 (1.0)	568 (2.0)	67 (1.2)	-1 (1.3)
Korea, Rep. of	589 (2.0)	62 (0.9)	589 (1.9)	63 (1.0)	0 (1.1)
Kuwait	337 (6.2)	126 (2.0)	340 (6.3)	124 (2.1)	3 (2.3)
Lithuania	528 (2.5)	69 (1.2)	528 (2.5)	70 (1.3)	0 (1.2)
Morocco	352 (4.7)	120 (2.7)	353 (4.6)	119 (2.5)	1 (1.6)
Netherlands	517 (2.7)	60 (1.3)	517 (2.4)	61 (1.2)	0 (1.6)
New Zealand	506 (2.7)	85 (1.6)	505 (2.4)	86 (1.6)	-1 (1.0)
Northern Ireland	520 (2.2)	70 (1.5)	519 (2.8)	71 (1.6)	-1 (1.6)
Norway (5)	538 (2.6)	63 (1.5)	537 (2.3)	63 (1.6)	0 (1.0)
Oman	431 (3.1)	119 (1.8)	432 (3.1)	119 (1.7)	1 (1.1)
Poland	547 (2.4)	69 (1.4)	548 (2.1)	70 (1.2)	1 (1.4)
Portugal	508 (2.2)	60 (1.0)	508 (2.1)	61 (1.0)	0 (0.7)
Qatar	436 (4.1)	111 (2.2)	437 (4.2)	111 (2.5)	1 (1.3)
Russian Federation	567 (3.2)	69 (1.9)	566 (3.0)	68 (2.0)	-1 (1.0)
Saudi Arabia	390 (4.9)	116 (2.9)	392 (4.7)	115 (2.6)	1 (1.7)
Serbia	525 (3.7)	81 (3.4)	524 (3.6)	82 (2.8)	-1 (1.2)
Singapore	590 (3.7)	85 (2.6)	591 (3.7)	85 (2.5)	1 (0.9)
Slovak Republic	520 (2.6)	85 (1.9)	520 (2.9)	86 (1.8)	-1 (1.2)

Linking error is the standard error associated with the difference. Standard errors are shown in parentheses.

Exhibit 12.23: Trend Linking Error for the paperTIMSS 2019 Grade 4 Science Scale (continued)

Country	TIMSS 2015 Published Results		TIMSS 2015 Re-Estimated Results		Difference (Linking Error)
	Mean	Standard Deviation	Mean	Standard Deviation	
Spain	518 (2.6)	69 (1.6)	518 (2.6)	70 (1.5)	0 (1.3)
Sweden	540 (3.6)	73 (2.5)	540 (3.3)	74 (2.5)	0 (1.5)
United Arab Emirates	451 (2.8)	121 (1.5)	452 (2.9)	120 (1.5)	1 (0.7)
United States	546 (2.2)	81 (1.2)	546 (2.3)	81 (1.4)	0 (0.5)
International Average	**506 (1.1)**	**80 (0.5)**	**506 (1.1)**	**81 (0.5)**	**0 (0.1)**

Exhibit 12.24: Trend Linking Error for the paperTIMSS 2019 Grade 8 Mathematics Scale

Country	TIMSS 2015 Published Results		TIMSS 2015 Re-Estimated Results		Difference (Linking Error)
	Mean	Standard Deviation	Mean	Standard Deviation	
Australia	505 (3.1)	82 (1.9)	505 (3.0)	83 (1.8)	0 (0.9)
Bahrain	454 (1.4)	80 (1.4)	453 (1.5)	80 (1.3)	0 (1.3)
Chile	427 (3.2)	80 (1.9)	427 (2.9)	80 (1.9)	0 (1.2)
Chinese Taipei	599 (2.4)	97 (1.7)	600 (2.5)	99 (1.7)	1 (0.8)
Egypt	392 (4.1)	99 (2.0)	392 (3.8)	97 (1.8)	0 (1.0)
England	518 (4.2)	80 (2.6)	518 (4.2)	81 (2.6)	0 (1.7)
Georgia	453 (3.4)	92 (1.7)	454 (3.8)	91 (2.3)	0 (1.2)
Hong Kong SAR	594 (4.6)	78 (2.8)	595 (4.7)	80 (2.7)	0 (0.8)
Hungary	514 (3.8)	93 (2.2)	514 (3.8)	94 (2.3)	0 (1.1)
Iran, Islamic Rep. of	436 (4.6)	94 (2.7)	436 (4.6)	94 (2.8)	-1 (1.8)
Ireland	523 (2.7)	74 (2.3)	523 (2.7)	74 (2.2)	-1 (1.0)
Israel	511 (4.1)	102 (2.3)	511 (4.1)	102 (2.2)	0 (0.6)
Italy	494 (2.5)	75 (1.8)	493 (2.5)	75 (1.5)	-1 (0.7)
Japan	586 (2.3)	89 (1.3)	587 (2.5)	89 (1.3)	0 (0.9)
Jordan	386 (3.2)	94 (1.7)	386 (3.2)	92 (1.5)	1 (0.9)
Korea, Rep. of	606 (2.6)	85 (1.1)	606 (2.8)	86 (1.4)	1 (1.3)
Kuwait	392 (4.6)	91 (3.3)	393 (4.5)	90 (3.2)	0 (1.7)
Lebanon	442 (3.6)	75 (1.7)	442 (3.8)	75 (1.9)	-1 (1.2)
Lithuania	511 (2.8)	77 (1.5)	511 (2.9)	79 (1.8)	-1 (1.1)
Malaysia	465 (3.6)	87 (2.1)	465 (3.5)	87 (1.9)	-1 (0.6)
Morocco	384 (2.3)	80 (1.3)	384 (2.1)	79 (1.3)	0 (0.6)
New Zealand	493 (3.4)	88 (2.0)	493 (3.3)	88 (1.9)	0 (0.8)
Norway (9)	512 (2.3)	70 (1.2)	512 (2.2)	70 (1.1)	0 (0.7)
Oman	403 (2.4)	96 (1.3)	403 (2.6)	94 (1.6)	0 (1.3)
Qatar	437 (3.0)	102 (2.2)	437 (2.8)	102 (1.8)	0 (1.2)
Russian Federation	538 (4.7)	82 (1.8)	537 (4.8)	83 (1.8)	-1 (1.2)
Saudi Arabia	368 (4.6)	86 (2.9)	368 (4.2)	85 (2.7)	0 (2.4)
Singapore	621 (3.2)	82 (2.2)	622 (3.3)	83 (2.3)	1 (0.7)
South Africa (9)	372 (4.5)	87 (3.0)	373 (4.5)	85 (3.1)	1 (0.8)
Sweden	501 (2.8)	72 (1.9)	501 (2.8)	72 (1.5)	0 (1.1)
Turkey	458 (4.7)	105 (2.8)	458 (4.5)	105 (2.2)	0 (1.4)
United Arab Emirates	465 (2.0)	98 (1.5)	464 (2.0)	97 (1.5)	0 (0.6)
United States	518 (3.1)	83 (1.6)	518 (3.1)	84 (1.6)	0 (0.6)
International Average	**481 (0.7)**	**87 (0.7)**	**481 (0.7)**	**87 (0.7)**	**0 (0.1)**

Linking error is the standard error associated with the difference. Standard errors are shown in parentheses.

Exhibit 12.25: Trend Linking Error for the paperTIMSS 2019 Grade 8 Science Scale

Country	TIMSS 2015 Published Results		TIMSS 2015 Re-Estimated Results		Difference (Linking Error)
	Mean	Standard Deviation	Mean	Standard Deviation	
Australia	512 (2.7)	82 (1.5)	512 (2.6)	82 (1.6)	0 (0.8)
Bahrain	466 (2.2)	106 (1.8)	466 (2.1)	105 (1.7)	1 (1.2)
Chile	454 (3.1)	81 (1.5)	454 (3.1)	81 (1.5)	0 (1.1)
Chinese Taipei	569 (2.1)	83 (1.2)	570 (2.1)	84 (1.3)	0 (1.1)
Egypt	371 (4.3)	115 (1.9)	371 (4.4)	113 (2.0)	0 (1.2)
England	537 (3.8)	81 (2.3)	537 (3.8)	82 (2.2)	0 (0.9)
Georgia	443 (3.1)	87 (1.7)	443 (3.1)	87 (1.6)	0 (2.4)
Hong Kong SAR	546 (3.9)	72 (2.2)	546 (3.9)	72 (2.3)	0 (0.8)
Hungary	527 (3.4)	85 (2.3)	526 (3.5)	86 (2.2)	-1 (1.6)
Iran, Islamic Rep. of	456 (4.0)	89 (2.3)	456 (4.0)	90 (2.4)	-1 (1.2)
Ireland	530 (2.8)	80 (2.5)	530 (2.9)	81 (2.5)	0 (0.8)
Israel	507 (3.9)	104 (2.5)	506 (3.9)	105 (2.3)	-1 (0.8)
Italy	499 (2.4)	76 (1.7)	499 (2.4)	76 (1.6)	0 (1.4)
Japan	571 (1.8)	75 (1.3)	571 (1.8)	76 (1.1)	0 (0.8)
Jordan	426 (3.4)	101 (2.1)	426 (3.2)	101 (2.2)	0 (1.2)
Korea, Rep. of	556 (2.2)	78 (1.1)	556 (2.1)	78 (1.0)	0 (1.1)
Kuwait	411 (5.2)	110 (3.7)	411 (5.3)	110 (3.6)	0 (1.8)
Lebanon	398 (5.3)	102 (2.6)	398 (5.6)	102 (3.0)	-1 (1.5)
Lithuania	519 (2.8)	78 (1.8)	518 (2.7)	77 (1.6)	-1 (1.0)
Malaysia	471 (4.1)	94 (2.7)	471 (4.1)	93 (2.7)	0 (1.0)
Morocco	393 (2.5)	84 (1.4)	393 (2.3)	83 (1.2)	0 (0.8)
New Zealand	513 (3.1)	90 (1.9)	512 (3.3)	91 (1.8)	0 (1.1)
Norway (9)	509 (2.8)	78 (1.6)	508 (2.8)	79 (1.4)	0 (1.1)
Oman	455 (2.7)	98 (1.6)	455 (2.6)	98 (1.9)	0 (0.8)
Qatar	457 (3.0)	112 (2.0)	457 (3.0)	112 (2.3)	0 (1.1)
Russian Federation	544 (4.2)	77 (1.9)	544 (4.2)	78 (2.1)	0 (0.9)
Saudi Arabia	396 (4.5)	98 (2.7)	396 (4.6)	97 (2.7)	0 (1.5)
Singapore	597 (3.2)	86 (2.3)	597 (3.3)	88 (2.3)	1 (0.8)
South Africa (9)	358 (5.6)	108 (3.6)	361 (5.7)	106 (3.6)	3 (1.2) ▲
Sweden	522 (3.4)	86 (2.4)	522 (3.4)	86 (2.2)	0 (1.2)
Turkey	493 (4.0)	96 (2.0)	493 (4.0)	97 (2.0)	-1 (1.1)
United Arab Emirates	477 (2.3)	105 (1.6)	477 (2.3)	106 (1.7)	0 (0.9)
United States	530 (2.8)	82 (1.4)	530 (2.8)	82 (1.4)	0 (0.7)
International Average	**485 (0.9)**	**90 (0.7)**	**485 (0.9)**	**90 (0.6)**	**0 (0.1)**

▲ statistically significant difference

Linking error is the standard error associated with the difference. Standard errors are shown in parentheses.

Scaling the Fourth Grade Less Difficult Mathematics Data

All 11 countries that participated in the TIMSS 2019 less difficult mathematics assessment required additional item calibration models to estimate appropriate item parameters and plausible values on the TIMSS trend scales. By its very nature, the less difficult mathematics assessment and the pool of countries that participated required special consideration. Although there were four mathematics item blocks shared with the regular fourth grade mathematics assessment, they proved to be more challenging to students than expected, and solely relying on these four blocks did not produce precise achievement results. Instead, linking the TIMSS 2019 less difficult mathematics assessment by including the data from the TIMSS Numeracy 2015 assessment provided a stronger design with eight shared mathematics item blocks. Item parameters were estimated using the concurrent calibration approach as described for paperTIMSS above, combining TIMSS Numeracy 2015 data from 7 countries and TIMSS 2019 less difficult mathematics data from 11 countries. Exhibit 12.26 shows the number of mathematics items present for the TIMSS 2019 less difficult mathematics concurrent calibration by item type and mathematics content and cognitive domain.

Exhibit 12.26: Mathematics Items for the TIMSS 2019 Grade 4 Less Difficult Concurrent Calibration

Item Type	Points	Items Released in 2015		Items Common in 2015 and 2019		Items Introduced in 2019		Total	
		Items	Points	Items	Points	Items	Points	Items	Points
Multiple Choice	1	11	11	45	45	35	35	91	91
Constructed Response	1	12	12	50	50	34	34	96	96
	2	1	2	5	10	8	16	14	28
Total		**24**	**25**	**100**	**105**	**77**	**85**	**201**	**215**

Items by Content and Cognitive Domains

Mathematics Content Domains	Items Released in 2015		Items Common in 2015 and 2019		Items Introduced in 2019		Total	
	Items	Points	Items	Points	Items	Points	Items	Points
Number	15	16	60	61	36	39	111	116
Measurement and Geometry	8	8	29	32	21	22	58	62
Data	1	1	11	12	20	24	32	37

Mathematics Cognitive Domains	Items Released in 2015		Items Common in 2015 and 2019		Items Introduced in 2019		Total	
	Items	Points	Items	Points	Items	Points	Items	Points
Knowing	10	11	52	52	27	28	89	91
Applying	11	11	34	35	32	37	77	83
Reasoning	3	3	14	18	18	20	35	41
Total	**24**	**25**	**100**	**105**	**77**	**85**	**201**	**215**

The fourth grade science assessment administered to these countries did not have a counterpart in the TIMSS Numeracy 2015 administration. Consequently, the scaling approach adopted for the science data relied entirely on the TIMSS 2019 data with fixed item parameters for trend items, as estimated from the regular fourth grade science item calibration, and allowing item parameters for the new science items to be estimated appropriately based on the 11 countries that participated in the less difficult assessment. Exhibit 12.27 shows the number of science items present for the TIMSS 2019 less difficult calibration by item type and science content and cognitive domain.

Exhibit 12.27: Science Items for the TIMSS 2019 Grade 4 Less Difficult Calibration

Item Type	Points	Trend Items		New Items		Total	
		Items	Points	Items	Points	Items	Points
Multiple Choice	1	47	47	40	40	87	87
Constructed Response	1	45	45	31	31	76	76
	2	3	6	2	4	5	10
Total		**95**	**98**	**73**	**75**	**168**	**173**

Items by Content and Cognitive Domains

Science Content Domains	Trend Items		New Items		Total	
	Items	Points	Items	Points	Items	Points
Life Science	41	43	32	34	73	77
Physical Science	36	37	25	25	61	62
Earth Science	18	18	16	16	34	34

Science Cognitive Domains	Trend Items		New Items		Total	
	Items	Points	Items	Points	Items	Points
Knowing	40	43	29	30	69	73
Applying	34	34	30	30	64	64
Reasoning	21	21	14	15	35	36
Total	**95**	**98**	**73**	**75**	**168**	**173**

Exhibit 12.28 shows the sample sizes for scaling the TIMSS 2019 less difficult data, both for item calibration and for proficiency estimation. The mathematics concurrent calibration made use of all TIMSS 2019 data from 11 participating countries and 61,884 students, as well as all the TIMSS Numeracy 2015 data from 7 participating countries and 40,684 students. Three countries participated in both assessments—Kuwait, Morocco, and South Africa. The science calibration made use of the TIMSS 2019 data only.

Exhibit 12.28: Sample Sizes for Scaling the TIMSS 2019 Less Difficult Data

Country	Item Calibration & Proficiency Estimation	
	2019	TIMSS Numeracy 2015
Albania	4,426	—
Bahrain	—	4,429
Bosnia and Herzegovina	5,617	—
Indonesia	—	4,294
Iran, Islamic Rep. of	—	4,105
Jordan	—	7,861
Kosovo	4,496	—
Kuwait	4,437	3,703
Montenegro	5,076	—
Morocco	7,723	5,360
North Macedonia	3,270	—
Pakistan	3,980	—
Philippines	5,515	—
Saudi Arabia	5,453	—
South Africa (5)	11,891	10,932
TOTAL	**61,884**	**40,684**

The item parameters estimated from the TIMSS 2019 less difficult calibrations for mathematics and science are presented in Appendices 12E and 12F, respectively. Appendices 12E and 12F also include the RMSD values computed to measure item-model fit. These item parameters we used to estimate student proficiency in both mathematics and science for all countries participating in the TIMSS 2019 less difficult assessment. They also were used to re-estimate student mathematics proficiency in TIMSS Numeracy 2015 for the countries that participated in that assessment, which was necessary to set the linear transformation that placed the TIMSS 2019 less difficult mathematics proficiency results on the TIMSS fourth grade mathematics trend scale.

Scaling the TIMSS 2019 less difficult assessment also required conditioning to enhance the reliability of student plausible values using student and parent context variables, as described for paperTIMSS earlier. Exhibit 12.29 provides details on the conditioning models used for proficiency estimation of the TIMSS 2019 less difficult data. The conditioning models for the 2015 data were relevant only for estimating mathematics proficiency for the TIMSS Numeracy 2015 data.

Exhibit 12.29: Conditioning Models for the TIMSS 2019 Less Difficult Data

Country	2019				TIMSS Numeracy 2015			
	Number of Primary Conditioning Variables	Number of Principal Components Available	Number of Principal Components Retained	Percentage of Variance Explained	Number of Primary Conditioning Variables	Number of Principal Components Available	Number of Principal Components Retained	Percentage of Variance Explained
Albania	2	557	221	81	—	—	—	—
Bahrain	—	—	—	—	3	637	221	77
Bosnia and Herzegovina	4	551	280	89	—	—	—	—
Indonesia	—	—	—	—	2	617	214	76
Iran, Islamic Rep. of	—	—	—	—	2	637	205	75
Jordan	—	—	—	—	2	637	334	90
Kosovo	2	557	224	81	—	—	—	—
Kuwait	3	539	221	80	3	629	185	72
Montenegro	2	563	253	85	—	—	—	—
Morocco	2	563	310	90	2	637	268	82
North Macedonia	3	563	163	72	—	—	—	—
Pakistan	4	563	199	80	—	—	—	—
Philippines	2	559	275	85	—	—	—	—
Saudi Arabia	3	557	272	85	—	—	—	—
South Africa (5)	3	563	320	90	3	533	301	90

Estimating fourth grade mathematics proficiency and science proficiency for the TIMSS 2019 less difficult data followed the same approach as the paperTIMSS 2019 fourth grade data described earlier, incorporating the TIMSS 2019 less difficult response data, item parameters, and conditioning models. A two-dimensional MGROUP model was used to estimate simultaneously overall mathematics proficiency and overall science proficiency. The same fourth grade multi-dimensional MGROUP models described for paperTIMSS were used to estimate proficiency in the fourth grade mathematics and science content and cognitive domains.

With respect to the TIMSS 2019 less difficult mathematics assessment, the item parameters estimated at the concurrent calibration stage also were used to generate mathematics plausible values for the TIMSS Numeracy 2015 assessment data. These TIMSS 2015 plausible values were used to establish the linear transformation necessary to place the TIMSS 2019 less difficult mathematics data on the appropriate TIMSS fourth grade mathematics trend scale. Setting this linear transformation was done in the same manner described earlier in equations (12.1) through (12.3). It required aligning the re-estimated TIMSS Numeracy 2015 student ability distribution with the TIMSS Numeracy 2015 ability distribution that was estimated and published back in 2015. This linear transformation was then applied to the TIMSS 2019 less difficult mathematics proficiency plausible values to place them on the TIMSS fourth grade mathematics trend scale. Exhibit 12.30 shows the transformation constants for the TIMSS 2019 less difficult mathematics assessment.

Exhibit 12.30: Transformation Constants for the TIMSS 2019 Less Difficult Mathematics Data

Less Difficult Mathematics	TIMSS Numeracy 2015 Published Scores		TIMSS Numeracy 2015 Re-scaled Scores		A_{ik}	B_{ik}
	Mean	Standard Deviation	Mean	Standard Deviation		
PV1	398.74801	105.35161	-0.05006	0.92525	404.44767	113.86313
PV2	398.36696	105.67865	-0.05089	0.92905	404.15595	113.74883
PV3	400.00943	104.28663	-0.04945	0.92667	405.57442	112.53916
PV4	398.59399	105.37049	-0.04897	0.92428	404.17690	114.00325
PV5	398.38464	105.37384	-0.04913	0.92296	403.99395	114.16995

No additional linear transformation was required for the fourth grade science data from the TIMSS 2019 less difficult assessment. Because of the fixed item parameter scaling approach applied to the science data, the regular TIMSS 2019 fourth grade science linear transformation constants shown in the science panel of Exhibit 12.12 were used to place the science plausible values of the TIMSS 2019 less difficult assessment on the TIMSS 2019 fourth grade science trend scale.

Scaling the eTIMSS Data

The main objective in this third phase of the scaling effort was to derive TIMSS 2019 student plausible values from the eTIMSS assessment data, suitable for reporting and publication, adjusting for any mode effect between the two assessment modes (see Chapter 11). The eTIMSS data and bridge data from the eTIMSS 2019 trend countries were submitted to a series of calibration models to estimate TIMSS 2019 student proficiency results from the eTIMSS assessment data relying on group equivalence between the eTIMSS and bridge samples and the presence of comparable items, that is, items that functioned equivalently under both modes of administration. Chapter 11 provides the conceptual framework and describes the models implemented and described in this section to address the presence of a mode effect.

Exhibits 12.31 through 12.34 show the numbers of items present in the eTIMSS 2019 calibrations by item type and content and cognitive domains for both grades and subjects. The bridge data consist of the paperTIMSS trend items. Consequently, the numbers for bridge items in Exhibits 12.31 through 12.34 match the numbers of trend items shown in Exhibits 12.3 through 12.6, respectively. They also match the numbers of eTIMSS trend items in their respective exhibits, with the exception of eighth grade science since one eTIMSS trend item (SE52134) was removed from scaling because it did not have suitable psychometric properties in its digital form (see Appendix 10E).

Exhibit 12.31: Mathematics Items for the eTIMSS 2019 Calibration—Grade 4

Item Type	Points	Bridge Items		eTIMSS Items					
				Trend		New		Total	
		Items	Points	Items	Points	Items	Points	Items	Points
Multiple Choice	1	42	42	42	42	26	26	68	68
Constructed Response	1	45	45	45	45	46	46	91	91
	2	5	10	5	10	7	14	12	24
Total		**92**	**97**	**92**	**97**	**79**	**86**	**171**	**183**

Items by Content and Cognitive Domains

Mathematics Content Domains	Bridge Items		eTIMSS Items					
			Trend		New		Total	
	Items	Points	Items	Points	Items	Points	Items	Points
Number	55	59	55	59	28	29	83	88
Measurement and Geometry	26	27	26	27	26	29	52	56
Data	11	11	11	11	25	28	36	39

Mathematics Cognitive Domains	Bridge Items		eTIMSS Items					
			Trend		New		Total	
	Items	Points	Items	Points	Items	Points	Items	Points
Knowing	34	34	34	34	25	25	59	59
Applying	40	42	40	42	34	38	74	80
Reasoning	18	21	18	21	20	23	38	44
Total	**92**	**97**	**92**	**97**	**79**	**86**	**171**	**183**

Exhibit 12.32: Science Items for the eTIMSS 2019 Calibration—Grade 4

Item Type	Points	Bridge Items		eTIMSS Items					
				Trend		New		Total	
		Items	Points	Items	Points	Items	Points	Items	Points
Multiple Choice	1	47	47	47	47	41	41	88	88
Constructed Response	1	45	45	45	45	31	31	76	76
	2	3	6	3	6	2	4	5	10
Total		**95**	**98**	**95**	**98**	**74**	**76**	**169**	**174**

Items by Content and Cognitive Domains

Science Content Domains	Bridge Items		eTIMSS Items					
			Trend		New		Total	
	Items	Points	Items	Points	Items	Points	Items	Points
Life Science	41	43	41	43	32	34	73	77
Physical Science	36	37	36	37	25	25	61	62
Earth Science	18	18	18	18	17	17	35	35

Science Cognitive Domains	Bridge Items		eTIMSS Items					
			Trend		New		Total	
	Items	Points	Items	Points	Items	Points	Items	Points
Knowing	40	43	40	43	29	30	69	73
Applying	34	34	34	34	30	30	64	64
Reasoning	21	21	21	21	15	16	36	37
Total	**95**	**98**	**95**	**98**	**74**	**76**	**169**	**174**

Exhibit 12.33: Mathematics Items for the eTIMSS 2019 Calibration—Grade 8

Item Type	Points	Bridge Items		eTIMSS Items					
				Trend		New		Total	
		Items	Points	Items	Points	Items	Points	Items	Points
Multiple Choice	1	62	62	62	62	28	28	90	90
Constructed Response	1	46	46	46	46	59	59	105	105
	2	6	12	6	12	5	10	11	22
Total		**114**	**120**	**114**	**120**	**92**	**97**	**206**	**217**

Items by Content and Cognitive Domains

Mathematics Content Domains	Bridge Items		eTIMSS Items					
			Trend		New		Total	
	Items	Points	Items	Points	Items	Points	Items	Points
Number	36	37	36	37	27	29	63	66
Algebra	30	31	30	31	31	31	61	62
Geometry	25	28	25	28	18	21	43	49
Data and Probability	23	24	23	24	16	16	39	40

Mathematics Cognitive Domains	Bridge Items		eTIMSS Items					
			Trend		New		Total	
	Items	Points	Items	Points	Items	Points	Items	Points
Knowing	35	35	35	35	29	31	64	66
Applying	57	60	57	60	39	39	96	99
Reasoning	22	25	22	25	24	27	46	52
Total	**114**	**120**	**114**	**120**	**92**	**97**	**206**	**217**

Exhibit 12.34: Science Items for the eTIMSS 2019 Calibration—Grade 8

Item Type	Points	Bridge Items		eTIMSS Items					
				Trend		New		Total	
		Items	Points	Items	Points	Items	Points	Items	Points
Multiple Choice	1	59	59	58	58	49	49	107	107
Constructed Response	1	48	48	48	48	34	34	82	82
	2	11	22	11	22	11	22	22	44
Total		**118**	**129**	**117**	**128**	**94**	**105**	**211**	**233**

Items by Content and Cognitive Domains

Science Content Domains	Bridge Items		eTIMSS Items					
			Trend		New		Total	
	Items	Points	Items	Points	Items	Points	Items	Points
Biology	39	48	39	48	36	41	75	89
Chemistry	22	23	21	22	21	24	42	46
Physics	30	30	30	30	22	24	52	54
Earth Science	27	28	27	28	15	16	42	44

Science Cognitive Domains	Bridge Items		eTIMSS Items					
			Trend		New		Total	
	Items	Points	Items	Points	Items	Points	Items	Points
Knowing	43	48	42	47	33	34	75	81
Applying	44	48	44	48	36	44	80	92
Reasoning	31	33	31	33	25	27	56	60
Total	**118**	**129**	**117**	**128**	**94**	**105**	**211**	**233**

Exhibit 12.35 shows the sample sizes for scaling the fourth grade eTIMSS 2019 and bridge data, both for item calibration and for proficiency estimation. Twenty-seven countries contributed bridge and eTIMSS data to the item calibration and 30 countries and 6 benchmarking participants were included in proficiency estimation. Although Austria was not a trend country and did not contribute to the fourth grade paperTIMSS concurrent calibration, they administered the bridge booklets and thus were included in the fourth grade eTIMSS 2019 item calibration.

Exhibit 12.35: Sample Sizes for Scaling the eTIMSS 2019 Grade 4 Data

Country	Item Calibration		Proficiency Estimation	
	eTIMSS	Bridge	eTIMSS	Bridge
Austria	4,464	1,964	4,464	1,964
Canada	13,653	1,604	13,653	1,604
Chile	4,174	1,612	4,174	1,612
Chinese Taipei	3,765	1,663	3,765	1,663
Croatia	3,785	1,472	3,785	1,472
Czech Republic	4,692	2,030	4,692	2,030
Denmark	3,227	1,432	3,227	1,432
England	3,396	1,242	3,396	1,242
Finland	4,730	1,983	4,730	1,983
France	4,186	1,948	4,186	1,948
Georgia	3,787	1,632	3,787	1,632
Germany	3,437	1,505	3,437	1,505
Hong Kong SAR	—	—	2,968	1,329
Hungary	4,571	1,778	4,571	1,778
Italy	3,741	1,921	3,741	1,921
Korea, Rep. of	3,893	1,541	3,893	1,541
Lithuania	3,741	1,587	3,741	1,587
Malta	—	—	3,630	—
Netherlands	3,355	1,295	3,355	1,295
Norway (5)	3,951	1,899	3,951	1,899
Portugal	4,300	1,612	4,300	1,612
Qatar	4,933	1,486	4,933	1,486
Russian Federation	4,022	2,128	4,022	2,128
Singapore	5,986	1,881	5,986	1,881
Slovak Republic	4,247	1,610	4,247	1,610
Spain	9,555	1,670	9,555	1,670
Sweden	3,965	1,697	3,965	1,697
Turkey (5)	—	—	4,028	—
United Arab Emirates	25,834	2,243	25,834	2,243
United States	8,776	1,652	8,776	1,652
Benchmarking Participants				
Ontario, Canada	—	—	3,830	—
Quebec, Canada	—	—	3,837	—
Moscow City, Russian Fed.	—	—	3,843	—
Madrid, Spain	—	—	3,390	—
Abu Dhabi, UAE	—	—	9,037	—
Dubai, UAE	—	—	7,265	—
TOTAL	**152,166**	**46,087**	**193,994**	**47,416**

Exhibit 12.36 shows the sample sizes for scaling the eighth grade eTIMSS 2019 and bridge data, both for item calibration and for proficiency estimation. Eighteen countries contributed bridge and eTIMSS data to the item calibration and 22 countries and 5 benchmarking participants were included in proficiency estimation.

Hong Kong SAR, despite being a trend country and having administered the bridge booklets, was excluded from the eTIMSS item calibration at both grades due to inconsistent mode differences at both grades and subjects. The response differences in Hong Kong SAR were more pronounced for science at both grades, particularly at the eighth grade, which ran counter to the general pattern of other eTIMSS countries where mathematics showed larger mode differences (see Exhibit 13.6 in Chapter 13).

Exhibit 12.36: Sample Sizes for Scaling the eTIMSS 2019 Grade 8 Data

Country	Item Calibration		Proficiency Estimation	
	eTIMSS	Bridge	eTIMSS	Bridge
Chile	4,115	1,526	4,115	1,526
Chinese Taipei	4,915	1,578	4,915	1,578
England	3,365	1,592	3,365	1,592
Finland	—	—	4,874	—
France	—	—	3,874	—
Georgia	3,315	1,314	3,315	1,314
Hong Kong SAR	—	—	3,265	1,423
Hungary	4,569	1,751	4,569	1,751
Israel	3,731	1,863	3,731	1,863
Italy	3,619	2,032	3,619	2,032
Korea, Rep. of	3,861	1,693	3,861	1,693
Lithuania	3,826	1,687	3,826	1,687
Malaysia	7,065	1,560	7,065	1,560
Norway (9)	4,575	2,018	4,575	2,018
Portugal	—	—	3,377	—
Qatar	3,884	1,490	3,884	1,490
Russian Federation	3,901	2,083	3,901	2,083
Singapore	4,853	1,871	4,853	1,871
Sweden	3,996	1,582	3,996	1,582
Turkey	4,077	1,819	4,077	1,819
United Arab Emirates	22,334	2,089	22,334	2,089
United States	8,698	1,484	8,698	1,484
Benchmarking Participants				
Ontario, Canada	—	—	3,776	—
Quebec, Canada	—	—	3,178	—
Moscow City, Russian Fed.	—	—	3,783	—
Abu Dhabi, UAE	—	—	8,204	—
Dubai, UAE	—	—	5,728	—
TOTAL	**98,699**	**31,032**	**138,758**	**32,455**

Identifying Invariant Items

As described earlier, an item equivalence study was carried out before the TIMSS 2019 assessment (Fishbein et al., 2018). This study led to the expectation that around 80 percent of the trend items could be considered comparable in terms of presentation and item content. That is, a large proportion of trend items, after being adapted to the digital interface for computer delivery, were from a visual and response requirement perspective deemed comparable to their paper counterpart. To confirm this comparability assessment, the starting point for scaling the eTIMSS 2019 data was the application of an interim item calibration model that made no assumption about the presence of a difference in mode of administration, thus relying exclusively on the group equivalence between the eTIMSS and bridge samples (see Chapter 9 for information about the samples). Combining eTIMSS and bridge data from all eTIMSS trend countries, item parameters were estimated for all eTIMSS 2019 items and then compared to their paperTIMSS counterparts. This "full non-invariance model" served as a baseline to provide statistical evidence of item equivalence, or invariance, between both modes of administration.

From the outset, many TIMSS 2019 items were expected to have similar behavior in both modes of administration based on the item equivalence study, in particular trend items that had been designed for paper-based administration in past TIMSS assessments. Some of the new eTIMSS 2019 items designed to capitalize on the digital environment of computer-based assessments were not expected to behave the same (Fishbein et al., 2018). Extensive analyses of item percent correct statistics and IRT parameters between eTIMSS and paperTIMSS, as well as RMSD statistics for the difference between paperTIMSS and eTIMSS ICC curves determined that three response input types showed more similarity in psychometric properties between modes and could be further analyzed for item equivalence. Consequently, the identification of equivalent or invariant items focused on the three major item types whose student responses were expected to be similar in both modes of administration based on detailed examination of items: traditional multiple-choice items, keyboard items, and number pad items.

Finalizing the groups of equivalent items was achieved, first, by using a modified version of the Root Mean Square Difference (RMSD) statistic, as described earlier. In the context of the full non-invariance model, the RMSD statistic measured the difference between an item's two empirical item characteristic curves, one based on the paperTIMSS item response data (including bridge for trend items) and the other based on the eTIMSS item response data. Appendices 12G through 12J show the item parameters estimated by the full non-invariance model for all eTIMSS items at both grades and both subjects, including the RMSD statistic for quantifying item invariance.[4] Items from the three major item types with RMSD values less than 0.1 were deemed suitable to serve as anchor items between modes.

All other items, including items with other input types (e.g., not multiple-choice, keyboard, or number pad), were left as non-equivalent items to have item parameters freely estimated in the final model.

4 The bridge item parameters are not presented in these Appendices since they were identical to the item parameters shown in Appendices 12A through 12D, respectively, for paperTIMSS trend items.

The group of equivalent items was further refined after estimating the adjusted model described below, where equivalent items had item parameters fixed to equal the paperTIMSS item parameters adjusted by a constant. After running the adjusted model, RMSD statistics for the fit of the empirical eTIMSS ICC curve to the theoretical eTIMSS ICC curve were examined. Any equivalent items with an RMSD greater than 0.1 were made non-equivalent for the subsequent model, so that, consistent with paperTIMSS, all eTIMSS items had good fit.

At the fourth grade, the full non-invariance model and resulting RMSD statistics identified 124 of 171 mathematics items as invariant. The results of the first adjusted model identified one item as having poor fit, resulting in 123 invariant items. In science, the full non-invariance model identified 148 of 169 items as invariant. The results of the first adjusted model identified one item as having poor fit, resulting in 147 invariant items. At the eighth grade, the full non-invariance model identified 170 of 206 mathematics items and 185 of 211 science items as invariant. In eighth grade mathematics, the first adjusted model identified three items as having poor model fit, resulting in 167 invariant items in the final model. In science, the adjusted model was estimated twice to finalize the invariant items—the first identified five poorly fitting items and the second identified two additional, resulting in 178 invariant items in the final model.

Exhibit 12.37 shows the numbers of equivalent and non-equivalent items in the final calibration models. The percentage of equivalent eTIMSS items ranged from 72 to 87 percent across fourth and eighth grades for mathematics and science. As could be anticipated, somewhat higher percentages of eTIMSS trend items were equivalent—ranging from 80 to 91 percent. Having a substantial percentage of equivalent items between paperTIMSS and eTIMSS strengthened the validity and interpretability of achievement results based on linking the two modes utilizing equivalent items as anchor, and estimating the mode adjustment based on the equivalence of the samples prior to mode assignment.

Exhibit 12.37: eTIMSS 2019 Achievement Items by Equivalence Classification

eTIMSS 2019 Fourth Grade Item Equivalence

Item Type		Mathematics			Science		
		Trend	New	Total	Trend	New	Total
Equivalent Items	Multiple Choice Items	41	24	65	47	39	86
	Keyboard Items	3	3	6	39	22	61
	Number Pad Items	30	22	52	—	—	—
All Equivalent Items		**74**	**49**	**123**	**86**	**61**	**147**
All Non–Equivalent Items		**18**	**30**	**48**	**9**	**13**	**22**
All Items		**92**	**79**	**171**	**95**	**74**	**169**
Percentage of Equivalent Items		**80%**	**62%**	**72%**	**91%**	**82%**	**87%**

eTIMSS 2019 Eighth Grade Item Equivalence

Item Type		Mathematics			Science		
		Trend	New	Total	Trend	New	Total
Equivalent Items	Multiple Choice Items	60	26	86	58	44	102
	Keyboard Items	9	10	19	47	26	73
	Number Pad Items	33	29	62	2	1	3
All Equivalent Items		**102**	**65**	**167**	**107**	**71**	**178**
All Non–Equivalent Items		**12**	**27**	**39**	**10**	**23**	**33**
All Items		**114**	**92**	**206**	**117**	**94**	**211**
Percentage of Equivalent Items		**89%**	**71%**	**81%**	**91%**	**76%**	**84%**

Estimating International Mode Effect Parameters for Equivalent Items

Dealing effectively with the two modes of administration in TIMSS 2019 required applying an overall mode adjustment constant to the difficulty parameter of invariant eTIMSS items. An extensive examination of percent correct statistics of paper bridge and eTIMSS trend items revealed there was a small but significant average international difference favoring paper bridge in each subject at both grades, with a smaller difference in science than mathematics (see Exhibit 13.6 in Chapter 13). These observed international mode differences required accounting for in the eTIMSS achievement results using an international adjustment of the invariant item parameters. While non-invariant eTIMSS items had distinct item parameters estimated for them, invariant items inherited the item parameters of their paperTIMSS counterparts with their location, or difficulty, parameter shifted by an international mode effect parameter to account for the average international difference (the international mode effect) between the paper and eTIMSS versions. Chapter 11 provides a description of how this adjustment is based on a simple extension of IRT models that utilizes the features of customary IRT linking methods.

Estimating an international mode effect parameter for each grade and subject was done using a weighted mean mode transformation. Simply stated, this adjustment parameter is the difference of the mean location parameters between the paper-based and computer-based versions of the eTIMSS items that were deemed invariant. The weighting factor assigned to each invariant eTIMSS item was the amount of information present in the two location parameters, quantified by the inverse of the two location parameter estimation error variances.

For each grade and subject combination, the international mode effect parameter δ_m was estimated over all invariant items ($i = 1, \ldots, N$) as follows:

$$\delta_m = \frac{\sum_{i=1}^{N} w_i \left(b_{eT,i} - b_{pT,i} \right)}{\sum_{i=1}^{N} w_i} \tag{12.4}$$

where

$b_{eT,i}$ is the estimated computer-based location parameter for invariant item i;

$b_{pT,i}$ is the estimated paper-based location parameter for invariant item i;

and the weight factor w_i is as follows:

$$w_i = \frac{1}{SD\left(b_{eT,i}\right)^2 + SD\left(b_{pT,i}\right)^2} \tag{12.5}$$

where

SD($b_{eT,i}$) is the estimated standard deviation of the computer-based location parameter for invariant item i; and

SD($b_{pT,i}$) is the estimated standard deviation of the paper-based location parameter for invariant item i.

Thus, the shifted location parameter b_i^* for invariant item i was calculated as follows:

$$b_i^* = b_i + \delta_m \tag{12.6}$$

Exhibit 12.38 shows the four estimated international mode effect parameters. The paper-based location parameters and their standard deviations were estimated from the paperTIMSS concurrent calibrations and are shown in Appendices 12A through 12D. The computer-based location parameters and their standard deviations were estimated from the eTIMSS full non-invariance calibration models and are shown in Appendices 12G through 12J.

Exhibit 12.38: eTIMSS 2019 Estimated International Mode Effect Parameters

		Mode Effect Parameter
Grade 4	Mathematics	0.09342
	Science	0.05894
Grade 8	Mathematics	0.10983
	Science	0.06766

eTIMSS 2019 Final Item Calibration

In the final eTIMSS 2019 item calibration models, which combined bridge and eTIMSS data, item parameters for the bridge items were fixed at their values from the paperTIMSS concurrent calibrations. Item parameters for eTIMSS items found to be invariant also were fixed at the values of their paperTIMSS counterparts with an additional international mode effect parameter estimated for each grade and subject added to the location parameters as shown in equation (12.6). Finally, item parameters for the remaining eTIMSS items—found to be non-invariant, i.e., affected by mode differences—were estimated freely. Appendices 12K through 12N show the item parameters for all eTIMSS 2019 items based on the final calibration models. These appendices include RMSD statistics to quantify model fit. All RMSD values are less than 0.10, the vast majority are less than 0.05, indicating good model fit.

Generating Plausible Values for the eTIMSS Data

Estimating student plausible values for the eTIMSS 2019 data followed the same general approach as for the paperTIMSS 2019 data. Conditioning was used to enhance the psychometric properties of student plausible values using student and parent context variables, as described for paperTIMSS earlier. Exhibits 12.39 and 12.40 provide details on the conditioning models used for proficiency estimation at the fourth grade and eighth grade, respectively.

Exhibit 12.39: Conditioning Models for the eTIMSS 2019 Grade 4 Data

Country	eTIMSS 2019			
	Number of Primary Conditioning Variables	Number of Principal Components Available	Number of Principal Components Retained	Percentage of Variance Explained
Austria	2	618	223	79
Canada	5	605	314	90
Chile	2	598	208	76
Chinese Taipei	2	622	188	75
Croatia	2	619	189	76
Czech Republic	2	618	234	82
Denmark	2	614	161	71
England	2	389	169	83
Finland	3	622	236	82
France	2	623	209	77
Georgia	2	620	189	73
Germany	2	623	171	73
Hong Kong SAR	3	623	148	69
Hungary	2	599	228	80
Italy	2	617	187	72
Korea, Rep. of	2	613	194	77
Lithuania	4	608	187	74
Malta	2	603	181	71
Netherlands	2	383	167	82
Norway (5)	4	543	197	80
Portugal	2	623	215	77
Qatar	3	622	246	81
Russian Federation	2	597	201	76
Singapore	2	599	299	90
Slovak Republic	3	623	212	77
Spain	6	616	317	90
Sweden	2	597	198	77
Turkey (5)	2	599	201	76
United Arab Emirates	5	623	326	90
United States	10	387	220	90
Benchmarking Participants				
Ontario, Canada	3	604	191	76
Quebec, Canada	3	605	191	76
Moscow City, Russian Fed.	2	591	192	75
Madrid, Spain	2	616	169	70
Abu Dhabi, UAE	3	623	318	90
Dubai, UAE	3	623	306	90

Exhibit 12.40: Conditioning Models for the eTIMSS 2019 Grade 8 Data

Country	eTIMSS 2019			
	Number of Primary Conditioning Variables	Number of Principal Components Available	Number of Principal Components Retained	Percentage of Variance Explained
Chile	2	638	205	79
Chinese Taipei	2	638	245	87
England	2	637	168	74
Finland	3	979	243	76
France	2	952	193	74
Georgia	2	978	165	63
Hong Kong SAR	3	639	163	78
Hungary	2	980	228	72
Israel	3	573	186	78
Italy	2	639	180	74
Korea, Rep. of	2	626	193	82
Lithuania	4	973	191	67
Malaysia	3	633	304	90
Norway (9)	4	595	228	85
Portugal	2	957	168	71
Qatar	3	639	194	77
Russian Federation	2	980	195	68
Singapore	2	615	242	86
Sweden	2	865	199	74
Turkey	2	639	203	77
United Arab Emirates	5	639	313	90
United States	10	634	300	90
Benchmarking Participants				
Ontario, Canada	3	639	188	77
Quebec, Canada	3	639	158	72
Moscow City, Russian Fed.	2	972	189	67
Abu Dhabi, UAE	3	639	311	90
Dubai, UAE	3	639	286	89

Mathematics proficiency and science proficiency for the eTIMSS 2019 data at both grades were estimated using the same psychometric models as for the paperTIMSS 2019 data, as described earlier in this chapter, incorporating the eTIMSS 2019 response data, item parameters, and conditioning models. A two-dimensional MGROUP model was used to estimate simultaneously overall mathematics proficiency and overall science proficiency. The same paperTIMSS multi-dimensional MGROUP models were used to estimate proficiency in the mathematics and science content and cognitive domains at both grades.

Because the eTIMSS 2019 item calibrations were anchored to the paperTIMSS concurrent calibrations via the bridge items, the scale transformations calculated and applied to the paperTIMSS data, as shown in Exhibits 12.12 and 12.13, were appropriate for placing the estimated eTIMSS 2019 student plausible values in mathematics and science on the TIMSS trend scales. These scale transformations also were applied to the eTIMSS 2019 mathematics and science plausible values in the content and cognitive domains at both grades.

Conclusion

Scaling the TIMSS 2019 achievement data was successful in estimating plausible values from its paperTIMSS and eTIMSS assessments, including the less difficult mathematics assessment at the fourth grade. The psychometric methods implemented and described in this chapter relied on past experience for scaling the paperTIMSS data. Scaling the eTIMSS data required careful consideration of any potential mode effect, which was dealt with effectively with the use of a paper bridge assessment administered in eTIMSS trend countries. The conceptual framework and mode effect models for linking the paperTIMSS and eTIMSS achievement data are described in Chapter 11.

The major outcome was the successful linking of all TIMSS 2019 assessments to the TIMSS trend scales such that results from the paper-based and the computer-based 2019 assessments can be compared directly without further need for adjustments. They also can be compared reliably with past TIMSS assessments. The high levels of comparability of the item parameters between modes of administration was established, and the mode-adjusted item parameters can be used in the population model to generate plausible values for estimating group level results and to examine the relation between the constructs of interest and additional variables. Chapter 13 provides valuable insight into the comparability of achievement results between both modes of administration.

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Appendix 12A: Mathematics Item Parameters from the paperTIMSS 2019 Concurrent Calibration—Grade 4

Item		RMSD 2015	RMSD 2019	Slope (a_i)	Location (b_i)	Guessing (c_i)	Step 1 (d_{i1})	Step 2 (d_{i2})
Items Released in 2015:								
M01_01	M041004	0.050	—	0.969 (0.064)	-1.538 (0.116)	0.207 (0.055)		
M01_02	M041023	0.028	—	1.559 (0.091)	-0.857 (0.049)	0.184 (0.029)		
M01_03	M041034	0.024	—	0.928 (0.061)	-0.084 (0.064)	0.159 (0.027)		
M01_04	M041087	0.030	—	0.766 (0.032)	-0.203 (0.033)			
M01_05	M041124	0.027	—	0.938 (0.036)	-0.346 (0.029)			
M01_06A	M041302A	0.026	—	1.038 (0.062)	-0.705 (0.069)	0.161 (0.033)		
M01_06B	M041302B	0.040	—	0.602 (0.028)	-0.419 (0.042)			
M01_06C	M041302C	0.023	—	1.034 (0.039)	-0.415 (0.028)			
M01_07	M041254	0.025	—	0.671 (0.063)	0.211 (0.109)	0.222 (0.036)		
M01_08	M041153	0.020	—	1.020 (0.065)	0.072 (0.051)	0.139 (0.022)		
M01_09	M041132	0.033	—	0.476 (0.056)	0.907 (0.125)	0.131 (0.036)		
M01_10	M041165	0.040	—	0.352 (0.013)	0.396 (0.039)		-0.984 (0.083)	0.984 (0.088)
M01_11	M041174	0.030	—	1.077 (0.042)	-0.785 (0.032)			
M01_12	M041191	0.028	—	0.997 (0.075)	-1.157 (0.122)	0.336 (0.051)		
M02_01	M061272	0.023	—	0.817 (0.034)	0.080 (0.030)			
M02_02	M061243	0.030	—	0.468 (0.014)	-0.315 (0.030)		-0.992 (0.072)	0.992 (0.068)
M02_03	M061029	0.028	—	1.087 (0.064)	-0.367 (0.055)	0.145 (0.026)		
M02_04	M061031	0.028	—	1.411 (0.078)	0.493 (0.027)	0.069 (0.011)		
M02_05	M061050	0.022	—	1.275 (0.089)	0.500 (0.039)	0.181 (0.017)		
M02_06	M061167	0.045	—	0.692 (0.031)	-0.973 (0.048)			
M02_07	M061206	0.022	—	0.712 (0.063)	0.736 (0.067)	0.121 (0.024)		
M02_08A	M061265A	0.026	—	0.953 (0.039)	0.371 (0.028)			
M02_08B	M061265B	0.025	—	0.912 (0.090)	1.082 (0.059)	0.179 (0.018)		
M02_09	M061185	0.031	—	0.963 (0.059)	-0.575 (0.070)	0.145 (0.032)		
M02_10	M061239	0.041	—	1.356 (0.053)	-0.734 (0.027)			
M03_01	M051205	0.037	—	0.709 (0.031)	-0.367 (0.036)			
M03_02	M051039	0.029	—	1.082 (0.041)	-0.204 (0.025)			
M03_03	M051055	0.023	—	1.076 (0.046)	0.853 (0.031)			
M03_04	M051006	0.035	—	0.522 (0.019)	1.049 (0.039)		-0.539 (0.058)	0.539 (0.072)
M03_05	M051070	0.026	—	1.344 (0.108)	0.913 (0.038)	0.178 (0.014)		
M03_06	M051018	0.019	—	0.864 (0.077)	0.530 (0.068)	0.227 (0.025)		
M03_07	M051407	0.024	—	0.852 (0.065)	0.016 (0.076)	0.197 (0.030)		
M03_08	M051410	0.022	—	0.883 (0.069)	0.445 (0.060)	0.166 (0.023)		
M03_09	M051059	0.060	—	0.685 (0.032)	-1.412 (0.060)			
M03_10	M051093	0.021	—	0.768 (0.069)	0.658 (0.069)	0.164 (0.025)		
M03_11	M051134	0.034	—	1.187 (0.046)	0.332 (0.023)			
M03_12	M051077	0.027	—	1.117 (0.064)	0.104 (0.040)	0.085 (0.017)		

Item		RMSD 2015	RMSD 2019	Slope (a_i)	Location (b_i)	Guessing (c_i)	Step 1 (d_{i1})	Step 2 (d_{i2})
M05_01	M041291	0.043	—	0.689 (0.031)	-0.796 (0.045)			
M05_02	M041289	0.023	—	1.059 (0.084)	0.160 (0.065)	0.299 (0.026)		
M05_03	M041068	0.031	—	1.105 (0.067)	0.503 (0.036)	0.082 (0.015)		
M05_04A	M041065A	0.024	—	1.435 (0.099)	0.596 (0.034)	0.182 (0.015)		
M05_04B	M041065B	0.024	—	0.929 (0.042)	1.027 (0.039)			
M05_05	M041096	0.024	—	0.989 (0.066)	0.514 (0.044)	0.106 (0.018)		
M05_06	M041125	0.020	—	1.114 (0.089)	0.765 (0.045)	0.186 (0.017)		
M05_07	M041135	0.032	—	0.731 (0.066)	-0.732 (0.166)	0.358 (0.053)		
M05_08	M041257	0.027	—	0.728 (0.032)	0.246 (0.034)			
M05_09	M041268	0.024	—	1.731 (0.147)	0.979 (0.034)	0.227 (0.012)		
M05_10	M041151	0.037	—	0.483 (0.047)	-0.528 (0.214)	0.191 (0.060)		
M05_11	M041264	0.027	—	0.508 (0.062)	0.471 (0.164)	0.225 (0.046)		
M05_12	M041182	0.080	—	0.769 (0.037)	-1.784 (0.069)			
M05_13	M041200	0.049	—	0.447 (0.017)	-0.623 (0.039)		-0.221 (0.073)	0.221 (0.062)
M06_01	M051140	0.029	—	0.664 (0.057)	0.143 (0.101)	0.176 (0.035)		
M06_02	M051017	0.018	—	0.924 (0.089)	0.628 (0.069)	0.298 (0.024)		
M06_03	M051111	0.025	—	0.706 (0.034)	0.911 (0.045)			
M06_04	M051089	0.030	—	1.104 (0.045)	0.657 (0.027)			
M06_05	M051094	0.027	—	1.059 (0.078)	0.399 (0.051)	0.201 (0.021)		
M06_06	M051227	0.028	—	1.009 (0.046)	1.115 (0.039)			
M06_07	M051060	0.029	—	0.593 (0.059)	0.535 (0.105)	0.163 (0.034)		
M06_08Z	M051061Z	0.028	—	0.700 (0.033)	0.659 (0.040)			
M06_09	M051129	0.035	—	0.645 (0.055)	-0.311 (0.133)	0.203 (0.045)		
M06_10	M051236	0.040	—	0.846 (0.035)	0.035 (0.030)			
M06_11A	M051125A	0.086	—	0.796 (0.038)	-1.791 (0.067)			
M06_11B	M051125B	0.030	—	0.642 (0.064)	0.001 (0.138)	0.253 (0.043)		
M07_01	M041298	0.043	—	0.930 (0.065)	-0.782 (0.099)	0.253 (0.041)		
M07_02	M041007	0.027	—	0.807 (0.066)	0.321 (0.071)	0.182 (0.027)		
M07_03	M041280	0.023	—	0.731 (0.077)	0.780 (0.082)	0.233 (0.027)		
M07_04	M041059	0.036	—	0.689 (0.030)	-0.315 (0.036)			
M07_05	M041046	0.025	—	1.255 (0.074)	0.176 (0.037)	0.117 (0.017)		
M07_06	M041048	0.021	—	1.309 (0.105)	0.557 (0.044)	0.277 (0.018)		
M07_07	M041169	0.025	—	0.942 (0.069)	0.051 (0.066)	0.205 (0.027)		
M07_08	M041333	0.023	—	0.963 (0.072)	0.565 (0.049)	0.147 (0.019)		
M07_09	M041262	0.022	—	0.799 (0.082)	0.984 (0.068)	0.197 (0.022)		
M07_10	M041267	0.026	—	0.558 (0.029)	0.771 (0.052)			
M07_11	M041177	0.047	—	0.809 (0.055)	-0.472 (0.088)	0.158 (0.035)		
M07_12	M041271	0.048	—	0.860 (0.051)	-0.668 (0.076)	0.115 (0.032)		
M07_13A	M041276A	0.038	—	0.948 (0.038)	0.042 (0.027)			
M07_13B	M041276B	0.025	—	0.885 (0.038)	0.573 (0.032)			

Item		RMSD 2015	RMSD 2019	Slope (a_i)	Location (b_i)	Guessing (c_i)	Step 1 (d_{i1})	Step 2 (d_{i2})
Items Common in 2015 and 2019:								
MP01_01	MP51043	0.055	0.042	0.489 (0.017)	-0.065 (0.030)			
MP01_02	MP51040	0.027	0.025	1.162 (0.066)	-0.042 (0.052)	0.422 (0.020)		
MP01_03	MP51008	0.021	0.023	1.270 (0.034)	0.917 (0.018)			
MP01_04A	MP51031A	0.032	0.023	1.449 (0.034)	0.085 (0.013)			
MP01_04B	MP51031B	0.032	0.027	1.619 (0.038)	0.159 (0.012)			
MP01_05	MP51508	0.021	0.024	1.256 (0.030)	0.097 (0.014)			
MP01_06A	MP51216A	0.024	0.019	1.272 (0.062)	0.498 (0.029)	0.237 (0.013)		
MP01_06B	MP51216B	0.051	0.045	0.576 (0.039)	-0.876 (0.174)	0.270 (0.055)		
MP01_07	MP51221	0.053	0.042	0.571 (0.033)	-1.000 (0.144)	0.168 (0.051)		
MP01_08	MP51115	0.036	0.039	0.591 (0.052)	1.613 (0.066)	0.113 (0.017)		
MP01_09A	MP51507A	0.044	0.036	0.704 (0.021)	-0.657 (0.028)			
MP01_09B	MP51507B	0.019	0.019	1.101 (0.030)	0.768 (0.018)			
MP03_01	MP61026	0.054	0.054	0.904 (0.034)	-0.833 (0.053)	0.098 (0.025)		
MP03_02	MP61273	0.031	0.031	0.779 (0.039)	0.241 (0.049)	0.138 (0.020)		
MP03_03	MP61034	0.017	0.029	1.187 (0.030)	0.601 (0.016)			
MP03_04	MP61040	0.032	0.017	1.504 (0.065)	0.590 (0.021)	0.174 (0.010)		
MP03_05	MP61228	0.025	0.029	0.734 (0.015)	0.872 (0.017)		-0.255 (0.027)	0.255 (0.033)
MP03_06	MP61166	0.031	0.042	1.106 (0.027)	-0.356 (0.017)			
MP03_07	MP61171	0.033	0.028	1.310 (0.054)	-0.343 (0.036)	0.231 (0.019)		
MP03_08	MP61080	0.029	0.026	0.765 (0.022)	0.541 (0.022)			
MP03_09	MP61222	0.042	0.030	0.853 (0.056)	0.483 (0.057)	0.323 (0.020)		
MP03_10	MP61076	0.051	0.042	0.553 (0.018)	-0.697 (0.034)			
MP03_11	MP61084	0.024	0.027	1.010 (0.028)	0.777 (0.020)			
MP05_01	MP51206	0.059	0.049	0.591 (0.019)	-0.887 (0.035)			
MP05_02	MP51052	0.036	0.034	0.824 (0.048)	-0.010 (0.070)	0.297 (0.026)		
MP05_03	MP51049	0.032	0.029	1.341 (0.051)	0.037 (0.026)	0.143 (0.013)		
MP05_04	MP51045	0.039	0.039	1.066 (0.026)	-0.109 (0.016)			
MP05_05	MP51098	0.027	0.033	0.990 (0.047)	0.660 (0.030)	0.121 (0.012)		
MP05_06	MP51030	0.038	0.037	0.945 (0.028)	1.093 (0.025)			
MP05_07	MP51502	0.023	0.024	0.961 (0.057)	1.098 (0.035)	0.153 (0.012)		
MP05_08	MP51224	0.036	0.025	0.938 (0.051)	-0.013 (0.058)	0.301 (0.023)		
MP05_09	MP51207	0.019	0.027	0.799 (0.062)	0.794 (0.061)	0.341 (0.019)		
MP05_10	MP51427	0.018	0.023	1.053 (0.050)	0.659 (0.029)	0.136 (0.012)		
MP05_11	MP51533	0.022	0.026	1.056 (0.027)	0.075 (0.016)			
MP05_12	MP51080	0.037	0.034	0.957 (0.025)	-0.162 (0.018)			
MP06_01	MP61018	0.025	0.028	0.860 (0.023)	0.026 (0.019)			
MP06_02	MP61274	0.052	0.047	0.665 (0.037)	-0.686 (0.108)	0.197 (0.040)		
MP06_03	MP61248	0.046	0.039	0.828 (0.019)	0.346 (0.014)		0.401 (0.021)	-0.401 (0.023)
MP06_04	MP61039	0.026	0.022	1.068 (0.027)	0.233 (0.016)			
MP06_05	MP61079	0.036	0.027	1.238 (0.031)	0.637 (0.016)			

Item		RMSD 2015	RMSD 2019	Slope (a_i)	Location (b_i)	Guessing (c_i)	Step 1 (d_{i1})	Step 2 (d_{i2})
MP06_06	MP61179	0.025	0.026	1.141 (0.047)	-0.023 (0.033)	0.157 (0.016)		
MP06_07	MP61052	0.031	0.024	0.945 (0.038)	0.022 (0.035)	0.091 (0.016)		
MP06_08	MP61207	0.033	0.023	1.429 (0.053)	0.282 (0.021)	0.113 (0.010)		
MP06_09	MP61236	0.043	0.040	0.795 (0.022)	0.182 (0.020)			
MP06_10	MP61266	0.031	0.035	0.466 (0.010)	0.671 (0.021)		-0.844 (0.043)	0.844 (0.047)
MP06_11	MP61106	0.029	0.030	0.974 (0.046)	-0.126 (0.050)	0.219 (0.022)		
MP07_01	MP51401	0.031	0.039	0.784 (0.022)	0.447 (0.021)			
MP07_02	MP51075	0.025	0.025	1.297 (0.088)	1.044 (0.033)	0.326 (0.011)		
MP07_03	MP51402	0.026	0.032	0.917 (0.024)	0.377 (0.018)			
MP07_04	MP51226	0.023	0.020	1.302 (0.067)	0.588 (0.029)	0.270 (0.012)		
MP07_05	MP51131	0.038	0.029	0.731 (0.021)	-0.032 (0.021)			
MP07_06	MP51103	0.020	0.025	1.258 (0.060)	0.174 (0.034)	0.280 (0.016)		
MP07_07	MP51217	0.024	0.020	1.153 (0.029)	0.576 (0.016)			
MP07_08	MP51079	0.024	0.025	0.851 (0.023)	0.257 (0.019)			
MP07_09	MP51211	0.039	0.036	0.783 (0.045)	-0.198 (0.078)	0.274 (0.029)		
MP07_10	MP51102	0.028	0.023	0.948 (0.050)	0.699 (0.034)	0.159 (0.014)		
MP07_11	MP51009	0.048	0.044	0.777 (0.021)	-0.032 (0.020)			
MP07_12	MP51100	0.032	0.028	0.642 (0.041)	0.123 (0.085)	0.195 (0.029)		
MP09_01	MP61275	0.039	0.032	0.709 (0.039)	-0.570 (0.096)	0.212 (0.036)		
MP09_02	MP61027	0.057	0.040	0.893 (0.024)	-0.577 (0.022)			
MP09_03	MP61255	0.026	0.025	0.812 (0.016)	0.483 (0.013)		-0.182 (0.024)	0.182 (0.026)
MP09_04	MP61021	0.024	0.029	0.825 (0.023)	0.621 (0.021)			
MP09_05	MP61043	0.031	0.027	1.232 (0.030)	0.300 (0.014)			
MP09_06	MP61151	0.025	0.029	1.203 (0.046)	-0.159 (0.031)	0.132 (0.016)		
MP09_07	MP61172	0.018	0.028	1.520 (0.065)	0.756 (0.019)	0.123 (0.008)		
MP09_08	MP61223	0.046	0.039	0.725 (0.033)	-0.726 (0.078)	0.119 (0.032)		
MP09_09	MP61269	0.037	0.033	0.851 (0.037)	-0.464 (0.058)	0.130 (0.026)		
MP09_10A	MP61081A	0.030	0.030	1.002 (0.027)	0.721 (0.019)			
MP09_10B	MP61081B	0.039	0.043	0.719 (0.024)	1.055 (0.031)			
MP11_01	MP61178	0.030	0.033	0.829 (0.023)	0.048 (0.019)			
MP11_02	MP61246	0.025	0.027	0.953 (0.038)	0.052 (0.034)	0.090 (0.015)		
MP11_03	MP61271	0.056	0.038	0.618 (0.019)	-0.720 (0.031)			
MP11_04	MP61256	0.038	0.039	0.835 (0.023)	0.125 (0.019)			
MP11_05	MP61182	0.026	0.034	1.210 (0.035)	1.079 (0.021)			
MP11_06	MP61049	0.040	0.029	0.910 (0.048)	-0.482 (0.073)	0.310 (0.029)		
MP11_07	MP61232	0.032	0.035	0.970 (0.063)	0.660 (0.045)	0.321 (0.016)		
MP11_08	MP61095	0.029	0.026	0.915 (0.024)	-0.128 (0.018)			
MP11_09	MP61264	0.036	0.034	0.577 (0.013)	0.389 (0.017)		-0.100 (0.031)	0.100 (0.034)
MP11_10	MP61108	0.033	0.025	0.520 (0.042)	0.554 (0.103)	0.182 (0.032)		
MP11_11A	MP61211A	0.022	0.024	1.222 (0.030)	0.148 (0.014)			
MP11_11B	MP61211B	0.024	0.021	1.512 (0.078)	0.626 (0.026)	0.276 (0.011)		

Item		RMSD 2015	RMSD 2019	Slope (a_i)	Location (b_i)	Guessing (c_i)	Step 1 (d_{i1})	Step 2 (d_{i2})
MP13_01	MP61240	0.024	0.022	0.751 (0.022)	0.518 (0.022)			
MP13_02	MP61254	0.045	0.035	0.901 (0.023)	-0.007 (0.018)			
MP13_03	MP61244	0.018	0.030	0.931 (0.044)	-0.161 (0.053)	0.220 (0.023)		
MP13_04	MP61041	0.032	0.029	1.209 (0.072)	0.997 (0.030)	0.242 (0.011)		
MP13_05	MP61173	0.033	0.040	0.706 (0.020)	-0.303 (0.023)			
MP13_06	MP61252	0.027	0.020	1.157 (0.049)	0.590 (0.024)	0.113 (0.011)		
MP13_07	MP61261	0.032	0.036	1.261 (0.030)	0.115 (0.014)			
MP13_08	MP61224	0.031	0.024	0.825 (0.023)	0.541 (0.020)			
MP13_09	MP61077	0.037	0.033	0.830 (0.035)	-0.161 (0.046)	0.093 (0.020)		
MP13_10A	MP61069A	0.036	0.049	0.725 (0.021)	-0.791 (0.028)			
MP13_10B	MP61069B	0.032	0.035	0.732 (0.021)	-0.114 (0.022)			
Items Introduced in 2019:								
MP02_01	MP71219	—	0.059	0.709 (0.084)	-1.165 (0.256)	0.032 (0.121)		
MP02_02	MP71021	—	0.033	1.146 (0.110)	0.098 (0.065)	0.089 (0.031)		
MP02_03	MP71167	—	0.027	1.192 (0.081)	0.849 (0.049)			
MP02_04	MP71041	—	0.037	1.375 (0.131)	-0.313 (0.071)	0.143 (0.039)		
MP02_05	MP71162	—	0.033	0.479 (0.029)	1.451 (0.090)		-0.840 (0.112)	0.840 (0.149)
MP02_06	MP71078	—	0.041	0.715 (0.051)	-0.194 (0.054)			
MP02_07	MP71090	—	0.026	1.102 (0.124)	0.183 (0.080)	0.164 (0.037)		
MP02_08	MP71151	—	0.023	0.593 (0.028)	0.897 (0.050)		-1.236 (0.109)	1.236 (0.122)
MP02_09	MP71119	—	0.056	0.589 (0.049)	-1.308 (0.104)			
MP02_10A	MP71217A	—	0.052	0.909 (0.059)	-0.627 (0.052)			
MP02_11	MP71142	—	0.044	1.190 (0.073)	-0.435 (0.040)			
MP02_12	MP71204	—	0.024	1.334 (0.084)	0.475 (0.037)			
MP04_01	MP71013	—	0.033	1.155 (0.143)	-0.260 (0.116)	0.234 (0.056)		
MP04_02	MP71026	—	0.035	1.118 (0.076)	0.161 (0.041)			
MP04_03	MP71036	—	0.051	0.945 (0.067)	-0.538 (0.054)			
MP04_04	MP71040	—	0.021	1.391 (0.146)	0.338 (0.056)	0.103 (0.027)		
MP04_05	MP71068	—	0.034	0.492 (0.118)	0.419 (0.336)	0.113 (0.109)		
MP04_06A	MP71075A	—	0.023	1.256 (0.084)	0.266 (0.038)			
MP04_06B	MP71075B	—	0.024	1.471 (0.103)	0.647 (0.039)			
MP04_07	MP71080	—	0.027	1.595 (0.236)	0.637 (0.069)	0.303 (0.029)		
MP04_08	MP71211	—	0.035	0.632 (0.054)	0.080 (0.066)			
MP04_09	MP71178	—	0.027	0.762 (0.061)	0.508 (0.062)			
MP04_10B	MP71135B	—	0.036	0.681 (0.056)	-0.549 (0.072)			
MP04_11	MP71201	—	0.027	0.787 (0.069)	0.987 (0.080)			
MP04_12	MP71175	—	0.035	0.801 (0.052)	-0.085 (0.040)		0.560 (0.068)	-0.560 (0.062)
MP08_01	MP71018	—	0.036	1.371 (0.140)	0.177 (0.060)	0.160 (0.029)		
MP08_02	MP71009	—	0.045	1.248 (0.075)	0.209 (0.035)			
MP08_03	MP71037	—	0.035	0.908 (0.058)	0.158 (0.045)			
MP08_04	MP71051	—	0.025	1.170 (0.081)	0.913 (0.052)			

Item		RMSD 2015	RMSD 2019	Slope (a_i)	Location (b_i)	Guessing (c_i)	Step 1 (d_{i1})	Step 2 (d_{i2})
MP08_05	MP71064	—	0.044	0.724 (0.122)	0.756 (0.124)	0.155 (0.045)		
MP08_06	MP71169	—	0.029	1.317 (0.082)	0.506 (0.037)			
MP08_07	MP71083	—	0.040	1.202 (0.150)	0.507 (0.072)	0.209 (0.030)		
MP08_09	MP71184	—	0.027	1.635 (0.258)	1.059 (0.064)	0.244 (0.020)		
MP08_10	MP71141	—	0.029	0.957 (0.066)	0.733 (0.054)			
MP08_11	MP71194	—	0.086	0.743 (0.056)	-1.035 (0.074)			
MP08_12	MP71193	—	0.033	0.585 (0.028)	0.449 (0.043)		-0.802 (0.092)	0.802 (0.100)
MP08_13	MP71192	—	0.018	0.499 (0.024)	0.947 (0.057)		-2.150 (0.161)	2.150 (0.173)
MP10_02	MP71016	—	0.024	0.949 (0.066)	-0.049 (0.047)			
MP10_03	MP71163	—	0.027	1.762 (0.208)	0.966 (0.048)	0.076 (0.015)		
MP10_04	MP71045	—	0.024	1.087 (0.135)	0.257 (0.087)	0.163 (0.040)		
MP10_05	MP71213	—	0.024	0.941 (0.069)	0.435 (0.051)			
MP10_06	MP71070	—	0.038	0.354 (0.108)	-0.609 (1.060)	0.021 (0.287)		
MP10_07	MP71181	—	0.026	0.733 (0.060)	0.629 (0.068)			
MP10_08	MP71179	—	0.021	0.852 (0.072)	1.061 (0.078)			
MP10_09	MP71067	—	0.032	0.543 (0.028)	0.961 (0.058)		-1.542 (0.138)	1.542 (0.152)
MP10_10A	MP71147A	—	0.041	1.302 (0.087)	-0.429 (0.042)			
MP10_10B	MP71147B	—	0.026	0.886 (0.066)	0.298 (0.052)			
MP10_11	MP71189	—	0.056	0.903 (0.072)	-1.359 (0.088)			
MP10_12A	MP71187A	—	0.048	0.813 (0.063)	-0.932 (0.076)			
MP10_12B	MP71187B	—	0.060	0.676 (0.056)	-0.354 (0.068)			
MP12_01	MP71001	—	0.050	0.857 (0.103)	-1.079 (0.211)	0.087 (0.107)		
MP12_02	MP71010	—	0.039	0.694 (0.055)	-0.186 (0.062)			
MP12_03	MP71062	—	0.027	1.337 (0.208)	1.169 (0.073)	0.129 (0.021)		
MP12_04A	MP71216A	—	0.032	1.253 (0.082)	-0.382 (0.042)			
MP12_04B	MP71216B	—	0.037	0.831 (0.065)	0.295 (0.057)			
MP12_05	MP71117	—	0.035	0.646 (0.053)	-0.414 (0.070)			
MP12_06	MP71071	—	0.022	1.248 (0.198)	0.517 (0.094)	0.332 (0.037)		
MP12_07	MP71098	—	0.028	0.729 (0.047)	0.762 (0.048)		0.060 (0.068)	-0.060 (0.086)
MP12_08A	MP71134A	—	0.030	1.769 (0.165)	-0.046 (0.047)	0.092 (0.026)		
MP12_08B	MP71134B	—	0.036	1.454 (0.097)	0.254 (0.035)			
MP12_09	MP71202	—	0.036	0.681 (0.057)	-0.492 (0.071)			
MP12_10	MP71190	—	0.026	1.052 (0.073)	-0.112 (0.045)			
MP12_11	MP71218	—	0.025	1.098 (0.094)	1.196 (0.072)			
MP14_01	MP71024	—	0.025	0.921 (0.066)	0.160 (0.048)			
MP14_02	MP71008	—	0.028	1.118 (0.123)	-0.198 (0.095)	0.128 (0.047)		
MP14_03	MP71165	—	0.022	1.277 (0.154)	0.200 (0.076)	0.190 (0.037)		
MP14_04	MP71049	—	0.041	0.805 (0.060)	-0.370 (0.057)			
MP14_05	MP71063	—	0.028	1.050 (0.073)	0.220 (0.044)			
MP14_06	MP71079	—	0.019	1.179 (0.170)	0.696 (0.078)	0.192 (0.032)		
MP14_07	MP71081	—	0.034	1.007 (0.069)	-0.105 (0.046)			

Item		RMSD 2015	RMSD 2019	Slope (a_i)	Location (b_i)	Guessing (c_i)	Step 1 (d_{i1})	Step 2 (d_{i2})
MP14_08	MP71094	—	0.024	1.007 (0.175)	0.648 (0.111)	0.280 (0.041)		
MP14_09	MP71177	—	0.029	0.606 (0.054)	0.389 (0.073)			
MP14_10	MP71206	—	0.042	0.681 (0.105)	-0.620 (0.282)	0.125 (0.114)		
MP14_11A	MP71138A	—	0.029	0.798 (0.060)	0.032 (0.054)			
MP14_11B	MP71138B	—	0.022	0.984 (0.076)	0.747 (0.058)			
MP14_12	MP71203	—	0.028	0.653 (0.139)	1.178 (0.143)	0.106 (0.047)		
MP14_13	MP71205	—	0.024	1.108 (0.079)	0.366 (0.044)			

Appendix 12B: Science Item Parameters from the paperTIMSS 2019 Concurrent Calibration— Grade 4

Item		RMSD 2015	RMSD 2019	Slope (a_i)	Location (b_i)	Guessing (c_i)	Step 1 (d_{i1})	Step 2 (d_{i2})
Items Released in 2015:								
S01_01	S041010	0.044	—	0.967 (0.067)	-0.786 (0.093)	0.259 (0.038)		
S01_02	S041034	0.034	—	0.647 (0.064)	-0.096 (0.134)	0.274 (0.042)		
S01_03	S041017	0.021	—	0.963 (0.108)	1.018 (0.061)	0.249 (0.021)		
S01_04	S041124	0.024	—	1.020 (0.102)	0.812 (0.057)	0.263 (0.022)		
S01_05	S041186	0.031	—	0.638 (0.036)	1.080 (0.057)			
S01_06	S041037	0.040	—	0.543 (0.020)	-0.186 (0.028)		-0.129 (0.055)	0.129 (0.050)
S01_07	S041119	0.028	—	1.115 (0.095)	-0.024 (0.076)	0.400 (0.029)		
S01_08	S041105	0.039	—	0.933 (0.060)	-0.130 (0.060)	0.141 (0.026)		
S01_10Z	S041149Z	0.024	—	0.606 (0.019)	1.033 (0.032)		-1.084 (0.062)	1.084 (0.072)
S01_11	S041032	0.079	—	0.827 (0.038)	-1.450 (0.061)			
S01_12	S041068	0.030	—	0.715 (0.035)	0.250 (0.033)			
S01_13	S041303	0.026	—	0.676 (0.085)	0.799 (0.102)	0.272 (0.033)		
S02_01	S061105	0.028	—	0.701 (0.078)	0.107 (0.135)	0.383 (0.039)		
S02_02	S061010	0.041	—	0.419 (0.026)	0.038 (0.053)			
S02_03	S061028	0.020	—	0.843 (0.119)	1.177 (0.083)	0.321 (0.024)		
S02_04	S061065	0.039	—	1.003 (0.067)	-0.227 (0.065)	0.198 (0.029)		
S02_05	S061130	0.031	—	0.797 (0.037)	0.420 (0.031)			
S02_06	S061081	0.028	—	0.926 (0.044)	0.828 (0.034)			
S02_07	S061060	0.041	—	0.829 (0.036)	-0.010 (0.030)			
S02_08	S061075	0.043	—	0.604 (0.050)	-0.260 (0.117)	0.145 (0.039)		
S02_09	S061031	0.034	—	0.992 (0.046)	0.875 (0.033)			
S02_10A	S061049A	0.047	—	0.773 (0.050)	-0.348 (0.074)	0.105 (0.028)		
S02_10B	S061049B	0.031	—	0.618 (0.057)	0.244 (0.101)	0.159 (0.034)		
S02_11	S061098	0.019	—	0.757 (0.105)	1.217 (0.088)	0.264 (0.026)		
S02_12	S061172	0.023	—	0.566 (0.034)	1.057 (0.061)			
S03_01	S051041	0.022	—	0.862 (0.098)	0.675 (0.081)	0.348 (0.027)		
S03_02	S051037	0.042	—	0.787 (0.035)	0.038 (0.031)			
S03_03	S051008	0.024	—	0.870 (0.045)	1.141 (0.046)			
S03_04	S051004	0.034	—	1.361 (0.088)	-0.099 (0.048)	0.248 (0.024)		
S03_05Z	S051026Z	0.028	—	0.532 (0.031)	0.752 (0.052)			
S03_06	S051130	0.022	—	0.530 (0.035)	1.478 (0.088)			
S03_07	S051114	0.024	—	1.155 (0.098)	0.607 (0.049)	0.251 (0.021)		
S03_08Z	S051121Z	0.045	—	0.414 (0.026)	0.097 (0.054)			
S03_09	S051147	0.027	—	0.841 (0.043)	0.978 (0.041)			
S03_10	S051105	0.031	—	1.005 (0.082)	-0.115 (0.081)	0.339 (0.032)		
S03_11	S051110	0.033	—	0.871 (0.066)	0.052 (0.072)	0.195 (0.029)		
S03_12	S051111	0.021	—	1.114 (0.101)	0.299 (0.068)	0.374 (0.027)		

Item		RMSD 2015	RMSD 2019	Slope (a_i)	Location (b_i)	Guessing (c_i)	Step 1 (d_{i1})	Step 2 (d_{i2})
S05_01	S041009	0.044	—	0.774 (0.059)	-0.931 (0.127)	0.246 (0.045)		
S05_02	S041223	0.028	—	1.000 (0.091)	0.432 (0.064)	0.297 (0.025)		
S05_03	S041026	0.037	—	0.536 (0.051)	0.222 (0.111)	0.126 (0.035)		
S05_04	S041177	0.026	—	0.424 (0.022)	1.054 (0.051)		0.377 (0.058)	-0.377 (0.078)
S05_05	S041183	0.052	—	0.646 (0.021)	0.207 (0.028)		1.136 (0.044)	-1.136 (0.045)
S05_06	S041008	0.026	—	1.171 (0.101)	0.666 (0.046)	0.237 (0.020)		
S05_08	S041195	0.018	—	0.618 (0.042)	1.664 (0.093)			
S05_09A	S041134A	0.028	—	0.804 (0.041)	0.953 (0.043)			
S05_09B	S041134B	0.045	—	0.768 (0.035)	0.162 (0.031)			
S05_09C	S041134C	0.025	—	0.756 (0.069)	0.471 (0.074)	0.184 (0.028)		
S05_10	S041191	0.024	—	0.841 (0.100)	0.802 (0.078)	0.309 (0.026)		
S05_11	S041107	0.047	—	0.394 (0.014)	-0.825 (0.047)		-0.797 (0.089)	0.797 (0.075)
S05_12	S041113	0.028	—	0.755 (0.037)	0.398 (0.033)			
S06_01	S051185	0.028	—	1.044 (0.075)	0.365 (0.048)	0.170 (0.021)		
S06_02	S051048	0.039	—	0.670 (0.025)	0.058 (0.023)		0.255 (0.043)	-0.255 (0.041)
S06_03	S051164	0.040	—	0.839 (0.051)	1.575 (0.072)			
S06_04	S051186	0.045	—	0.635 (0.030)	-1.065 (0.058)			
S06_05	S051137	0.050	—	0.661 (0.048)	-1.053 (0.139)	0.163 (0.047)		
S06_06	S051007	0.033	—	0.835 (0.036)	-0.131 (0.031)			
S06_07	S051087	0.032	—	1.020 (0.071)	-0.533 (0.080)	0.258 (0.034)		
S06_08Z	S051188Z	0.029	—	0.597 (0.031)	0.255 (0.039)			
S06_10	S051201	0.036	—	0.663 (0.033)	0.381 (0.036)			
S06_11	S051102	0.024	—	0.815 (0.068)	0.035 (0.085)	0.235 (0.032)		
S06_12	S051095	0.053	—	0.540 (0.028)	-0.429 (0.049)			
S07_01	S041027	0.074	—	0.715 (0.035)	-1.989 (0.083)			
S07_02	S041043	0.048	—	0.608 (0.030)	-0.664 (0.049)			
S07_03	S041050	0.025	—	0.459 (0.060)	0.656 (0.157)	0.181 (0.044)		
S07_04	S041070	0.025	—	0.797 (0.072)	0.411 (0.075)	0.212 (0.029)		
S07_05	S041006	0.037	—	0.453 (0.021)	0.601 (0.036)		0.354 (0.056)	-0.354 (0.065)
S07_06	S041052	0.027	—	0.918 (0.075)	-0.432 (0.103)	0.349 (0.038)		
S07_07	S041301	0.025	—	0.569 (0.033)	0.822 (0.052)			
S07_09	S041033	0.025	—	0.854 (0.043)	1.000 (0.042)			
S07_11	S041077	0.032	—	0.745 (0.035)	0.328 (0.033)			
S07_12	S041209	0.028	—	0.689 (0.070)	0.690 (0.080)	0.167 (0.029)		
S07_13	S041081	0.030	—	0.540 (0.019)	0.495 (0.028)		-0.440 (0.055)	0.440 (0.059)
S07_14	S041102	0.028	—	0.941 (0.070)	-0.248 (0.081)	0.244 (0.034)		

Item		RMSD 2015	RMSD 2019	Slope (a_i)	Location (b_i)	Guessing (c_i)	Step 1 (d_{i1})	Step 2 (d_{i2})
Items Common in 2015 and 2019:								
SP01_01	SP51054	0.049	0.035	0.934 (0.044)	-0.419 (0.058)	0.261 (0.024)		
SP01_02	SP51024	0.038	0.034	0.612 (0.021)	0.674 (0.028)			
SP01_03A	SP51132A	0.026	0.015	0.881 (0.031)	1.254 (0.032)			
SP01_03B	SP51132B	0.039	0.031	0.810 (0.027)	1.065 (0.029)			
SP01_04	SP51040	0.030	0.037	0.453 (0.018)	0.606 (0.036)			
SP01_05	SP51193	0.033	0.037	0.940 (0.048)	-0.126 (0.053)	0.274 (0.022)		
SP01_06	SP51063	0.018	0.029	1.148 (0.066)	0.754 (0.030)	0.222 (0.013)		
SP01_07	SP51012	0.027	0.029	0.989 (0.052)	0.268 (0.042)	0.253 (0.018)		
SP01_08	SP51115	0.054	0.032	1.090 (0.028)	0.146 (0.015)			
SP01_09	SP51180	0.034	0.037	0.880 (0.054)	0.057 (0.064)	0.360 (0.022)		
SP01_10	SP51106	0.018	0.026	1.024 (0.061)	0.721 (0.034)	0.215 (0.014)		
SP01_11	SP51148	0.025	0.038	1.049 (0.050)	0.043 (0.041)	0.241 (0.018)		
SP03_01	SP61141	0.028	0.021	1.235 (0.068)	0.519 (0.032)	0.300 (0.014)		
SP03_02	SP61023	0.034	0.035	0.770 (0.022)	0.015 (0.020)			
SP03_03	SP61054	0.046	0.042	0.479 (0.010)	0.643 (0.024)		1.489 (0.034)	-1.489 (0.043)
SP03_04	SP61007	0.040	0.035	0.647 (0.036)	-0.209 (0.079)	0.163 (0.028)		
SP03_05	SP61006	0.056	0.047	0.785 (0.022)	-0.650 (0.026)			
SP03_06	SP61108	0.025	0.026	1.050 (0.061)	0.233 (0.047)	0.352 (0.018)		
SP03_07	SP61109	0.029	0.032	0.583 (0.050)	0.710 (0.081)	0.235 (0.026)		
SP03_08	SP61080	0.024	0.024	0.968 (0.053)	0.297 (0.044)	0.264 (0.018)		
SP03_09	SP61088	0.028	0.017	0.672 (0.026)	1.417 (0.046)			
SP03_10	SP61151	0.033	0.031	0.952 (0.026)	0.440 (0.017)			
SP03_11	SP61150	0.045	0.043	0.624 (0.021)	0.408 (0.025)			
SP03_12	SP61169	0.024	0.032	1.077 (0.053)	0.079 (0.041)	0.268 (0.018)		
SP05_01	SP51044	0.034	0.035	0.503 (0.018)	0.201 (0.028)			
SP05_03	SP51003	0.044	0.038	0.711 (0.034)	-0.122 (0.054)	0.104 (0.021)		
SP05_04	SP51168	0.066	0.060	0.704 (0.021)	-0.475 (0.026)			
SP05_05	SP51010	0.039	0.038	0.766 (0.022)	0.076 (0.020)			
SP05_06	SP51035	0.024	0.030	1.249 (0.101)	1.298 (0.037)	0.236 (0.010)		
SP05_07	SP51059	0.035	0.035	0.584 (0.020)	0.104 (0.025)			
SP05_08	SP51142	0.036	0.023	0.802 (0.050)	0.598 (0.046)	0.199 (0.018)		
SP05_09A	SP51131A	0.030	0.034	1.014 (0.045)	-0.089 (0.041)	0.193 (0.019)		
SP05_09B	SP51131B	0.023	0.030	0.988 (0.055)	0.576 (0.035)	0.197 (0.015)		
SP05_10	SP51151	0.063	0.058	0.918 (0.026)	-1.120 (0.030)			
SP05_11	SP51157	0.030	0.022	0.739 (0.057)	0.999 (0.049)	0.190 (0.017)		
SP06_01	SP61071	0.051	0.043	0.335 (0.028)	-1.372 (0.337)	0.197 (0.071)		
SP06_02	SP61138	0.055	0.046	0.616 (0.020)	0.002 (0.024)			
SP06_03A	SP61016A	0.032	0.025	0.926 (0.050)	0.365 (0.041)	0.216 (0.017)		
SP06_03B	SP61016B	0.038	0.037	0.990 (0.027)	0.509 (0.017)			
SP06_04	SP61011	0.059	0.050	0.733 (0.021)	-0.536 (0.026)			

Item		RMSD 2015	RMSD 2019	Slope (a_i)	Location (b_i)	Guessing (c_i)	Step 1 (d_{i1})	Step 2 (d_{i2})
SP06_06	SP61083	0.055	0.051	0.726 (0.021)	-1.025 (0.034)			
SP06_07	SP61034	0.026	0.028	0.788 (0.027)	1.088 (0.030)			
SP06_08	SP61044	0.030	0.030	0.740 (0.023)	0.551 (0.022)			
SP06_09A	SP61142A	0.034	0.034	0.623 (0.021)	0.351 (0.024)			
SP06_09B	SP61142B	0.027	0.026	0.788 (0.027)	1.034 (0.029)			
SP06_10A	SP61115A	0.033	0.031	1.468 (0.068)	0.346 (0.026)	0.264 (0.013)		
SP06_10B	SP61115B	0.037	0.028	1.345 (0.081)	0.662 (0.030)	0.328 (0.013)		
SP07_01	SP51161	0.036	0.032	0.488 (0.051)	1.007 (0.099)	0.217 (0.029)		
SP07_02	SP51051	0.027	0.021	1.391 (0.122)	1.370 (0.037)	0.281 (0.009)		
SP07_03Z	SP51138Z	0.033	0.034	0.583 (0.020)	0.313 (0.025)			
SP07_04	SP51194	0.024	0.027	0.970 (0.030)	1.014 (0.024)			
SP07_05	SP51029	0.022	0.023	0.518 (0.055)	1.220 (0.083)	0.202 (0.026)		
SP07_06	SP51077	0.046	0.041	0.747 (0.022)	-0.167 (0.022)			
SP07_07	SP51200	0.023	0.030	0.679 (0.025)	1.196 (0.037)			
SP07_08	SP51075	0.062	0.052	0.670 (0.020)	-0.586 (0.029)			
SP07_09	SP51065	0.037	0.041	0.870 (0.049)	-0.215 (0.070)	0.333 (0.026)		
SP07_10	SP51191	0.024	0.033	1.342 (0.065)	0.578 (0.025)	0.205 (0.012)		
SP07_11	SP51099	0.024	0.027	0.868 (0.049)	0.332 (0.047)	0.216 (0.019)		
SP07_12	SP51175	0.020	0.031	0.978 (0.030)	0.968 (0.023)			
SP09_01	SP61135	0.050	0.036	0.758 (0.041)	-0.598 (0.085)	0.268 (0.030)		
SP09_02	SP61069	0.044	0.041	0.400 (0.016)	-0.481 (0.041)			
SP09_03	SP61134	0.039	0.038	0.651 (0.036)	0.181 (0.060)	0.126 (0.022)		
SP09_04	SP61140	0.029	0.024	1.039 (0.064)	0.601 (0.039)	0.296 (0.016)		
SP09_05	SP61019	0.024	0.028	0.887 (0.028)	0.943 (0.024)			
SP09_06	SP61022	0.028	0.030	0.656 (0.044)	0.183 (0.079)	0.241 (0.026)		
SP09_07	SP61036	0.029	0.028	0.951 (0.029)	0.903 (0.022)			
SP09_08	SP61160	0.052	0.051	0.761 (0.022)	-0.954 (0.032)			
SP09_09	SP61159	0.063	0.054	0.826 (0.023)	-0.788 (0.027)			
SP09_10	SP61091	0.029	0.031	0.452 (0.014)	1.170 (0.032)		-0.176 (0.038)	0.176 (0.050)
SP09_11	SP61118	0.020	0.029	1.001 (0.056)	0.542 (0.036)	0.217 (0.016)		
SP09_12	SP61097	0.024	0.028	0.798 (0.055)	0.517 (0.056)	0.275 (0.021)		
SP11_01	SP61132	0.028	0.023	0.710 (0.048)	0.539 (0.058)	0.213 (0.021)		
SP11_02	SP61120	0.028	0.028	0.884 (0.047)	0.333 (0.043)	0.197 (0.018)		
SP11_03	SP61025	0.041	0.041	0.531 (0.018)	-0.366 (0.031)			
SP11_04A	SP61133A	0.028	0.023	1.370 (0.067)	0.245 (0.032)	0.326 (0.015)		
SP11_04B	SP61133B	0.028	0.030	1.701 (0.073)	0.792 (0.016)	0.114 (0.008)		
SP11_05	SP61074	0.044	0.035	0.772 (0.023)	0.219 (0.020)			
SP11_06	SP61093	0.063	0.056	0.761 (0.016)	-0.057 (0.016)		0.937 (0.026)	-0.937 (0.022)
SP11_07	SP61161	0.034	0.032	0.614 (0.021)	0.664 (0.028)			
SP11_08A	SP61042A	0.020	0.024	1.366 (0.077)	0.806 (0.025)	0.239 (0.011)		
SP11_08B	SP61042B	0.022	0.029	0.791 (0.047)	0.640 (0.042)	0.150 (0.017)		

Item		RMSD 2015	RMSD 2019	Slope (a_i)	Location (b_i)	Guessing (c_i)	Step 1 (d_{i1})	Step 2 (d_{i2})
SP11_09A	SP61041A	0.032	0.033	0.871 (0.024)	0.116 (0.018)			
SP11_09B	SP61041B	0.044	0.041	0.719 (0.022)	0.167 (0.021)			
SP11_10	SP61155	0.044	0.040	0.735 (0.043)	-0.488 (0.093)	0.286 (0.032)		
SP13_02	SP61014	0.039	0.036	0.495 (0.018)	0.425 (0.030)			
SP13_03	SP61056	0.068	0.060	0.853 (0.023)	-0.738 (0.026)			
SP13_04	SP61015	0.060	0.055	0.692 (0.020)	-0.395 (0.025)			
SP13_05	SP61113	0.036	0.024	0.760 (0.025)	0.954 (0.028)			
SP13_06	SP61107	0.020	0.032	1.001 (0.054)	0.641 (0.032)	0.180 (0.014)		
SP13_07	SP61046	0.019	0.030	1.164 (0.068)	0.804 (0.029)	0.227 (0.012)		
SP13_08	SP61047	0.042	0.043	0.751 (0.043)	-0.518 (0.089)	0.313 (0.030)		
SP13_09	SP61048	0.027	0.032	1.300 (0.062)	0.509 (0.026)	0.221 (0.012)		
SP13_10	SP61096	0.029	0.019	1.100 (0.066)	0.730 (0.033)	0.257 (0.014)		
SP13_11	SP61124	0.026	0.028	0.590 (0.023)	1.242 (0.043)			
SP13_12	SP61116	0.039	0.031	0.681 (0.021)	0.159 (0.022)			
Items Introduced in 2019:								
SP02_01	SP71002	—	0.046	0.572 (0.047)	0.043 (0.065)			
SP02_02	SP71402	—	0.048	1.119 (0.135)	-0.253 (0.108)	0.299 (0.045)		
SP02_03	SP71017	—	0.035	0.710 (0.054)	0.271 (0.056)			
SP02_04	SP71077	—	0.036	1.100 (0.071)	0.226 (0.038)			
SP02_05	SP71072	—	0.022	1.212 (0.186)	0.786 (0.072)	0.232 (0.027)		
SP02_06	SP71054	—	0.042	0.941 (0.064)	0.213 (0.043)			
SP02_07	SP71115	—	0.028	0.848 (0.159)	0.797 (0.110)	0.249 (0.039)		
SP02_08	SP71140	—	0.043	0.703 (0.110)	-0.071 (0.182)	0.240 (0.062)		
SP02_09	SP71128	—	0.040	0.852 (0.133)	0.016 (0.152)	0.330 (0.052)		
SP02_10	SP71147	—	0.044	0.883 (0.113)	-0.224 (0.134)	0.241 (0.052)		
SP02_11A	SP71920A	—	0.038	0.802 (0.059)	0.344 (0.052)			
SP02_11B	SP71920B	—	0.031	0.956 (0.070)	0.612 (0.051)			
SP02_12	SP71268	—	0.023	0.941 (0.204)	1.253 (0.119)	0.203 (0.029)		
SP04_01	SP71013	—	0.049	0.852 (0.106)	-0.766 (0.181)	0.278 (0.067)		
SP04_02	SP71902	—	0.031	0.272 (0.040)	1.509 (0.259)			
SP04_03	SP71076	—	0.050	0.860 (0.091)	-0.563 (0.126)	0.134 (0.052)		
SP04_04	SP71041	—	0.036	0.778 (0.049)	0.977 (0.050)		0.021 (0.060)	-0.021 (0.084)
SP04_05	SP71046	—	0.033	0.803 (0.059)	0.442 (0.053)			
SP04_06	SP71095	—	0.040	0.654 (0.051)	0.225 (0.059)			
SP04_07	SP71129	—	0.042	0.855 (0.118)	-0.617 (0.192)	0.346 (0.066)		
SP04_08	SP71102	—	0.032	0.751 (0.059)	0.669 (0.064)			
SP04_09	SP71124	—	0.031	1.132 (0.159)	0.510 (0.079)	0.252 (0.032)		
SP04_10	SP71112	—	0.062	0.743 (0.094)	-1.183 (0.243)	0.216 (0.090)		
SP04_11	SP71265	—	0.030	0.708 (0.157)	0.628 (0.170)	0.341 (0.052)		
SP04_12	SP71223	—	0.059	0.548 (0.100)	-1.573 (0.565)	0.298 (0.161)		
SP08_02	SP71033	—	0.038	0.544 (0.123)	0.276 (0.275)	0.289 (0.076)		

Item		RMSD 2015	RMSD 2019	Slope (a_i)	Location (b_i)	Guessing (c_i)	Step 1 (d_{i1})	Step 2 (d_{i2})
SP08_03	SP71065	—	0.049	0.670 (0.048)	-0.637 (0.066)			
SP08_04	SP71025	—	0.043	0.270 (0.095)	-0.329 (1.177)	0.000 (0.251)		
SP08_05	SP71081	—	0.027	0.949 (0.162)	1.051 (0.091)	0.157 (0.027)		
SP08_06	SP71056	—	0.034	0.635 (0.055)	0.853 (0.083)			
SP08_07	SP71145	—	0.046	0.516 (0.094)	-0.290 (0.313)	0.181 (0.091)		
SP08_08	SP71104	—	0.067	0.795 (0.053)	-0.850 (0.064)			
SP08_09	SP71144	—	0.044	0.515 (0.083)	-0.087 (0.229)	0.081 (0.073)		
SP08_10	SP71150	—	0.046	1.055 (0.065)	-0.402 (0.044)			
SP08_11	SP71201	—	0.031	1.048 (0.133)	-0.026 (0.106)	0.285 (0.043)		
SP08_12	SP71237	—	0.044	1.086 (0.070)	0.213 (0.039)			
SP08_13	SP71260	—	0.024	0.735 (0.145)	1.105 (0.119)	0.151 (0.036)		
SP10_01	SP71009	—	0.073	0.591 (0.033)	-0.470 (0.049)		1.127 (0.086)	-1.127 (0.069)
SP10_02	SP71093	—	0.049	0.727 (0.050)	-0.409 (0.057)			
SP10_03	SP71069	—	0.028	0.946 (0.213)	1.140 (0.118)	0.295 (0.032)		
SP10_04	SP71051	—	0.029	0.748 (0.058)	0.622 (0.062)			
SP10_05	SP71039	—	0.034	0.766 (0.101)	0.150 (0.117)	0.147 (0.045)		
SP10_06	SP71080	—	0.026	0.929 (0.170)	0.928 (0.099)	0.235 (0.033)		
SP10_07	SP71137	—	0.063	0.705 (0.050)	-0.283 (0.057)			
SP10_08	SP71103	—	0.035	0.815 (0.127)	0.275 (0.130)	0.259 (0.046)		
SP10_09	SP71106	—	0.040	0.629 (0.051)	0.442 (0.067)			
SP10_10	SP71100	—	0.029	0.910 (0.155)	0.275 (0.136)	0.374 (0.045)		
SP10_12	SP71220	—	0.030	0.998 (0.160)	0.732 (0.088)	0.232 (0.033)		
SP10_13	SP71254	—	0.030	0.704 (0.057)	0.652 (0.068)			
SP12_01	SP71031	—	0.043	0.630 (0.048)	0.021 (0.060)			
SP12_02	SP71090	—	0.041	0.767 (0.053)	0.011 (0.051)			
SP12_03	SP71048	—	0.024	1.433 (0.269)	1.191 (0.078)	0.220 (0.021)		
SP12_04	SP71071	—	0.028	0.990 (0.075)	0.875 (0.058)			
SP12_05	SP71011	—	0.045	1.209 (0.119)	-0.421 (0.085)	0.193 (0.040)		
SP12_06	SP71142	—	0.037	0.826 (0.149)	0.493 (0.133)	0.323 (0.044)		
SP12_07	SP71138	—	0.055	0.771 (0.052)	-0.619 (0.059)			
SP12_08	SP71127	—	0.040	0.920 (0.127)	0.034 (0.123)	0.288 (0.045)		
SP12_10	SP71500	—	0.035	0.792 (0.106)	0.333 (0.103)	0.140 (0.040)		
SP12_11	SP71257	—	0.033	1.395 (0.431)	1.384 (0.132)	0.431 (0.023)		
SP12_12	SP71222	—	0.038	0.906 (0.062)	0.231 (0.045)			
SP12_13	SP71252	—	0.030	0.988 (0.146)	0.352 (0.104)	0.290 (0.039)		
SP14_01	SP71063	—	0.050	0.407 (0.040)	-0.311 (0.090)			
SP14_02	SP71900	—	0.036	1.029 (0.149)	-0.022 (0.125)	0.373 (0.046)		
SP14_04	SP71043	—	0.024	0.644 (0.065)	1.381 (0.127)			
SP14_05	SP71005	—	0.062	1.021 (0.065)	-0.584 (0.049)			
SP14_06	SP71118	—	0.028	1.130 (0.170)	0.827 (0.073)	0.188 (0.027)		
SP14_07	SP71139	—	0.041	0.952 (0.143)	0.007 (0.135)	0.359 (0.048)		

Item		RMSD 2015	RMSD 2019	Slope (a_i)	Location (b_i)	Guessing (c_i)	Step 1 (d_{i1})	Step 2 (d_{i2})
SP14_08	SP71114	—	0.059	0.784 (0.054)	-0.391 (0.054)			
SP14_09	SP71131	—	0.050	0.577 (0.047)	-0.028 (0.065)			
SP14_10	SP71152	—	0.029	1.235 (0.178)	0.479 (0.078)	0.300 (0.033)		
SP14_11	SP71218	—	0.056	0.795 (0.112)	-0.626 (0.205)	0.309 (0.070)		
SP14_12	SP71214	—	0.037	1.098 (0.123)	0.119 (0.076)	0.167 (0.035)		
SP14_13	SP71213	—	0.034	1.005 (0.081)	0.950 (0.063)			

Appendix 12C: Mathematics Item Parameters from the paperTIMSS 2019 Concurrent Calibration—Grade 8

Item		RMSD 2015	RMSD 2019	Slope (a_i)	Location (b_i)	Guessing (c_i)	Step 1 (d_{i1})	Step 2 (d_{i2})
Items Released in 2015:								
M01_01	M042182	0.018	—	1.565 (0.137)	0.177 (0.053)	0.360 (0.022)		
M01_02	M042081	0.032	—	0.838 (0.040)	0.581 (0.038)			
M01_03	M042049	0.038	—	1.031 (0.088)	-0.045 (0.083)	0.261 (0.034)		
M01_04	M042052	0.030	—	1.712 (0.106)	-0.132 (0.035)	0.126 (0.019)		
M01_05	M042076	0.031	—	1.049 (0.087)	0.408 (0.059)	0.179 (0.024)		
M01_06A	M042302A	0.026	—	0.987 (0.032)	0.317 (0.021)		-0.175 (0.039)	0.175 (0.041)
M01_06B	M042302B	0.027	—	0.984 (0.029)	0.411 (0.020)		-0.617 (0.048)	0.617 (0.050)
M01_06C	M042302C	0.035	—	0.510 (0.022)	1.723 (0.066)		-1.007 (0.087)	1.007 (0.115)
M01_07	M042100	0.031	—	1.181 (0.097)	0.042 (0.066)	0.258 (0.028)		
M01_08	M042202	0.017	—	1.471 (0.121)	0.392 (0.047)	0.260 (0.020)		
M01_09	M042240	0.025	—	1.319 (0.090)	0.131 (0.045)	0.141 (0.021)		
M01_10	M042093	0.022	—	1.710 (0.086)	1.091 (0.029)			
M01_11	M042271	0.028	—	1.111 (0.079)	0.156 (0.054)	0.132 (0.023)		
M01_12	M042268	0.017	—	1.519 (0.140)	1.053 (0.041)	0.168 (0.013)		
M01_13	M042159	0.075	—	0.453 (0.029)	-0.917 (0.075)			
M01_14	M042164	0.023	—	1.451 (0.062)	0.424 (0.025)			
M01_15	M042167	0.012	—	1.380 (0.064)	0.757 (0.029)			
M02_01	M062208	0.044	—	0.983 (0.042)	-0.180 (0.031)			
M02_02	M062153	0.024	—	0.897 (0.086)	0.495 (0.077)	0.210 (0.029)		
M02_03A	M062111A	0.033	—	1.326 (0.054)	0.095 (0.025)			
M02_03B	M062111B	0.018	—	1.673 (0.073)	0.591 (0.023)			
M02_04	M062237	0.018	—	1.636 (0.080)	1.024 (0.029)			
M02_05	M062314	0.023	—	1.072 (0.054)	1.182 (0.043)			
M02_06	M062074	0.021	—	0.908 (0.119)	1.172 (0.080)	0.276 (0.023)		
M02_07	M062183	0.031	—	0.949 (0.042)	0.245 (0.032)			
M02_08	M062202	0.039	—	1.136 (0.085)	-0.106 (0.066)	0.196 (0.030)		
M02_09	M062246	0.017	—	2.108 (0.194)	1.073 (0.033)	0.172 (0.011)		
M02_10	M062286	0.018	—	1.095 (0.044)	1.329 (0.031)		-0.179 (0.043)	0.179 (0.057)
M02_11	M062325	0.019	—	0.896 (0.126)	1.034 (0.093)	0.366 (0.025)		
M02_12	M062106	0.041	—	0.425 (0.064)	0.789 (0.222)	0.177 (0.057)		
M02_13	M062124	0.020	—	1.455 (0.103)	0.516 (0.037)	0.123 (0.015)		
M03_01	M052209	0.041	—	1.397 (0.091)	-0.170 (0.046)	0.148 (0.024)		
M03_02	M052142	0.028	—	1.004 (0.088)	0.761 (0.055)	0.145 (0.020)		
M03_03	M052006	0.016	—	1.266 (0.131)	0.939 (0.054)	0.273 (0.018)		
M03_04	M052035	0.029	—	1.480 (0.061)	0.249 (0.023)			
M03_05	M052016	0.036	—	1.467 (0.061)	0.367 (0.024)			
M03_06	M052064	0.025	—	1.296 (0.109)	0.512 (0.050)	0.233 (0.020)		

Item		RMSD 2015	RMSD 2019	Slope (a_i)	Location (b_i)	Guessing (c_i)	Step 1 (d_{i1})	Step 2 (d_{i2})
M03_07	M052126	0.017	—	1.790 (0.089)	1.067 (0.028)			
M03_08	M052103	0.040	—	0.964 (0.070)	0.063 (0.064)	0.122 (0.027)		
M03_09	M052066	0.026	—	1.304 (0.103)	0.367 (0.049)	0.213 (0.021)		
M03_10	M052041	0.034	—	1.226 (0.063)	1.273 (0.042)			
M03_11	M052057	0.053	—	0.661 (0.060)	-0.008 (0.124)	0.150 (0.044)		
M03_12	M052417	0.037	—	0.947 (0.041)	0.225 (0.032)			
M03_13	M052501	0.026	—	0.866 (0.042)	0.892 (0.043)			
M03_14	M052410	0.033	—	0.904 (0.096)	0.574 (0.085)	0.281 (0.029)		
M03_15	M052170	0.016	—	1.115 (0.130)	1.116 (0.064)	0.271 (0.019)		
M05_01	M042183	0.038	—	0.703 (0.062)	-0.152 (0.123)	0.163 (0.045)		
M05_02	M042060	0.025	—	1.318 (0.093)	-0.006 (0.050)	0.179 (0.024)		
M05_03	M042019	0.046	—	0.796 (0.037)	0.379 (0.038)			
M05_04	M042023	0.024	—	1.260 (0.053)	0.379 (0.027)			
M05_05	M042197	0.030	—	0.993 (0.047)	0.869 (0.039)			
M05_06	M042234	0.020	—	1.323 (0.093)	0.196 (0.045)	0.157 (0.020)		
M05_07	M042066	0.039	—	0.693 (0.034)	0.133 (0.040)			
M05_08	M042243	0.021	—	1.804 (0.114)	0.277 (0.029)	0.103 (0.013)		
M05_09	M042248	0.023	—	1.434 (0.062)	0.607 (0.026)			
M05_10Z	M042229Z	0.016	—	1.295 (0.044)	0.592 (0.019)		-0.119 (0.033)	0.119 (0.037)
M05_11A	M042080A	0.068	—	0.772 (0.037)	0.437 (0.040)			
M05_11B	M042080B	0.034	—	1.286 (0.068)	1.274 (0.041)			
M05_12	M042120	0.035	—	1.012 (0.087)	-0.090 (0.087)	0.266 (0.035)		
M05_13	M042203	0.025	—	1.404 (0.093)	0.005 (0.043)	0.140 (0.021)		
M05_14	M042264	0.025	—	0.795 (0.043)	1.192 (0.056)			
M05_15	M042255	0.055	—	0.661 (0.053)	-0.443 (0.127)	0.128 (0.047)		
M05_16	M042224	0.056	—	0.921 (0.040)	-0.185 (0.033)			
M06_01	M052017	0.028	—	1.167 (0.086)	0.006 (0.059)	0.185 (0.027)		
M06_02	M052217	0.019	—	1.371 (0.060)	0.667 (0.027)			
M06_03	M052021	0.019	—	1.035 (0.033)	0.566 (0.021)		-0.305 (0.041)	0.305 (0.045)
M06_04	M052095	0.016	—	1.606 (0.067)	0.390 (0.023)			
M06_05	M052094	0.019	—	1.188 (0.058)	1.067 (0.037)			
M06_06	M052131	0.013	—	1.130 (0.107)	0.730 (0.057)	0.233 (0.020)		
M06_07	M052090	0.019	—	1.161 (0.110)	0.776 (0.055)	0.213 (0.020)		
M06_08A	M052121A	0.029	—	0.994 (0.070)	0.197 (0.055)	0.100 (0.023)		
M06_08B	M052121B	0.022	—	1.810 (0.107)	1.439 (0.036)			
M06_09	M052042	0.020	—	0.873 (0.040)	0.460 (0.036)			
M06_10	M052047	0.024	—	1.126 (0.048)	0.248 (0.028)			
M06_11	M052044	0.024	—	1.581 (0.201)	1.115 (0.056)	0.391 (0.016)		
M06_12A	M052422A	0.034	—	0.754 (0.073)	-0.292 (0.146)	0.258 (0.052)		
M06_12B	M052422B	0.034	—	0.691 (0.060)	0.117 (0.104)	0.127 (0.038)		
M06_13	M052505	0.050	—	1.232 (0.096)	-0.860 (0.091)	0.262 (0.049)		

Item		RMSD 2015	RMSD 2019	Slope (a_i)	Location (b_i)	Guessing (c_i)	Step 1 (d_{i1})	Step 2 (d_{i2})
M07_01	M042015	0.048	—	0.863 (0.065)	-0.598 (0.107)	0.167 (0.048)		
M07_02	M042196	0.029	—	1.090 (0.069)	-0.042 (0.051)	0.088 (0.023)		
M07_03	M042194	0.039	—	1.195 (0.050)	-0.519 (0.029)			
M07_04A	M042114A	0.027	—	1.522 (0.062)	-0.108 (0.023)			
M07_04B	M042114B	0.035	—	1.553 (0.064)	0.169 (0.022)			
M07_05	M042112	0.043	—	0.871 (0.119)	1.140 (0.088)	0.313 (0.024)		
M07_06	M042109	0.016	—	1.527 (0.142)	0.968 (0.043)	0.214 (0.015)		
M07_07	M042050	0.015	—	1.074 (0.048)	0.628 (0.032)			
M07_08A	M042074A	0.037	—	1.019 (0.045)	0.487 (0.032)			
M07_08B	M042074B	0.037	—	0.954 (0.044)	0.662 (0.036)			
M07_08C	M042074C	0.023	—	1.690 (0.080)	0.922 (0.026)			
M07_09	M042151	0.032	—	0.818 (0.037)	-0.040 (0.035)			
M07_10	M042132	0.021	—	1.867 (0.185)	1.136 (0.038)	0.204 (0.012)		
M07_11	M042257	0.025	—	0.731 (0.071)	0.789 (0.077)	0.114 (0.026)		
M07_12	M042158	0.028	—	0.723 (0.081)	0.117 (0.144)	0.295 (0.046)		
M07_13	M042252	0.023	—	1.126 (0.099)	0.730 (0.053)	0.182 (0.020)		
M07_14	M042261	0.031	—	0.728 (0.060)	-0.140 (0.109)	0.139 (0.042)		
Items Common in 2015 and 2019:								
MP01_01	MP52024	0.027	0.024	1.646 (0.082)	0.441 (0.026)	0.232 (0.012)		
MP01_02A	MP52058A	0.043	0.045	1.281 (0.035)	-0.364 (0.017)			
MP01_02B	MP52058B	0.014	0.015	1.504 (0.043)	0.882 (0.018)			
MP01_03	MP52125	0.022	0.024	1.196 (0.054)	0.575 (0.027)	0.098 (0.011)		
MP01_04	MP52229	0.039	0.033	0.887 (0.025)	0.000 (0.021)			
MP01_05	MP52063	0.035	0.028	1.320 (0.068)	0.562 (0.030)	0.196 (0.013)		
MP01_06	MP52072	0.041	0.030	1.009 (0.049)	-0.003 (0.046)	0.146 (0.021)		
MP01_07A	MP52146A	0.042	0.030	0.859 (0.025)	0.182 (0.022)			
MP01_07B	MP52146B	0.021	0.021	1.533 (0.048)	1.153 (0.020)			
MP01_08	MP52092	0.022	0.026	1.244 (0.090)	1.514 (0.037)	0.151 (0.008)		
MP01_09	MP52046	0.023	0.025	1.125 (0.086)	1.477 (0.041)	0.188 (0.010)		
MP01_10	MP52083	0.018	0.018	1.501 (0.080)	0.882 (0.025)	0.169 (0.010)		
MP01_11	MP52082	0.034	0.030	1.202 (0.057)	0.161 (0.036)	0.174 (0.017)		
MP01_12	MP52161	0.042	0.033	1.187 (0.056)	-0.210 (0.044)	0.189 (0.022)		
MP01_13A	MP52418A	0.034	0.032	1.908 (0.089)	0.649 (0.020)	0.147 (0.009)		
MP01_13B	MP52418B	0.021	0.014	1.916 (0.100)	0.554 (0.023)	0.250 (0.011)		
MP03_01	MP62005	0.025	0.023	0.871 (0.061)	0.478 (0.064)	0.304 (0.022)		
MP03_02	MP62139	0.020	0.019	0.986 (0.028)	0.583 (0.021)			
MP03_03	MP62164	0.028	0.022	1.357 (0.061)	0.075 (0.031)	0.172 (0.015)		
MP03_04	MP62142	0.034	0.033	0.916 (0.026)	-0.261 (0.021)			
MP03_05	MP62084	0.017	0.022	1.393 (0.102)	1.553 (0.035)	0.144 (0.007)		
MP03_06	MP62351	0.022	0.027	0.804 (0.071)	1.405 (0.056)	0.207 (0.015)		
MP03_07	MP62223	0.031	0.034	1.420 (0.064)	-0.163 (0.033)	0.188 (0.018)		

Item		RMSD 2015	RMSD 2019	Slope (a_i)	Location (b_i)	Guessing (c_i)	Step 1 (d_{i1})	Step 2 (d_{i2})
MP03_08	MP62027	0.027	0.021	0.772 (0.024)	0.556 (0.026)			
MP03_09	MP62174	0.020	0.018	1.403 (0.092)	0.862 (0.034)	0.319 (0.012)		
MP03_10	MP62244	0.019	0.028	0.971 (0.028)	0.462 (0.021)			
MP03_11	MP62261	0.020	0.026	1.889 (0.128)	1.460 (0.025)	0.132 (0.006)		
MP03_12	MP62300	0.029	0.029	0.752 (0.015)	0.412 (0.016)		-0.488 (0.033)	0.488 (0.035)
MP03_13	MP62254	0.024	0.028	0.744 (0.028)	1.490 (0.044)			
MP03_14A	MP62132A	0.037	0.045	1.185 (0.033)	-0.296 (0.018)			
MP03_14B	MP62132B	0.027	0.021	1.049 (0.070)	0.777 (0.044)	0.263 (0.016)		
MP05_01	MP52413	0.034	0.033	1.063 (0.060)	0.027 (0.054)	0.286 (0.023)		
MP05_02	MP52134	0.037	0.036	1.261 (0.053)	-0.270 (0.036)	0.130 (0.019)		
MP05_03	MP52078	0.026	0.026	0.990 (0.061)	0.884 (0.040)	0.183 (0.014)		
MP05_04	MP52034	0.020	0.033	1.216 (0.071)	0.549 (0.038)	0.279 (0.015)		
MP05_05A	MP52174A	0.032	0.032	1.088 (0.030)	0.213 (0.018)			
MP05_05B	MP52174B	0.024	0.019	1.118 (0.034)	1.021 (0.023)			
MP05_06	MP52130	0.019	0.015	1.232 (0.071)	0.970 (0.031)	0.173 (0.011)		
MP05_07	MP52073	0.021	0.018	1.385 (0.066)	0.473 (0.028)	0.174 (0.012)		
MP05_08	MP52110	0.019	0.020	1.464 (0.040)	0.653 (0.016)			
MP05_09	MP52105	0.025	0.026	1.172 (0.040)	1.428 (0.029)			
MP05_10	MP52407	0.012	0.020	1.344 (0.082)	0.359 (0.042)	0.378 (0.016)		
MP05_11	MP52036	0.034	0.029	0.730 (0.023)	0.439 (0.026)			
MP05_12	MP52502	0.045	0.042	1.165 (0.032)	-0.249 (0.018)			
MP05_13	MP52117	0.027	0.035	0.625 (0.028)	2.096 (0.075)			
MP05_14	MP52426	0.069	0.061	0.785 (0.040)	-0.797 (0.092)	0.142 (0.042)		
MP06_01	MP62150	0.039	0.044	1.111 (0.030)	-0.303 (0.019)			
MP06_02	MP62335	0.041	0.032	1.377 (0.061)	-0.106 (0.033)	0.175 (0.017)		
MP06_03	MP62219	0.019	0.020	2.050 (0.112)	0.851 (0.021)	0.218 (0.009)		
MP06_04	MP62002	0.027	0.032	0.703 (0.023)	0.620 (0.028)			
MP06_05	MP62149	0.031	0.032	1.089 (0.052)	0.507 (0.032)	0.111 (0.013)		
MP06_06	MP62241	0.024	0.017	1.708 (0.047)	0.633 (0.014)			
MP06_08	MP62105	0.026	0.027	0.757 (0.015)	0.850 (0.017)		-1.718 (0.062)	1.718 (0.064)
MP06_09	MP62040	0.027	0.023	0.769 (0.061)	0.947 (0.060)	0.224 (0.020)		
MP06_10	MP62288	0.024	0.022	0.776 (0.017)	1.140 (0.020)		-0.880 (0.041)	0.880 (0.047)
MP06_11	MP62173	0.025	0.027	1.119 (0.033)	0.812 (0.021)			
MP06_12	MP62133	0.014	0.019	1.315 (0.071)	0.616 (0.031)	0.214 (0.013)		
MP06_13A	MP62123A	0.021	0.027	1.562 (0.085)	0.354 (0.032)	0.306 (0.014)		
MP06_13B	MP62123B	0.020	0.025	1.444 (0.070)	0.704 (0.025)	0.138 (0.010)		
MP07_01	MP52079	0.026	0.028	0.966 (0.060)	0.424 (0.052)	0.271 (0.020)		
MP07_02	MP52204	0.031	0.026	0.871 (0.051)	0.396 (0.052)	0.180 (0.020)		
MP07_03	MP52364	0.045	0.050	1.177 (0.031)	-0.093 (0.017)			
MP07_04	MP52215	0.043	0.043	0.878 (0.025)	-0.248 (0.022)			
MP07_05	MP52147	0.016	0.020	1.572 (0.091)	0.762 (0.028)	0.275 (0.011)		

Item		RMSD 2015	RMSD 2019	Slope (a_i)	Location (b_i)	Guessing (c_i)	Step 1 (d_{i1})	Step 2 (d_{i2})
MP07_06	MP52067	0.032	0.033	1.063 (0.059)	0.067 (0.051)	0.263 (0.021)		
MP07_07	MP52068	0.016	0.015	1.417 (0.085)	1.264 (0.028)	0.132 (0.008)		
MP07_08	MP52087	0.022	0.028	1.622 (0.051)	1.139 (0.019)			
MP07_09	MP52048	0.021	0.024	1.019 (0.032)	1.148 (0.027)			
MP07_10	MP52039	0.018	0.018	1.235 (0.033)	0.272 (0.017)			
MP07_11	MP52208	0.018	0.018	2.264 (0.113)	1.111 (0.017)	0.081 (0.005)		
MP07_12A	MP52419A	0.048	0.048	0.888 (0.034)	-0.373 (0.042)	0.050 (0.018)		
MP07_12B	MP52419B	0.054	0.048	1.372 (0.055)	-0.672 (0.036)	0.104 (0.022)		
MP07_13	MP52115	0.031	0.021	1.738 (0.068)	0.348 (0.018)	0.080 (0.008)		
MP07_14	MP52421	0.038	0.031	0.824 (0.025)	0.641 (0.025)			
MP09_01	MP62329	0.069	0.074	0.793 (0.043)	-0.836 (0.103)	0.184 (0.046)		
MP09_02	MP62151	0.019	0.025	1.247 (0.035)	0.717 (0.019)			
MP09_03	MP62346	0.024	0.038	1.185 (0.033)	0.646 (0.019)			
MP09_04	MP62212	0.015	0.019	1.397 (0.077)	1.090 (0.026)	0.124 (0.008)		
MP09_05	MP62056	0.021	0.018	1.244 (0.039)	1.127 (0.023)			
MP09_06	MP62317	0.017	0.021	1.328 (0.038)	0.823 (0.018)			
MP09_07	MP62350	0.016	0.019	1.389 (0.099)	1.538 (0.034)	0.129 (0.007)		
MP09_08	MP62078	0.029	0.031	1.441 (0.040)	0.612 (0.016)			
MP09_09	MP62284	0.042	0.052	0.676 (0.056)	0.412 (0.100)	0.290 (0.031)		
MP09_10	MP62245	0.019	0.024	1.273 (0.069)	0.642 (0.031)	0.204 (0.013)		
MP09_11	MP62287	0.022	0.029	1.283 (0.044)	1.390 (0.027)			
MP09_12A	MP62345A	0.047	0.045	0.589 (0.016)	0.447 (0.021)		0.267 (0.034)	-0.267 (0.038)
MP09_13	MP62115	0.024	0.018	1.507 (0.108)	1.358 (0.031)	0.202 (0.009)		
MP11_01	MP62271	0.040	0.031	1.536 (0.081)	0.526 (0.029)	0.252 (0.012)		
MP11_02	MP62152	0.014	0.025	1.197 (0.032)	0.348 (0.017)			
MP11_03	MP62215	0.023	0.027	0.889 (0.019)	0.655 (0.015)		-0.188 (0.027)	0.188 (0.030)
MP11_04	MP62143	0.023	0.020	1.655 (0.047)	0.804 (0.016)			
MP11_05	MP62230	0.020	0.024	1.555 (0.112)	1.358 (0.031)	0.224 (0.008)		
MP11_06	MP62095	0.014	0.013	1.586 (0.080)	0.550 (0.026)	0.219 (0.011)		
MP11_07	MP62076	0.017	0.022	1.745 (0.089)	0.231 (0.028)	0.291 (0.014)		
MP11_08	MP62030	0.054	0.054	0.536 (0.020)	0.058 (0.032)			
MP11_09	MP62171	0.048	0.041	0.832 (0.042)	-0.145 (0.062)	0.128 (0.027)		
MP11_10	MP62301	0.018	0.024	1.080 (0.032)	0.998 (0.024)			
MP11_11	MP62194	0.049	0.039	1.025 (0.058)	-0.273 (0.066)	0.290 (0.028)		
MP11_12	MP62344	0.032	0.033	0.874 (0.028)	1.092 (0.030)			
MP11_13	MP62320	0.020	0.018	1.899 (0.077)	0.470 (0.018)	0.092 (0.008)		
MP11_14	MP62296	0.029	0.043	1.222 (0.033)	0.049 (0.017)			
MP13_01	MP62001	0.020	0.021	1.007 (0.077)	0.847 (0.050)	0.339 (0.016)		
MP13_02	MP62214	0.024	0.020	1.151 (0.031)	0.389 (0.018)			
MP13_03	MP62146	0.023	0.018	1.444 (0.068)	0.705 (0.023)	0.124 (0.010)		
MP13_04	MP62154	0.028	0.034	1.359 (0.036)	-0.086 (0.016)			

Item		RMSD 2015	RMSD 2019	Slope (a_i)	Location (b_i)	Guessing (c_i)	Step 1 (d_{i1})	Step 2 (d_{i2})
MP13_05	MP62067	0.037	0.038	1.159 (0.068)	0.096 (0.051)	0.335 (0.020)		
MP13_06	MP62341	0.027	0.035	0.932 (0.088)	1.643 (0.057)	0.218 (0.012)		
MP13_07	MP62242	0.032	0.024	1.269 (0.059)	0.175 (0.033)	0.171 (0.016)		
MP13_08A	MP62250A	0.025	0.024	1.207 (0.032)	0.138 (0.017)			
MP13_08B	MP62250B	0.021	0.025	1.403 (0.040)	0.817 (0.018)			
MP13_09	MP62170	0.087	0.083	0.535 (0.016)	0.921 (0.027)		0.551 (0.035)	-0.551 (0.046)
MP13_10	MP62192	0.017	0.021	1.044 (0.033)	1.120 (0.026)			
MP13_11	MP62072	0.046	0.045	1.024 (0.028)	0.110 (0.019)			
MP13_13	MP62120	0.029	0.022	1.250 (0.062)	0.465 (0.031)	0.166 (0.013)		
Items Introduced in 2019:								
MP02_01	MP72007	—	0.032	0.528 (0.034)	1.023 (0.082)		-0.407 (0.102)	0.407 (0.137)
MP02_02	MP72025	—	0.023	1.492 (0.214)	0.629 (0.067)	0.195 (0.024)		
MP02_03	MP72017	—	0.024	1.319 (0.106)	1.017 (0.065)			
MP02_04	MP72190	—	0.048	0.740 (0.057)	-0.038 (0.059)			
MP02_05	MP72068	—	0.044	1.285 (0.156)	-0.020 (0.080)	0.185 (0.038)		
MP02_06	MP72076	—	0.036	0.859 (0.127)	0.550 (0.100)	0.092 (0.038)		
MP02_07	MP72056	—	0.028	1.159 (0.082)	0.551 (0.053)			
MP02_08	MP72098	—	0.022	1.597 (0.122)	0.813 (0.049)			
MP02_09	MP72103	—	0.019	1.249 (0.176)	0.645 (0.073)	0.150 (0.026)		
MP02_10	MP72121	—	0.049	1.309 (0.084)	-0.264 (0.037)			
MP02_11	MP72180	—	0.027	0.671 (0.057)	0.634 (0.086)			
MP02_12	MP72198	—	0.024	1.233 (0.089)	0.610 (0.052)			
MP02_13	MP72227	—	0.028	1.507 (0.107)	0.578 (0.045)			
MP02_14	MP72170	—	0.033	0.875 (0.064)	0.071 (0.054)			
MP02_15	MP72209	—	0.018	1.057 (0.097)	1.360 (0.099)			
MP04_01	MP72178	—	0.025	0.933 (0.076)	1.032 (0.082)			
MP04_02	MP72234	—	0.028	0.959 (0.195)	0.942 (0.118)	0.258 (0.034)		
MP04_03	MP72020	—	0.040	0.639 (0.035)	-0.020 (0.042)		-0.266 (0.082)	0.266 (0.087)
MP04_04	MP72027	—	0.025	1.225 (0.150)	0.211 (0.074)	0.154 (0.033)		
MP04_05	MP72052	—	0.036	0.814 (0.080)	1.554 (0.133)			
MP04_06	MP72067	—	0.028	1.318 (0.164)	-0.004 (0.081)	0.218 (0.038)		
MP04_07A	MP72083A	—	0.049	1.406 (0.090)	-0.091 (0.036)			
MP04_07B	MP72083B	—	0.033	0.776 (0.116)	0.469 (0.113)	0.076 (0.044)		
MP04_08A	MP72108A	—	0.049	0.728 (0.056)	-0.011 (0.060)			
MP04_08B	MP72108B	—	0.031	1.025 (0.074)	0.513 (0.056)			
MP04_09	MP72181	—	0.024	1.211 (0.087)	0.634 (0.053)			
MP04_10	MP72126	—	0.041	0.679 (0.037)	0.900 (0.058)		-0.811 (0.102)	0.811 (0.123)
MP04_11	MP72164	—	0.020	0.858 (0.071)	0.981 (0.086)			
MP04_12A	MP72185A	—	0.025	1.612 (0.112)	0.447 (0.039)			
MP04_12B	MP72185B	—	0.027	1.506 (0.105)	0.429 (0.041)			

Item		RMSD 2015	RMSD 2019	Slope (a_i)	Location (b_i)	Guessing (c_i)	Step 1 (d_{i1})	Step 2 (d_{i2})
MP08_01	MP72002	—	0.026	1.517 (0.106)	0.542 (0.042)			
MP08_02	MP72188	—	0.022	1.280 (0.183)	0.770 (0.071)	0.138 (0.023)		
MP08_03	MP72035	—	0.023	1.132 (0.081)	0.551 (0.053)			
MP08_04	MP72055	—	0.023	1.391 (0.102)	0.707 (0.050)			
MP08_05	MP72222	—	0.047	0.603 (0.125)	0.651 (0.177)	0.098 (0.065)		
MP08_06	MP72090	—	0.025	1.211 (0.203)	0.877 (0.085)	0.198 (0.026)		
MP08_07	MP72233	—	0.022	1.075 (0.220)	0.692 (0.119)	0.367 (0.035)		
MP08_08A	MP72106A	—	0.047	1.068 (0.071)	-0.298 (0.043)			
MP08_08B	MP72106B	—	0.024	1.376 (0.097)	0.569 (0.046)			
MP08_08C	MP72106C	—	0.032	1.344 (0.104)	0.887 (0.058)			
MP08_09A	MP72128A	—	0.027	0.999 (0.073)	0.544 (0.058)			
MP08_09B	MP72128B	—	0.042	0.892 (0.058)	1.035 (0.058)		0.042 (0.065)	-0.042 (0.098)
MP08_10	MP72119	—	0.043	0.826 (0.063)	0.425 (0.064)			
MP08_11A	MP72153A	—	0.036	1.021 (0.072)	0.378 (0.053)			
MP08_11B	MP72153B	—	0.018	1.548 (0.140)	1.231 (0.068)			
MP08_12	MP72172	—	0.033	1.048 (0.116)	0.094 (0.075)	0.060 (0.033)		
MP10_01	MP72187	—	0.070	0.770 (0.057)	-0.336 (0.055)			
MP10_02	MP72022	—	0.020	1.631 (0.322)	1.070 (0.083)	0.279 (0.021)		
MP10_04	MP72045	—	0.025	1.307 (0.089)	0.461 (0.046)			
MP10_05	MP72049	—	0.039	0.986 (0.068)	0.059 (0.048)			
MP10_06	MP72069	—	0.052	1.335 (0.085)	-0.062 (0.038)			
MP10_07	MP72074	—	0.027	1.162 (0.090)	0.926 (0.066)			
MP10_08	MP72013	—	0.031	1.126 (0.152)	0.594 (0.075)	0.120 (0.027)		
MP10_09	MP72095	—	0.034	1.416 (0.098)	0.514 (0.045)			
MP10_10	MP72109	—	0.021	1.467 (0.122)	1.084 (0.062)			
MP10_11	MP72125	—	0.026	2.017 (0.268)	0.820 (0.050)	0.107 (0.015)		
MP10_12	MP72196	—	0.032	1.376 (0.096)	0.544 (0.046)			
MP10_13	MP72237	—	0.054	0.963 (0.136)	-0.045 (0.125)	0.194 (0.054)		
MP10_14	MP72232	—	0.049	0.787 (0.059)	-0.072 (0.056)			
MP10_15	MP72206	—	0.024	1.330 (0.120)	1.289 (0.079)			
MP12_01	MP72001	—	0.021	1.523 (0.109)	0.611 (0.046)			
MP12_02	MP72019	—	0.030	1.726 (0.118)	0.391 (0.037)			
MP12_03	MP72189	—	0.051	0.993 (0.162)	0.246 (0.120)	0.262 (0.046)		
MP12_04	MP72024	—	0.044	0.899 (0.069)	0.616 (0.068)			
MP12_05	MP72043	—	0.022	2.286 (0.337)	0.759 (0.050)	0.171 (0.016)		
MP12_06	MP72221	—	0.041	1.207 (0.173)	0.331 (0.084)	0.219 (0.034)		
MP12_07	MP72220	—	0.023	1.330 (0.259)	1.153 (0.097)	0.202 (0.021)		
MP12_08	MP72225	—	0.027	1.263 (0.088)	0.450 (0.048)			
MP12_09A	MP72110A	—	0.025	1.493 (0.107)	0.586 (0.046)			
MP12_09B	MP72110B	—	0.018	1.649 (0.130)	0.873 (0.051)			
MP12_10	MP72150	—	0.019	1.827 (0.346)	0.413 (0.083)	0.481 (0.027)		

Item		RMSD 2015	RMSD 2019	Slope (a_i)	Location (b_i)	Guessing (c_i)	Step 1 (d_{i1})	Step 2 (d_{i2})
MP12_11	MP72139	—	0.019	1.155 (0.093)	0.995 (0.072)			
MP12_12	MP72229	—	0.013	0.966 (0.067)	1.433 (0.069)		-1.025 (0.143)	1.025 (0.170)
MP12_13	MP72171	—	0.026	1.437 (0.099)	0.405 (0.043)			
MP12_14A	MP72211A	—	0.022	1.497 (0.213)	0.472 (0.068)	0.220 (0.027)		
MP14_01	MP72005	—	0.039	0.704 (0.113)	0.125 (0.169)	0.100 (0.068)		
MP14_02	MP72021	—	0.036	0.916 (0.065)	0.241 (0.054)			
MP14_03	MP72026	—	0.057	0.651 (0.055)	0.615 (0.085)			
MP14_04A	MP72041A	—	0.024	1.268 (0.083)	0.104 (0.040)			
MP14_04B	MP72041B	—	0.035	1.471 (0.098)	0.364 (0.040)			
MP14_05	MP72223	—	0.019	1.948 (0.294)	0.663 (0.058)	0.250 (0.021)		
MP14_06	MP72094	—	0.053	1.172 (0.077)	-0.033 (0.041)			
MP14_07	MP72059	—	0.024	1.363 (0.096)	0.616 (0.048)			
MP14_08	MP72080	—	0.016	1.587 (0.217)	0.874 (0.061)	0.118 (0.017)		
MP14_09	MP72081	—	0.028	0.961 (0.075)	0.861 (0.072)			
MP14_10	MP72140	—	0.031	0.837 (0.062)	0.344 (0.060)			
MP14_11	MP72120	—	0.022	1.146 (0.085)	0.779 (0.060)			
MP14_12	MP72131	—	0.018	1.349 (0.119)	1.286 (0.076)			
MP14_13	MP72147	—	0.013	1.697 (0.149)	1.172 (0.060)			
MP14_14	MP72154	—	0.034	1.325 (0.164)	0.106 (0.075)	0.189 (0.035)		
MP14_15	MP72192	—	0.032	1.009 (0.157)	0.444 (0.104)	0.209 (0.040)		
MP14_16	MP72161	—	0.035	1.164 (0.084)	0.618 (0.054)			

Appendix 12D: Science Item Parameters from the paperTIMSS 2019 Concurrent Calibration—Grade 8

Item		RMSD 2015	RMSD 2019	Slope (a_i)	Location (b_i)	Guessing (c_i)	Step 1 (d_{i1})	Step 2 (d_{i2})
Items Released in 2015:								
S01_01	S042258	0.018	—	0.791 (0.098)	1.025 (0.078)	0.186 (0.026)		
S01_02	S042005	0.024	—	0.353 (0.012)	0.568 (0.043)		-2.479 (0.126)	2.479 (0.131)
S01_03	S042016	0.019	—	1.022 (0.115)	1.220 (0.060)	0.135 (0.017)		
S01_04A	S042300A	0.030	—	1.349 (0.056)	0.064 (0.024)			
S01_04B	S042300B	0.056	—	0.549 (0.042)	1.743 (0.116)			
S01_04C	S042300C	0.026	—	1.132 (0.049)	0.132 (0.027)			
S01_05	S042319	0.022	—	1.345 (0.063)	0.762 (0.028)			
S01_06	S042068	0.020	—	1.305 (0.142)	1.022 (0.049)	0.220 (0.017)		
S01_07	S042216	0.026	—	1.045 (0.110)	0.414 (0.078)	0.338 (0.029)		
S01_08	S042249	0.024	—	0.771 (0.076)	0.474 (0.083)	0.163 (0.032)		
S01_09	S042094	0.024	—	0.832 (0.044)	0.761 (0.041)			
S01_10A	S042293A	0.040	—	0.917 (0.042)	-0.393 (0.035)			
S01_10B	S042293B	0.015	—	0.905 (0.065)	1.813 (0.092)			
S01_11	S042195	0.015	—	0.617 (0.047)	1.856 (0.118)			
S01_12	S042400	0.019	—	1.017 (0.053)	0.976 (0.040)			
S01_14	S042164	0.023	—	1.015 (0.087)	0.503 (0.056)	0.154 (0.024)		
S02_01	S062189	0.034	—	0.450 (0.022)	0.004 (0.038)		0.311 (0.069)	-0.311 (0.068)
S02_02	S062094	0.023	—	0.981 (0.087)	0.444 (0.063)	0.188 (0.026)		
S02_03	S062118	0.050	—	0.886 (0.041)	-0.004 (0.032)			
S02_04A	S062103A	0.022	—	1.125 (0.109)	0.562 (0.060)	0.265 (0.024)		
S02_04B	S062103B	0.027	—	0.723 (0.033)	1.006 (0.036)		0.218 (0.043)	-0.218 (0.060)
S02_05	S062010	0.028	—	0.513 (0.034)	0.830 (0.065)			
S02_06	S062253	0.024	—	0.876 (0.083)	0.852 (0.058)	0.115 (0.021)		
S02_07	S062051	0.023	—	0.905 (0.046)	0.776 (0.038)			
S02_08	S062044	0.019	—	1.091 (0.124)	1.326 (0.061)	0.121 (0.015)		
S02_09	S062046	0.032	—	0.896 (0.042)	0.166 (0.032)			
S02_10	S062149	0.029	—	0.442 (0.032)	0.908 (0.078)			
S02_11	S062268	0.035	—	0.997 (0.080)	-0.354 (0.091)	0.253 (0.039)		
S02_12	S062170	0.030	—	0.697 (0.088)	0.247 (0.146)	0.336 (0.044)		
S02_13	S062234	0.050	—	0.811 (0.033)	0.605 (0.027)		0.677 (0.037)	-0.677 (0.047)
S02_14	S062271	0.018	—	0.743 (0.110)	1.028 (0.101)	0.284 (0.031)		
S03_01	S052261	0.021	—	0.936 (0.096)	0.705 (0.066)	0.214 (0.025)		
S03_02Z	S052092Z	0.068	—	0.364 (0.019)	0.733 (0.054)		0.998 (0.077)	-0.998 (0.095)
S03_03A	S052263A	0.031	—	1.419 (0.077)	1.222 (0.037)			
S03_03B	S052263B	0.029	—	1.637 (0.080)	0.972 (0.027)			
S03_04	S052265	0.039	—	0.787 (0.043)	0.904 (0.047)			
S03_05	S052280	0.026	—	0.994 (0.095)	0.418 (0.071)	0.259 (0.028)		

Item		RMSD 2015	RMSD 2019	Slope (a_i)	Location (b_i)	Guessing (c_i)	Step 1 (d_{i1})	Step 2 (d_{i2})
S03_06	S052256	0.024	—	1.175 (0.104)	0.694 (0.048)	0.185 (0.020)		
S03_07Z	S052043Z	0.024	—	0.531 (0.035)	1.089 (0.074)			
S03_08	S052194	0.023	—	1.174 (0.113)	0.771 (0.051)	0.218 (0.021)		
S03_09	S052179	0.018	—	0.931 (0.114)	1.060 (0.069)	0.225 (0.023)		
S03_10	S052233	0.022	—	0.711 (0.048)	1.601 (0.086)			
S03_11	S052159	0.035	—	0.483 (0.077)	0.299 (0.255)	0.321 (0.061)		
S03_12A	S052289A	0.066	—	0.840 (0.067)	-0.998 (0.134)	0.226 (0.055)		
S03_12B	S052289B	0.027	—	0.658 (0.081)	0.848 (0.098)	0.174 (0.033)		
S03_12C	S052289C	0.035	—	0.847 (0.044)	0.729 (0.040)			
S05_01	S042053	0.026	—	1.216 (0.092)	-0.167 (0.064)	0.243 (0.030)		
S05_02	S042408	0.019	—	0.740 (0.040)	0.630 (0.042)			
S05_03	S042015	0.024	—	0.902 (0.094)	0.629 (0.072)	0.223 (0.027)		
S05_04	S042309	0.041	—	0.369 (0.062)	1.045 (0.231)	0.166 (0.054)		
S05_05A	S042049A	0.050	—	1.048 (0.047)	-0.596 (0.035)			
S05_05B	S042049B	0.033	—	1.187 (0.052)	0.220 (0.026)			
S05_06	S042182	0.043	—	0.660 (0.060)	-0.466 (0.144)	0.186 (0.050)		
S05_07	S042402	0.017	—	0.909 (0.051)	1.126 (0.050)			
S05_08A	S042228A	0.018	—	1.465 (0.077)	1.100 (0.033)			
S05_08B	S042228B	0.023	—	1.336 (0.057)	0.012 (0.024)			
S05_08C	S042228C	0.022	—	1.542 (0.068)	0.504 (0.022)			
S05_09	S042126	0.020	—	0.806 (0.099)	0.214 (0.129)	0.402 (0.039)		
S05_10	S042210	0.021	—	0.985 (0.185)	1.587 (0.112)	0.312 (0.020)		
S05_11	S042176	0.023	—	1.069 (0.051)	0.650 (0.032)			
S05_12	S042211	0.022	—	0.885 (0.042)	0.110 (0.032)			
S05_13	S042135	0.030	—	0.791 (0.039)	-0.238 (0.038)			
S05_14	S042257	0.016	—	0.543 (0.106)	1.313 (0.164)	0.304 (0.040)		
S06_01	S052003	0.022	—	0.911 (0.100)	0.122 (0.108)	0.393 (0.036)		
S06_02	S052071	0.018	—	1.310 (0.102)	0.469 (0.043)	0.172 (0.020)		
S06_03	S052246	0.019	—	0.909 (0.103)	0.850 (0.070)	0.227 (0.025)		
S06_04	S052276	0.032	—	0.739 (0.070)	-0.025 (0.112)	0.212 (0.040)		
S06_05A	S052303A	0.030	—	0.631 (0.070)	0.012 (0.150)	0.239 (0.048)		
S06_05B	S052303B	0.021	—	0.795 (0.041)	0.611 (0.039)			
S06_06	S052125	0.028	—	0.751 (0.125)	0.913 (0.123)	0.422 (0.032)		
S06_07	S052145	0.022	—	1.201 (0.053)	0.389 (0.026)			
S06_08	S052049	0.037	—	0.690 (0.032)	0.861 (0.034)		0.456 (0.043)	-0.456 (0.059)
S06_09	S052063	0.027	—	0.639 (0.074)	0.524 (0.112)	0.189 (0.038)		
S06_10	S052192	0.020	—	1.421 (0.088)	0.206 (0.035)	0.098 (0.017)		
S06_11	S052232	0.020	—	0.472 (0.093)	1.664 (0.178)	0.200 (0.039)		
S06_12	S052141	0.016	—	1.278 (0.062)	0.876 (0.031)			
S06_13	S052096	0.025	—	0.948 (0.084)	-0.089 (0.091)	0.277 (0.036)		
S06_14	S052116	0.029	—	0.870 (0.033)	0.205 (0.022)		0.172 (0.039)	-0.172 (0.039)

Item		RMSD 2015	RMSD 2019	Slope (a_i)	Location (b_i)	Guessing (c_i)	Step 1 (d_{i1})	Step 2 (d_{i2})
S06_15	S052110	0.019	—	0.861 (0.049)	1.084 (0.050)			
S07_01	S042042	0.046	—	0.638 (0.070)	-0.431 (0.192)	0.304 (0.058)		
S07_02	S042030	0.016	—	0.864 (0.049)	1.098 (0.050)			
S07_03	S042003	0.021	—	0.685 (0.108)	1.079 (0.112)	0.287 (0.033)		
S07_04	S042110	0.052	—	0.596 (0.054)	-0.549 (0.157)	0.160 (0.052)		
S07_05A	S042222A	0.018	—	0.961 (0.055)	1.238 (0.052)			
S07_05B	S042222B	0.017	—	0.957 (0.049)	0.842 (0.038)			
S07_05C	S042222C	0.030	—	0.823 (0.074)	-0.133 (0.105)	0.235 (0.040)		
S07_06	S042065	0.050	—	0.724 (0.072)	-0.925 (0.194)	0.335 (0.064)		
S07_07	S042280	0.022	—	1.268 (0.090)	0.202 (0.046)	0.155 (0.022)		
S07_08	S042088	0.030	—	0.666 (0.035)	0.108 (0.041)			
S07_09	S042218	0.016	—	1.339 (0.114)	0.453 (0.049)	0.246 (0.022)		
S07_10	S042104	0.025	—	0.862 (0.048)	1.065 (0.049)			
S07_11	S042064	0.024	—	0.765 (0.041)	0.712 (0.043)			
S07_12	S042273	0.024	—	1.171 (0.051)	0.243 (0.026)			
S07_13	S042301	0.027	—	0.820 (0.040)	0.102 (0.034)			
S07_14	S042312	0.045	—	0.372 (0.050)	-0.414 (0.352)	0.219 (0.077)		
S07_15	S042217	0.022	—	1.769 (0.158)	0.717 (0.036)	0.246 (0.016)		
S07_16	S042406	0.018	—	1.060 (0.052)	0.710 (0.033)			
Items Common in 2015 and 2019:								
SP01_01	SP52006	0.048	0.050	0.635 (0.017)	-0.098 (0.019)		0.620 (0.034)	-0.620 (0.030)
SP01_02	SP52069	0.023	0.029	0.984 (0.072)	0.601 (0.051)	0.325 (0.018)		
SP01_03	SP52012	0.020	0.026	0.947 (0.051)	0.342 (0.042)	0.163 (0.018)		
SP01_04	SP52021	0.019	0.028	1.029 (0.031)	0.638 (0.020)			
SP01_05Z	SP52095Z	0.040	0.038	0.505 (0.020)	-0.198 (0.035)			
SP01_06	SP52134	0.024	0.033	2.121 (0.201)	1.373 (0.029)	0.296 (0.009)		
SP01_07	SP52054	0.047	0.038	0.749 (0.024)	-0.380 (0.027)			
SP01_08	SP52150	0.020	0.030	0.787 (0.067)	1.170 (0.051)	0.181 (0.017)		
SP01_09A	SP52243A	0.028	0.029	0.624 (0.022)	0.373 (0.028)			
SP01_09B	SP52243B	0.032	0.025	0.769 (0.025)	0.394 (0.024)			
SP01_09C	SP52243C	0.029	0.027	0.671 (0.061)	1.026 (0.065)	0.200 (0.022)		
SP01_10	SP52206	0.022	0.022	1.127 (0.063)	0.478 (0.036)	0.207 (0.016)		
SP01_11A	SP52112A	0.031	0.037	0.672 (0.046)	-0.042 (0.095)	0.221 (0.033)		
SP01_11B	SP52112B	0.026	0.028	0.992 (0.031)	0.764 (0.022)			
SP01_12	SP52294	0.034	0.026	1.085 (0.054)	-0.084 (0.045)	0.206 (0.021)		
SP03_01	SP62055	0.040	0.032	0.962 (0.067)	-0.088 (0.079)	0.438 (0.026)		
SP03_02	SP62007	0.022	0.022	1.176 (0.064)	0.457 (0.034)	0.205 (0.015)		
SP03_03	SP62275	0.046	0.023	0.888 (0.029)	0.786 (0.024)			
SP03_04	SP62225	0.022	0.022	1.004 (0.098)	1.334 (0.050)	0.259 (0.014)		
SP03_05	SP62111	0.033	0.034	0.587 (0.016)	0.516 (0.020)		0.033 (0.034)	-0.033 (0.038)
SP03_06A	SP62116A	0.027	0.025	1.164 (0.034)	0.529 (0.017)			

Item		RMSD 2015	RMSD 2019	Slope (a_i)	Location (b_i)	Guessing (c_i)	Step 1 (d_{i1})	Step 2 (d_{i2})
SP03_06B	SP62116B	0.019	0.029	1.319 (0.041)	0.859 (0.018)			
SP03_06C	SP62116C	0.021	0.027	0.946 (0.035)	1.247 (0.033)			
SP03_07	SP62262	0.017	0.023	0.891 (0.080)	1.063 (0.051)	0.277 (0.017)		
SP03_08	SP62035	0.023	0.022	1.076 (0.077)	1.029 (0.036)	0.199 (0.013)		
SP03_09	SP62144	0.061	0.062	0.725 (0.040)	-0.600 (0.090)	0.163 (0.035)		
SP03_10	SP62162	0.023	0.025	0.777 (0.027)	0.813 (0.028)			
SP03_11	SP62233	0.021	0.015	0.927 (0.077)	0.753 (0.055)	0.343 (0.019)		
SP03_13	SP62171	0.039	0.031	0.384 (0.048)	0.825 (0.188)	0.185 (0.047)		
SP05_01	SP52076	0.030	0.034	0.934 (0.059)	0.343 (0.052)	0.257 (0.021)		
SP05_02	SP52272	0.037	0.044	1.130 (0.031)	-0.074 (0.018)			
SP05_03A	SP52085A	0.020	0.024	1.038 (0.036)	1.164 (0.028)			
SP05_03B	SP52085B	0.045	0.045	1.034 (0.029)	-0.059 (0.019)			
SP05_04	SP52094	0.026	0.028	0.614 (0.024)	0.963 (0.038)			
SP05_05	SP52248	0.021	0.021	1.188 (0.148)	1.547 (0.061)	0.364 (0.012)		
SP05_06	SP52146	0.031	0.026	1.023 (0.030)	0.343 (0.019)			
SP05_07	SP52282	0.028	0.028	0.828 (0.059)	0.790 (0.048)	0.185 (0.018)		
SP05_08	SP52299	0.027	0.025	1.224 (0.072)	0.325 (0.041)	0.309 (0.017)		
SP05_09	SP52144	0.016	0.026	1.160 (0.072)	0.642 (0.036)	0.249 (0.015)		
SP05_10	SP52214	0.032	0.028	0.996 (0.029)	0.288 (0.019)			
SP05_12	SP52101	0.037	0.026	0.563 (0.023)	0.975 (0.041)			
SP05_13	SP52113	0.027	0.020	1.565 (0.089)	0.529 (0.029)	0.292 (0.013)		
SP05_14	SP52107	0.022	0.021	1.000 (0.084)	1.260 (0.043)	0.197 (0.013)		
SP06_01	SP62090	0.038	0.038	1.011 (0.061)	0.112 (0.055)	0.304 (0.022)		
SP06_02	SP62274	0.050	0.050	0.577 (0.015)	0.811 (0.024)		1.149 (0.032)	-1.149 (0.044)
SP06_03	SP62284	0.047	0.052	0.375 (0.042)	0.410 (0.211)	0.172 (0.050)		
SP06_04A	SP62098A	0.036	0.035	0.639 (0.016)	0.432 (0.018)		-0.050 (0.033)	0.050 (0.035)
SP06_04B	SP62098B	0.016	0.023	0.798 (0.023)	1.269 (0.024)		-0.091 (0.029)	0.091 (0.041)
SP06_05	SP62032	0.042	0.037	1.742 (0.171)	1.436 (0.036)	0.287 (0.009)		
SP06_06	SP62043	0.033	0.016	0.907 (0.031)	0.914 (0.026)			
SP06_07	SP62158	0.034	0.032	0.697 (0.062)	0.610 (0.082)	0.299 (0.026)		
SP06_08	SP62159	0.035	0.027	0.983 (0.056)	0.333 (0.044)	0.204 (0.019)		
SP06_09	SP62005	0.026	0.032	1.250 (0.036)	0.598 (0.017)			
SP06_10	SP62075	0.019	0.030	0.990 (0.074)	0.702 (0.049)	0.314 (0.018)		
SP06_11	SP62004	0.022	0.025	1.806 (0.095)	0.817 (0.020)	0.173 (0.009)		
SP06_12	SP62175	0.054	0.043	0.739 (0.025)	0.607 (0.026)			
SP06_13A	SP62173A	0.032	0.035	0.702 (0.024)	0.266 (0.025)			
SP06_13B	SP62173B	0.020	0.020	0.808 (0.100)	1.794 (0.086)	0.203 (0.014)		
SP07_01A	SP52090A	0.042	0.036	0.494 (0.062)	0.472 (0.186)	0.393 (0.041)		
SP07_01B	SP52090B	0.041	0.022	0.609 (0.030)	1.894 (0.075)			
SP07_02	SP52262	0.030	0.026	0.694 (0.060)	0.843 (0.066)	0.227 (0.023)		
SP07_03	SP52267	0.024	0.029	0.988 (0.064)	0.695 (0.041)	0.216 (0.016)		

Item		RMSD 2015	RMSD 2019	Slope (a_i)	Location (b_i)	Guessing (c_i)	Step 1 (d_{i1})	Step 2 (d_{i2})
SP07_04	SP52273	0.035	0.035	0.638 (0.018)	0.866 (0.022)		0.174 (0.031)	-0.174 (0.039)
SP07_05Z	SP52015Z	0.043	0.043	0.830 (0.025)	-0.301 (0.024)			
SP07_06	SP52051	0.028	0.026	1.005 (0.032)	0.748 (0.021)			
SP07_07	SP52026	0.048	0.048	0.587 (0.059)	0.400 (0.129)	0.350 (0.034)		
SP07_08	SP52130	0.020	0.026	0.909 (0.075)	1.134 (0.045)	0.215 (0.015)		
SP07_09	SP52028	0.030	0.027	0.858 (0.063)	0.552 (0.058)	0.282 (0.021)		
SP07_10	SP52189	0.028	0.045	1.041 (0.030)	0.382 (0.018)			
SP07_11	SP52217	0.025	0.022	0.722 (0.070)	0.991 (0.068)	0.283 (0.022)		
SP07_12	SP52038	0.020	0.019	0.994 (0.079)	0.909 (0.045)	0.290 (0.016)		
SP07_13	SP52099	0.032	0.026	0.947 (0.031)	0.817 (0.023)			
SP07_14	SP52118	0.017	0.025	0.766 (0.030)	1.225 (0.038)			
SP09_01	SP62099	0.031	0.028	0.842 (0.047)	0.256 (0.050)	0.146 (0.021)		
SP09_02	SP62095	0.024	0.030	0.501 (0.015)	0.683 (0.024)		-0.076 (0.039)	0.076 (0.046)
SP09_03	SP62106	0.056	0.055	0.750 (0.037)	-0.721 (0.078)	0.116 (0.032)		
SP09_04	SP62064	0.048	0.033	0.879 (0.026)	-0.356 (0.023)			
SP09_05	SP62132	0.021	0.029	0.992 (0.063)	0.332 (0.052)	0.289 (0.020)		
SP09_06	SP62163	0.016	0.026	1.196 (0.043)	1.308 (0.028)			
SP09_07	SP62153	0.015	0.025	1.278 (0.089)	0.853 (0.035)	0.294 (0.013)		
SP09_08	SP62018	0.028	0.032	0.520 (0.015)	1.485 (0.038)		-0.653 (0.046)	0.653 (0.061)
SP09_09	SP62143	0.025	0.017	0.850 (0.037)	1.704 (0.052)			
SP09_10	SP62276	0.030	0.027	0.718 (0.027)	0.995 (0.034)			
SP09_11	SP62050	0.039	0.022	0.920 (0.031)	1.006 (0.027)			
SP09_12	SP62205	0.024	0.023	1.100 (0.066)	0.825 (0.032)	0.158 (0.013)		
SP09_13	SP62190	0.035	0.031	0.883 (0.045)	0.023 (0.051)	0.140 (0.022)		
SP09_14A	SP62024A	0.027	0.023	0.605 (0.059)	0.876 (0.085)	0.226 (0.028)		
SP09_14B	SP62024B	0.018	0.020	0.801 (0.032)	1.446 (0.044)			
SP11_01	SP62279	0.046	0.049	1.185 (0.055)	0.007 (0.037)	0.187 (0.017)		
SP11_02	SP62112	0.058	0.039	0.534 (0.020)	0.216 (0.032)			
SP11_03	SP62119	0.028	0.025	1.214 (0.063)	0.158 (0.038)	0.249 (0.017)		
SP11_04	SP62093	0.048	0.036	0.630 (0.017)	0.063 (0.018)		0.306 (0.033)	-0.306 (0.032)
SP11_05	SP62089	0.015	0.030	1.347 (0.078)	0.934 (0.026)	0.153 (0.010)		
SP11_06	SP62006	0.033	0.036	0.953 (0.028)	0.362 (0.020)			
SP11_07	SP62067	0.036	0.026	0.823 (0.026)	0.365 (0.022)			
SP11_08	SP62247	0.030	0.030	0.977 (0.090)	1.232 (0.048)	0.268 (0.014)		
SP11_09	SP62177	0.021	0.019	0.711 (0.062)	1.008 (0.060)	0.207 (0.020)		
SP11_10	SP62186	0.023	0.026	1.545 (0.119)	1.177 (0.030)	0.263 (0.010)		
SP11_11A	SP62211A	0.024	0.026	0.814 (0.026)	0.346 (0.022)			
SP11_11B	SP62211B	0.017	0.020	0.868 (0.045)	2.081 (0.075)			
SP11_13	SP62033	0.035	0.021	1.106 (0.034)	0.694 (0.019)			
SP11_14	SP62037	0.027	0.028	0.747 (0.062)	0.564 (0.074)	0.305 (0.024)		
SP11_15	SP62242	0.080	0.072	0.786 (0.026)	-1.200 (0.038)			

Item		RMSD 2015	RMSD 2019	Slope (a_i)	Location (b_i)	Guessing (c_i)	Step 1 (d_{i1})	Step 2 (d_{i2})
SP13_01A	SP62091A	0.034	0.042	0.958 (0.053)	-0.706 (0.081)	0.304 (0.035)		
SP13_01B	SP62091B	0.054	0.051	0.587 (0.035)	-1.185 (0.152)	0.167 (0.054)		
SP13_02	SP62100	0.024	0.024	0.898 (0.027)	0.336 (0.021)			
SP13_03	SP62097	0.021	0.029	0.909 (0.049)	0.266 (0.046)	0.147 (0.020)		
SP13_04	SP62101	0.027	0.026	0.668 (0.018)	0.179 (0.017)		0.287 (0.031)	-0.287 (0.031)
SP13_06	SP62128	0.027	0.028	0.867 (0.026)	-0.024 (0.021)			
SP13_07	SP62047	0.048	0.058	0.497 (0.021)	0.592 (0.037)			
SP13_08	SP62042	0.027	0.024	0.710 (0.025)	0.639 (0.028)			
SP13_09	SP62250	0.051	0.033	0.580 (0.024)	1.200 (0.047)			
SP13_10	SP62246	0.020	0.022	0.924 (0.088)	1.189 (0.051)	0.288 (0.016)		
SP13_11	SP62056	0.022	0.027	1.147 (0.033)	0.428 (0.017)			
SP13_12	SP62235	0.027	0.023	0.765 (0.060)	0.854 (0.056)	0.195 (0.020)		
SP13_13	SP62180	0.019	0.023	1.210 (0.062)	0.259 (0.036)	0.211 (0.017)		
SP13_14	SP62022	0.025	0.029	0.562 (0.022)	0.621 (0.034)			
SP13_15	SP62243	0.027	0.031	0.664 (0.015)	-0.015 (0.017)		-0.331 (0.036)	0.331 (0.034)
Items Introduced in 2019:								
SP02_01	SP72072	—	0.031	0.824 (0.145)	0.518 (0.125)	0.216 (0.046)		
SP02_02	SP72029	—	0.030	1.324 (0.310)	1.057 (0.102)	0.364 (0.027)		
SP02_03	SP72902	—	0.048	1.017 (0.071)	0.145 (0.046)			
SP02_04	SP72077	—	0.032	0.685 (0.150)	0.395 (0.203)	0.300 (0.064)		
SP02_05A	SP72900A	—	0.037	0.959 (0.079)	0.884 (0.069)			
SP02_05B	SP72900B	—	0.022	0.954 (0.093)	1.360 (0.104)			
SP02_06	SP72103	—	0.048	0.500 (0.049)	-0.078 (0.084)			
SP02_07	SP72110	—	0.026	0.773 (0.069)	0.982 (0.089)			
SP02_08	SP72130	—	0.029	0.559 (0.057)	0.992 (0.118)			
SP02_09	SP72148	—	0.030	0.679 (0.153)	1.158 (0.145)	0.132 (0.042)		
SP02_10	SP72200	—	0.029	0.854 (0.129)	0.672 (0.092)	0.103 (0.034)		
SP02_11	SP72232	—	0.042	1.433 (0.096)	0.257 (0.036)			
SP02_12	SP72275	—	0.057	1.016 (0.108)	-0.521 (0.106)	0.117 (0.050)		
SP02_13	SP72244	—	0.030	0.950 (0.072)	0.497 (0.055)			
SP02_14	SP72301	—	0.020	0.936 (0.217)	1.199 (0.127)	0.220 (0.032)		
SP02_15	SP72721	—	0.033	1.028 (0.130)	0.253 (0.084)	0.137 (0.036)		
SP02_16	SP72335	—	0.029	0.859 (0.147)	0.552 (0.115)	0.199 (0.043)		
SP04_01	SP72002	—	0.031	1.393 (0.172)	0.239 (0.068)	0.212 (0.031)		
SP04_03	SP72021	—	0.035	0.896 (0.140)	0.336 (0.115)	0.221 (0.044)		
SP04_04	SP72082	—	0.057	0.960 (0.069)	0.291 (0.050)			
SP04_05	SP72066	—	0.032	0.837 (0.128)	0.591 (0.099)	0.123 (0.037)		
SP04_06	SP72063	—	0.026	0.582 (0.246)	1.996 (0.389)	0.200 (0.047)		
SP04_07	SP72102	—	0.043	0.482 (0.049)	0.544 (0.102)			
SP04_08A	SP72141A	—	0.024	1.069 (0.086)	0.876 (0.063)			
SP04_08B	SP72141B	—	0.032	0.731 (0.045)	0.601 (0.047)		-0.141 (0.075)	0.141 (0.090)

Item		RMSD 2015	RMSD 2019	Slope (a_i)	Location (b_i)	Guessing (c_i)	Step 1 (d_{i1})	Step 2 (d_{i2})
SP04_09	SP72921	—	0.021	0.766 (0.077)	1.371 (0.122)			
SP04_10	SP72234	—	0.029	1.141 (0.277)	1.472 (0.139)	0.167 (0.022)		
SP04_11	SP72251	—	0.020	1.064 (0.189)	0.855 (0.090)	0.208 (0.030)		
SP04_12	SP72284	—	0.046	0.786 (0.058)	-0.058 (0.055)			
SP04_13	SP72345	—	0.048	0.860 (0.054)	0.372 (0.040)		0.552 (0.056)	-0.552 (0.068)
SP04_14	SP72349	—	0.037	1.086 (0.134)	0.083 (0.089)	0.178 (0.039)		
SP04_15	SP72363	—	0.049	0.613 (0.102)	0.073 (0.188)	0.101 (0.067)		
SP08_01	SP72070	—	0.057	0.568 (0.111)	-0.261 (0.322)	0.207 (0.099)		
SP08_02	SP72400	—	0.038	0.859 (0.061)	-0.012 (0.051)			
SP08_03	SP72024	—	0.046	0.891 (0.105)	-0.094 (0.107)	0.113 (0.045)		
SP08_04	SP72462	—	0.036	0.490 (0.138)	0.724 (0.286)	0.198 (0.086)		
SP08_05	SP72443	—	0.024	1.165 (0.254)	0.983 (0.103)	0.334 (0.030)		
SP08_06	SP72903	—	0.039	0.796 (0.048)	0.754 (0.046)		-0.090 (0.067)	0.090 (0.084)
SP08_07	SP72145	—	0.018	0.949 (0.091)	1.373 (0.102)			
SP08_08	SP72100	—	0.039	0.560 (0.132)	0.579 (0.227)	0.195 (0.073)		
SP08_10	SP72137	—	0.037	0.836 (0.132)	0.367 (0.122)	0.194 (0.046)		
SP08_11	SP72298	—	0.033	0.814 (0.064)	0.558 (0.063)			
SP08_12	SP72215	—	0.023	0.515 (0.033)	0.963 (0.072)		-0.538 (0.104)	0.538 (0.130)
SP08_13	SP72260	—	0.032	0.671 (0.056)	0.451 (0.071)			
SP08_14	SP72265	—	0.041	0.708 (0.057)	0.249 (0.063)			
SP08_15	SP72347	—	0.031	1.061 (0.208)	1.117 (0.099)	0.186 (0.028)		
SP08_16	SP72351	—	0.029	0.847 (0.072)	0.930 (0.077)			
SP08_17	SP72367	—	0.029	1.114 (0.159)	0.638 (0.076)	0.156 (0.030)		
SP10_01	SP72033	—	0.033	0.649 (0.035)	0.355 (0.044)		-0.436 (0.084)	0.436 (0.094)
SP10_02	SP72440	—	0.043	0.670 (0.053)	-0.347 (0.063)			
SP10_03	SP72032	—	0.029	1.540 (0.315)	1.001 (0.083)	0.315 (0.024)		
SP10_04	SP72031	—	0.025	0.655 (0.139)	0.941 (0.143)	0.137 (0.047)		
SP10_05	SP72086	—	0.038	0.556 (0.049)	-0.161 (0.073)			
SP10_06	SP72005	—	0.038	1.030 (0.065)	0.729 (0.040)		0.248 (0.050)	-0.248 (0.070)
SP10_08	SP72123	—	0.033	0.551 (0.125)	-0.003 (0.329)	0.249 (0.095)		
SP10_09	SP72116	—	0.026	0.574 (0.180)	1.172 (0.213)	0.198 (0.060)		
SP10_10	SP72920	—	0.060	0.599 (0.036)	0.920 (0.061)		1.334 (0.071)	-1.334 (0.128)
SP10_11	SP72294	—	0.033	0.914 (0.066)	0.207 (0.051)			
SP10_12	SP72231	—	0.029	1.257 (0.239)	0.923 (0.088)	0.265 (0.027)		
SP10_13	SP72261	—	0.043	0.671 (0.053)	-0.379 (0.064)			
SP10_14	SP72220	—	0.041	1.761 (0.627)	1.732 (0.166)	0.210 (0.017)		
SP10_15	SP72348	—	0.074	0.805 (0.059)	-0.844 (0.065)			
SP10_16	SP72720	—	0.030	0.412 (0.179)	1.745 (0.333)	0.135 (0.090)		
SP12_01	SP72078	—	0.029	1.019 (0.074)	0.458 (0.052)			
SP12_02	SP72460	—	0.022	0.962 (0.178)	0.710 (0.107)	0.254 (0.036)		
SP12_03	SP72000	—	0.030	0.717 (0.042)	0.318 (0.042)		-0.024 (0.070)	0.024 (0.080)

Item		RMSD 2015	RMSD 2019	Slope (a_i)	Location (b_i)	Guessing (c_i)	Step 1 (d_{i1})	Step 2 (d_{i2})
SP12_05	SP72901	—	0.022	0.612 (0.185)	1.121 (0.202)	0.273 (0.057)		
SP12_06	SP72038	—	0.039	0.487 (0.108)	0.297 (0.277)	0.103 (0.089)		
SP12_07	SP72120	—	0.043	0.441 (0.104)	-0.046 (0.410)	0.092 (0.121)		
SP12_08	SP72143	—	0.036	0.731 (0.058)	0.314 (0.064)			
SP12_09	SP72523	—	0.049	0.663 (0.043)	0.319 (0.047)		0.309 (0.071)	-0.309 (0.084)
SP12_10	SP72168	—	0.032	1.195 (0.152)	0.319 (0.075)	0.176 (0.031)		
SP12_11	SP72205	—	0.025	1.159 (0.214)	0.881 (0.090)	0.244 (0.029)		
SP12_12	SP72293	—	0.029	0.959 (0.078)	0.858 (0.069)			
SP12_13A	SP72280A	—	0.027	1.309 (0.098)	0.755 (0.050)			
SP12_13B	SP72280B	—	0.029	1.433 (0.202)	-0.062 (0.095)	0.387 (0.039)		
SP12_14	SP72370	—	0.023	1.461 (0.214)	0.419 (0.073)	0.289 (0.030)		
SP14_01	SP72011	—	0.031	1.602 (0.170)	0.059 (0.057)	0.165 (0.029)		
SP14_02	SP72905	—	0.053	0.687 (0.053)	-0.340 (0.062)			
SP14_03	SP72049	—	0.030	0.805 (0.162)	0.616 (0.139)	0.270 (0.047)		
SP14_04	SP72016	—	0.027	0.782 (0.045)	0.560 (0.042)		-0.167 (0.069)	0.167 (0.082)
SP14_05	SP72451	—	0.047	1.084 (0.072)	-0.162 (0.043)			
SP14_06	SP72074	—	0.033	0.785 (0.061)	0.344 (0.060)			
SP14_07	SP72091	—	0.025	1.170 (0.198)	0.763 (0.084)	0.233 (0.030)		
SP14_08	SP72109	—	0.036	0.551 (0.054)	0.836 (0.108)			
SP14_09	SP72140	—	0.024	0.906 (0.206)	0.981 (0.125)	0.279 (0.037)		
SP14_10	SP72132	—	0.018	0.853 (0.096)	1.693 (0.151)			
SP14_11	SP72209	—	0.024	1.207 (0.200)	0.640 (0.085)	0.268 (0.032)		
SP14_12	SP72210	—	0.064	0.484 (0.038)	1.244 (0.088)		0.992 (0.087)	-0.992 (0.154)
SP14_13	SP72249	—	0.022	1.008 (0.170)	0.929 (0.089)	0.143 (0.028)		
SP14_14	SP72323	—	0.028	0.697 (0.169)	0.723 (0.179)	0.295 (0.056)		
SP14_15	SP72368	—	0.024	1.197 (0.191)	0.488 (0.090)	0.286 (0.034)		
SP14_16	SP72303	—	0.021	1.205 (0.255)	1.065 (0.102)	0.210 (0.026)		

Appendix 12E: Mathematics Item Parameters from the TIMSS 2019 Grade 4 Less Difficult Calibration

Item		RMSD 2015	RMSD 2019	Slope (a_i)	Location (b_i)	Guessing (c_i)	Step 1 (d_{i1})	Step 2 (d_{i2})
Items Released in 2015:								
N1_01	M011135	0.026	—	0.868 (0.091)	-0.272 (0.124)	0.211 (0.051)		
N1_02	M011114	0.014	—	1.386 (0.081)	0.655 (0.034)			
N1_03	M011216	0.030	—	1.473 (0.079)	0.130 (0.029)			
N1_04	M011255	0.018	—	1.079 (0.109)	0.119 (0.079)	0.191 (0.035)		
N1_05	M011027	0.022	—	1.127 (0.062)	-0.100 (0.035)			
N1_06	M011259	0.020	—	1.703 (0.172)	0.599 (0.043)	0.173 (0.020)		
N1_07	M011031	0.026	—	0.873 (0.081)	-0.304 (0.103)	0.144 (0.044)		
N1_08	M011227	0.026	—	0.613 (0.050)	1.246 (0.098)			
N1_09	M011267	0.042	—	0.711 (0.052)	-1.472 (0.094)			
N1_10	M011042	0.022	—	0.693 (0.046)	-0.114 (0.051)			
N1_11	M011184	0.014	—	0.870 (0.054)	0.311 (0.044)			
N1_12	M011190	0.021	—	1.236 (0.075)	0.717 (0.039)			
N1_13	M011193	0.019	—	1.728 (0.257)	1.068 (0.057)	0.280 (0.019)		
N4_01	M061272	0.018	—	1.024 (0.076)	1.283 (0.068)			
N4_02	M061243	0.019	—	0.663 (0.030)	0.739 (0.039)		-0.566 (0.073)	0.566 (0.084)
N4_03	M061029	0.025	—	1.430 (0.157)	0.665 (0.051)	0.183 (0.022)		
N4_04	M061031	0.017	—	1.411 (0.177)	1.361 (0.065)	0.070 (0.012)		
N4_05	M061050	0.019	—	1.442 (0.244)	1.448 (0.081)	0.186 (0.017)		
N4_06	M061167	0.027	—	0.975 (0.057)	-0.030 (0.039)			
N4_07	M061206	0.018	—	1.327 (0.247)	1.625 (0.103)	0.164 (0.016)		
N4_08A	M061265A	0.034	—	0.869 (0.090)	2.083 (0.155)			
N4_08B	M061265B	0.022	—	1.255 (0.324)	2.019 (0.185)	0.175 (0.015)		
N4_09	M061185	0.030	—	1.392 (0.146)	0.552 (0.053)	0.175 (0.023)		
N4_10	M061239	0.017	—	1.422 (0.083)	0.558 (0.032)			
Items Common in 2015 and 2019:								
MN01_01	MN11128	0.032	0.077	0.998 (0.047)	0.388 (0.032)			
MN01_02	MN11022	0.027	0.047	1.278 (0.056)	-0.440 (0.029)			
MN01_03	MN11010	0.027	0.035	1.239 (0.056)	0.447 (0.027)			
MN01_04A	MN11278A	0.039	0.065	1.161 (0.077)	-0.603 (0.066)	0.134 (0.034)		
MN01_04B	MN11278B	0.034	0.039	1.576 (0.141)	0.928 (0.037)	0.146 (0.014)		
MN01_05	MN11136	0.029	0.035	0.951 (0.044)	-0.079 (0.032)			
MN01_06	MN11261	0.014	0.047	1.099 (0.055)	0.875 (0.036)			
MN01_07	MN11033	0.042	0.062	0.427 (0.030)	-0.128 (0.063)			
MN01_08	MN11039	0.040	0.060	0.727 (0.057)	-0.824 (0.132)	0.151 (0.053)		

Item		RMSD 2015	RMSD 2019	Slope (a_i)	Location (b_i)	Guessing (c_i)	Step 1 (d_{i1})	Step 2 (d_{i2})
MN01_09	MN11040	0.036	0.040	0.425 (0.055)	0.259 (0.226)	0.162 (0.059)		
MN01_10	MN11195	0.037	0.053	0.583 (0.042)	1.607 (0.102)			
MN01_11	MN11188	0.021	0.036	0.603 (0.037)	0.831 (0.059)			
MN01_12	MN11252	0.036	0.060	1.925 (0.169)	0.797 (0.033)	0.185 (0.014)		
MN03_01	MN11055	0.031	0.057	1.031 (0.049)	-0.730 (0.038)			
MN03_02	MN11214	0.024	0.044	1.308 (0.107)	0.214 (0.054)	0.229 (0.025)		
MN03_03A	MN11116A	0.030	0.050	1.102 (0.052)	-0.779 (0.037)			
MN03_03B	MN11116B	0.025	0.047	1.100 (0.052)	0.533 (0.031)			
MN03_04A	MN11066A	0.032	0.042	1.176 (0.057)	0.721 (0.032)			
MN03_04B	MN11066B	0.043	0.051	1.236 (0.065)	1.030 (0.038)			
MN03_05	MN11260	0.025	0.027	1.563 (0.113)	0.129 (0.042)	0.183 (0.022)		
MN03_06	MN11032	0.052	0.070	0.814 (0.061)	-0.270 (0.085)	0.112 (0.035)		
MN03_07	MN11170	0.059	0.095	0.462 (0.066)	0.638 (0.191)	0.169 (0.053)		
MN03_08	MN11068	0.046	0.066	0.599 (0.035)	0.022 (0.046)			
MN03_09	MN11269	0.024	0.038	1.045 (0.048)	-0.403 (0.033)			
MN03_10	MN11001	0.046	0.101	1.046 (0.101)	0.629 (0.060)	0.185 (0.024)		
MN03_11	MN11235	0.022	0.039	0.549 (0.024)	1.432 (0.056)		-0.886 (0.080)	0.886 (0.102)
MN05_01	MN11076	0.024	0.038	0.878 (0.072)	-0.454 (0.106)	0.201 (0.044)		
MN05_02	MN11141	0.016	0.031	1.124 (0.050)	-0.107 (0.029)			
MN05_03	MN11142	0.023	0.038	1.888 (0.136)	0.505 (0.029)	0.128 (0.014)		
MN05_04	MN11005	0.031	0.057	2.191 (0.189)	0.640 (0.031)	0.228 (0.015)		
MN05_05A	MN11256A	0.060	0.065	0.989 (0.045)	-0.507 (0.036)			
MN05_05B	MN11256B	0.044	0.054	0.987 (0.045)	-0.030 (0.031)			
MN05_06	MN11108	0.034	0.046	1.000 (0.055)	1.049 (0.045)			
MN05_07	MN11062	0.046	0.067	0.397 (0.031)	0.685 (0.081)			
MN05_08	MN11174	0.037	0.069	0.814 (0.042)	0.529 (0.039)			
MN05_09	MN11067	0.041	0.052	0.488 (0.064)	-0.054 (0.241)	0.223 (0.065)		
MN05_10	MN11043	0.052	0.099	0.687 (0.045)	-2.155 (0.113)			
MN05_11	MN11268	0.027	0.048	0.782 (0.067)	0.264 (0.076)	0.107 (0.029)		
MN05_12	MN11270	0.027	0.026	1.214 (0.058)	0.622 (0.030)			
MN07_01	MN11023	0.029	0.045	1.527 (0.116)	0.169 (0.045)	0.216 (0.022)		
MN07_02	MN11056	0.029	0.063	1.164 (0.094)	0.258 (0.056)	0.183 (0.025)		
MN07_03	MN11057	0.023	0.060	1.235 (0.054)	-0.274 (0.028)			
MN07_04	MN11113	0.021	0.059	1.045 (0.047)	-0.151 (0.031)			
MN07_05	MN11200	0.045	0.073	0.475 (0.016)	-1.102 (0.048)		-1.648 (0.116)	1.648 (0.102)
MN07_06	MN11129	0.023	0.047	1.313 (0.108)	0.466 (0.046)	0.180 (0.021)		
MN07_07	MN11218	0.024	0.070	0.854 (0.042)	-0.770 (0.045)			
MN07_08	MN11036	0.020	0.037	1.373 (0.136)	1.041 (0.045)	0.156 (0.015)		
MN07_09	MN11225	0.054	0.074	0.644 (0.040)	1.090 (0.066)			
MN07_10	MN11041	0.020	0.058	0.913 (0.095)	0.269 (0.094)	0.281 (0.035)		
MN07_11	MN11179	0.028	0.082	0.946 (0.048)	0.710 (0.038)			

Item		RMSD 2015	RMSD 2019	Slope (a_i)	Location (b_i)	Guessing (c_i)	Step 1 (d_{i1})	Step 2 (d_{i2})
MN07_12	MN11303	0.030	0.076	1.113 (0.062)	1.156 (0.044)			
MN07_13	MN11305	0.020	0.041	1.136 (0.161)	1.256 (0.071)	0.279 (0.020)		
MN09_01	MN11019	0.027	0.048	0.953 (0.088)	0.237 (0.078)	0.219 (0.031)		
MN09_02	MN11145	0.035	0.069	1.060 (0.048)	-0.379 (0.032)			
MN09_03	MN11211	0.034	0.023	1.858 (0.135)	0.286 (0.034)	0.179 (0.018)		
MN09_04	MN11014	0.020	0.074	1.196 (0.054)	0.395 (0.028)			
MN09_05	MN11300	0.018	0.027	1.148 (0.055)	0.620 (0.031)			
MN09_06	MN11028	0.031	0.041	1.383 (0.060)	0.040 (0.025)			
MN09_07	MN11231	0.029	0.040	1.327 (0.201)	1.610 (0.079)	0.190 (0.014)		
MN09_08	MN11061	0.064	0.096	0.660 (0.051)	-1.040 (0.146)	0.138 (0.054)		
MN09_09	MN11045	0.029	0.072	0.999 (0.081)	0.075 (0.069)	0.165 (0.030)		
MN09_10	MN11265	0.038	0.091	0.851 (0.069)	-1.083 (0.141)	0.215 (0.061)		
MN09_11	MN11154	0.034	0.042	0.685 (0.025)	0.425 (0.028)		-0.377 (0.055)	0.377 (0.059)
MN09_12	MN11240	0.020	0.043	1.100 (0.148)	1.214 (0.069)	0.252 (0.020)		
MN11_01	MN11009	0.034	0.039	0.978 (0.084)	0.073 (0.078)	0.210 (0.033)		
MN11_02	MN11024	0.028	0.063	1.072 (0.048)	0.172 (0.029)			
MN11_03	MN11134	0.025	0.051	1.272 (0.116)	0.430 (0.056)	0.262 (0.024)		
MN11_04	MN11212	0.034	0.060	0.873 (0.042)	-0.178 (0.035)			
MN11_05	MN11253	0.025	0.044	0.960 (0.080)	0.079 (0.075)	0.179 (0.032)		
MN11_06	MN11221	0.035	0.049	2.127 (0.177)	0.767 (0.029)	0.161 (0.013)		
MN11_07	MN11146	0.052	0.078	0.760 (0.042)	0.820 (0.048)			
MN11_08	MN11177	0.019	0.032	1.337 (0.067)	0.910 (0.032)			
MN11_09	MN11158	0.045	0.081	0.675 (0.037)	0.273 (0.044)			
MN11_10	MN11002	0.029	0.054	1.288 (0.143)	1.083 (0.052)	0.204 (0.017)		
MN11_11A	MN11182A	0.037	0.078	0.987 (0.072)	-1.076 (0.105)	0.172 (0.051)		
MN11_11B	MN11182B	0.045	0.070	0.859 (0.064)	-0.548 (0.096)	0.142 (0.042)		
MN11_12	MN11272	0.019	0.028	0.766 (0.043)	1.859 (0.071)		-0.185 (0.060)	0.185 (0.104)
MN13_01	MN11017	0.042	0.060	0.786 (0.040)	-0.936 (0.052)			
MN13_02	MN11125	0.042	0.080	0.894 (0.044)	0.322 (0.034)			
MN13_03	MN11077	0.025	0.020	1.141 (0.058)	0.844 (0.035)			
MN13_04A	MN11047A	0.053	0.075	1.045 (0.072)	-0.753 (0.083)	0.147 (0.040)		
MN13_04B	MN11047B	0.051	0.063	1.100 (0.083)	-0.407 (0.078)	0.198 (0.037)		
MN13_05	MN11223	0.022	0.021	1.154 (0.056)	0.703 (0.032)			
MN13_06	MN11034	0.047	0.070	0.915 (0.113)	1.123 (0.070)	0.173 (0.022)		
MN13_07	MN11175	0.039	0.030	1.049 (0.050)	0.473 (0.031)			
MN13_08	MN11262	0.022	0.035	0.975 (0.105)	0.825 (0.063)	0.191 (0.024)		
MN13_09	MN11239	0.023	0.027	0.800 (0.123)	1.408 (0.097)	0.202 (0.024)		
MN13_10	MN11202	0.025	0.026	0.910 (0.043)	-0.152 (0.034)			
MN13_11	MN11299	0.027	0.083	1.349 (0.061)	0.321 (0.025)			
MP03_01	MP61026	0.025	0.034	1.112 (0.093)	0.459 (0.053)	0.158 (0.023)		
MP03_02	MP61273	0.041	0.043	1.083 (0.110)	0.953 (0.054)	0.156 (0.019)		

Item		RMSD 2015	RMSD 2019	Slope (a_i)	Location (b_i)	Guessing (c_i)	Step 1 (d_{i1})	Step 2 (d_{i2})
MP03_03	MP61034	0.016	0.040	1.221 (0.077)	1.498 (0.056)			
MP03_04	MP61040	0.029	0.037	1.722 (0.226)	1.443 (0.054)	0.180 (0.012)		
MP03_05	MP61228	0.026	0.032	0.808 (0.046)	1.885 (0.072)		-0.178 (0.059)	0.178 (0.105)
MP03_06	MP61166	0.021	0.030	1.194 (0.058)	0.709 (0.031)			
MP03_07	MP61171	0.020	0.041	1.404 (0.129)	0.605 (0.047)	0.236 (0.020)		
MP03_08	MP61080	0.021	0.030	0.677 (0.048)	1.668 (0.097)			
MP03_09	MP61222	0.026	0.038	0.880 (0.115)	0.952 (0.081)	0.253 (0.027)		
MP03_10	MP61076	0.035	0.030	0.522 (0.035)	0.790 (0.066)			
MP03_11	MP61084	0.035	0.027	0.961 (0.068)	1.725 (0.083)			
Items Introduced in 2019:								
MN04_01	MN21061	—	0.027	1.821 (0.197)	-0.071 (0.061)	0.142 (0.034)		
MN04_02	MN21067	—	0.023	1.223 (0.181)	0.332 (0.099)	0.254 (0.043)		
MN04_03	MN21046	—	0.024	1.023 (0.084)	0.635 (0.054)			
MN04_04	MN21023	—	0.034	1.193 (0.088)	-0.450 (0.053)			
MN04_05	MN21018	—	0.046	0.894 (0.081)	0.935 (0.071)			
MN04_06	MN21020	—	0.035	1.318 (0.153)	0.384 (0.065)	0.096 (0.030)		
MN04_07	MN21069	—	0.031	1.658 (0.200)	-0.065 (0.076)	0.214 (0.041)		
MN04_08	MN21040	—	0.031	1.990 (0.249)	0.399 (0.054)	0.193 (0.029)		
MN04_09	MN21070	—	0.027	1.154 (0.217)	1.135 (0.091)	0.179 (0.030)		
MN04_10	MN21037	—	0.027	1.675 (0.198)	0.389 (0.057)	0.137 (0.028)		
MN04_11	MN21033	—	0.035	0.719 (0.074)	1.183 (0.102)			
MN04_12	MN21001	—	0.028	1.039 (0.185)	0.809 (0.101)	0.210 (0.039)		
MN04_13	MN21060	—	0.034	0.487 (0.027)	-0.219 (0.059)		-1.214 (0.150)	1.214 (0.142)
MN04_14	MN21003	—	0.062	0.518 (0.041)	-0.174 (0.063)		0.244 (0.116)	-0.244 (0.104)
MN12_01	MN21066	—	0.037	1.003 (0.128)	-0.385 (0.143)	0.157 (0.067)		
MN12_02	MN21045	—	0.036	0.606 (0.132)	0.530 (0.231)	0.151 (0.080)		
MN12_03	MN21064	—	0.024	1.686 (0.207)	0.663 (0.052)	0.114 (0.023)		
MN12_04	MN21051	—	0.026	1.568 (0.112)	0.224 (0.038)			
MN12_05	MN21054	—	0.043	1.363 (0.180)	-0.662 (0.132)	0.279 (0.069)		
MN12_06	MN21025	—	0.027	0.850 (0.045)	0.179 (0.037)		-0.499 (0.084)	0.499 (0.084)
MN12_07	MN21038	—	0.025	1.156 (0.179)	0.359 (0.109)	0.260 (0.045)		
MN12_08	MN21043	—	0.026	1.226 (0.097)	0.699 (0.049)			
MN12_09	MN21030	—	0.028	0.933 (0.156)	0.665 (0.110)	0.163 (0.044)		
MN12_10	MN21032	—	0.034	0.665 (0.059)	-0.335 (0.077)			
MN12_11	MN21053	—	0.029	1.107 (0.155)	-0.160 (0.136)	0.248 (0.061)		
MN12_12A	MN21010A	—	0.031	0.808 (0.150)	-0.086 (0.236)	0.302 (0.083)		
MN12_12B	MN21010B	—	0.040	0.893 (0.120)	2.081 (0.188)			
MN12_13	MN21059	—	0.027	1.166 (0.094)	0.678 (0.051)			
MN14_01	MN21049	—	0.041	0.442 (0.038)	0.355 (0.070)		0.666 (0.116)	-0.666 (0.125)
MN14_02	MN21050	—	0.047	0.512 (0.053)	0.210 (0.089)			
MN14_03	MN21065	—	0.031	1.794 (0.295)	0.817 (0.066)	0.283 (0.028)		

Item		RMSD		Slope (a_i)	Location (b_i)	Guessing (c_i)	Step 1 (d_{i1})	Step 2 (d_{i2})
		2015	2019					
MN14_04	MN21014	—	0.055	0.910 (0.073)	-0.823 (0.075)			
MN14_05	MN21019	—	0.031	1.210 (0.168)	-0.037 (0.118)	0.266 (0.053)		
MN14_06	MN21024	—	0.025	1.498 (0.223)	1.023 (0.062)	0.121 (0.023)		
MN14_07	MN21035	—	0.020	1.261 (0.190)	0.368 (0.099)	0.270 (0.043)		
MN14_08	MN21039	—	0.028	1.190 (0.162)	0.069 (0.110)	0.231 (0.050)		
MN14_09	MN21062	—	0.046	0.517 (0.053)	-0.136 (0.091)			
MN14_10	MN21057	—	0.025	0.650 (0.064)	0.828 (0.088)			
MN14_11	MN21063	—	0.030	1.225 (0.155)	-0.017 (0.103)	0.193 (0.049)		
MN14_12	MN21005	—	0.026	0.919 (0.077)	0.581 (0.058)			
MN14_13A	MN21012A	—	0.053	0.767 (0.064)	-0.319 (0.071)			
MN14_13B	MN21012B	—	0.032	1.605 (0.252)	0.848 (0.066)	0.213 (0.028)		
MP02_01	MP71219	—	0.035	0.995 (0.140)	0.107 (0.122)	0.174 (0.053)		
MP02_02	MP71021	—	0.033	1.692 (0.240)	0.892 (0.057)	0.140 (0.023)		
MP02_03	MP71167	—	0.042	1.084 (0.119)	1.638 (0.111)			
MP02_04	MP71041	—	0.033	0.973 (0.157)	0.810 (0.095)	0.129 (0.037)		
MP02_05	MP71162	—	0.024	0.540 (0.045)	1.972 (0.140)		-0.968 (0.153)	0.968 (0.215)
MP02_06	MP71078	—	0.027	0.788 (0.070)	0.573 (0.068)			
MP02_07	MP71090	—	0.029	0.788 (0.182)	1.355 (0.140)	0.139 (0.040)		
MP02_08	MP71151	—	0.027	0.590 (0.044)	1.819 (0.107)		-1.918 (0.219)	1.918 (0.253)
MP02_09	MP71119	—	0.041	0.649 (0.059)	-0.203 (0.077)			
MP02_10A	MP71217A	—	0.030	0.711 (0.065)	0.411 (0.071)			
MP02_11	MP71142	—	0.031	1.207 (0.094)	0.440 (0.047)			
MP02_12	MP71204	—	0.027	1.112 (0.115)	1.418 (0.091)			
MP08_01	MP71018	—	0.024	1.343 (0.235)	1.140 (0.078)	0.175 (0.026)		
MP08_02	MP71009	—	0.039	1.361 (0.116)	1.019 (0.053)			
MP08_03	MP71037	—	0.052	0.761 (0.071)	0.961 (0.082)			
MP08_04	MP71051	—	0.032	1.049 (0.132)	1.973 (0.150)			
MP08_05	MP71064	—	0.027	1.016 (0.257)	1.590 (0.142)	0.195 (0.030)		
MP08_06	MP71169	—	0.030	1.379 (0.135)	1.391 (0.071)			
MP08_07	MP71083	—	0.033	1.708 (0.432)	1.590 (0.103)	0.237 (0.022)		
MP08_09	MP71184	—	0.027	2.331 (0.847)	1.883 (0.120)	0.244 (0.018)		
MP08_10	MP71141	—	0.050	0.585 (0.089)	2.430 (0.293)			
MP08_11	MP71194	—	0.044	0.750 (0.064)	-0.224 (0.071)			
MP08_12	MP71193	—	0.033	0.596 (0.043)	1.289 (0.077)		-0.565 (0.114)	0.565 (0.143)
MP08_13	MP71192	—	0.025	0.498 (0.037)	1.885 (0.120)		-2.221 (0.247)	2.221 (0.283)
MP13_01	MP61240	—	0.045	0.572 (0.081)	2.083 (0.241)			
MP13_02	MP61254	—	0.062	0.678 (0.069)	1.111 (0.102)			
MP13_03	MP61244	—	0.025	1.382 (0.236)	0.802 (0.083)	0.257 (0.033)		
MP13_04	MP61041	—	0.029	0.729 (0.267)	1.997 (0.286)	0.195 (0.040)		
MP13_05	MP61173	—	0.038	0.774 (0.067)	0.458 (0.066)			
MP13_06	MP61252	—	0.027	1.748 (0.395)	1.650 (0.097)	0.127 (0.017)		

Item		RMSD 2015	RMSD 2019	Slope (a_i)	Location (b_i)	Guessing (c_i)	Step 1 (d_{i1})	Step 2 (d_{i2})
MP13_07	MP61261	—	0.032	1.562 (0.137)	1.084 (0.051)			
MP13_08	MP61224	—	0.023	0.821 (0.083)	1.321 (0.101)			
MP13_09	MP61077	—	0.027	1.151 (0.232)	1.438 (0.105)	0.126 (0.025)		
MP13_10A	MP61069A	—	0.035	0.716 (0.063)	0.290 (0.069)			
MP13_10B	MP61069B	—	0.033	0.726 (0.070)	0.874 (0.084)			

Appendix 12F: Science Item Parameters from the TIMSS 2019 Grade 4 Less Difficult Calibration

Item		RMSD	Slope (a_i)	Location (b_i)	Guessing (c_i)	Step 1 (d_{i1})	Step 2 (d_{i2})
Trend Items*:							
SP01_01	SP51054	0.114	0.934	-0.419	0.261		
SP01_02	SP51024	0.058	0.612	0.674			
SP01_03A	SP51132A	0.033	0.881	1.254			
SP01_03B	SP51132B	0.059	0.810	1.065			
SP01_04	SP51040	0.126	0.453	0.606			
SP01_05	SP51193	0.064	0.940	-0.126	0.274		
SP01_06	SP51063	0.034	1.148	0.754	0.222		
SP01_07	SP51012	0.049	0.989	0.268	0.253		
SP01_08	SP51115	0.033	1.090	0.146			
SP01_09	SP51180	0.062	0.880	0.057	0.360		
SP01_10	SP51106	0.062	1.024	0.721	0.215		
SP01_11	SP51148	0.067	1.049	0.043	0.241		
SP03_01	SP61141	0.097	1.235	0.519	0.300		
SP03_02	SP61023	0.039	0.770	0.015			
SP03_03	SP61054	0.075	0.479	0.643		1.489	-1.489
SP03_04	SP61007	0.082	0.647	-0.209	0.163		
SP03_05	SP61006	0.118	0.785	-0.650			
SP03_06	SP61108	0.058	1.050	0.233	0.352		
SP03_07	SP61109	0.064	0.583	0.710	0.235		
SP03_08	SP61080	0.056	0.968	0.297	0.264		
SP03_09	SP61088	0.051	0.672	1.417			
SP03_10	SP61151	0.069	0.952	0.440			
SP03_11	SP61150	0.090	0.624	0.408			
SP03_12	SP61169	0.037	1.077	0.079	0.268		
SP05_01	SP51044	0.119	0.503	0.201			
SP05_03	SP51003	0.061	0.711	-0.122	0.104		
SP05_04	SP51168	0.179	0.704	-0.475			
SP05_05	SP51010	0.060	0.766	0.076			
SP05_06	SP51035	0.035	1.249	1.298	0.236		
SP05_07	SP51059	0.064	0.584	0.104			
SP05_08	SP51142	0.048	0.802	0.598	0.199		
SP05_09A	SP51131A	0.054	1.014	-0.089	0.193		
SP05_09B	SP51131B	0.029	0.988	0.576	0.197		
SP05_10	SP51151	0.122	0.918	-1.120			
SP05_11	SP51157	0.065	0.739	0.999	0.190		

* Item parameters for trend items were fixed from the paperTIMSS fourth grade science concurrent calibration.

Item		RMSD	Slope (a_i)	Location (b_i)	Guessing (c_i)	Step 1 (d_{i1})	Step 2 (d_{i2})
Trend Items*:							
SP06_01	SP61071	0.124	0.335	-1.372	0.197		
SP06_02	SP61138	0.119	0.616	0.002			
SP06_03A	SP61016A	0.049	0.926	0.365	0.216		
SP06_03B	SP61016B	0.026	0.990	0.509			
SP06_04	SP61011	0.103	0.733	-0.536			
SP06_06	SP61083	0.100	0.726	-1.025			
SP06_07	SP61034	0.038	0.788	1.088			
SP06_08	SP61044	0.052	0.740	0.551			
SP06_09A	SP61142A	0.056	0.623	0.351			
SP06_09B	SP61142B	0.052	0.788	1.034			
SP06_10A	SP61115A	0.062	1.468	0.346	0.264		
SP06_10B	SP61115B	0.072	1.345	0.662	0.328		
SP07_01	SP51161	0.109	0.488	1.007	0.217		
SP07_02	SP51051	0.121	1.391	1.370	0.281		
SP07_03Z	SP51138Z	0.055	0.583	0.313			
SP07_04	SP51194	0.017	0.970	1.014			
SP07_05	SP51029	0.040	0.518	1.220	0.202		
SP07_06	SP51077	0.079	0.747	-0.167			
SP07_07	SP51200	0.129	0.679	1.196			
SP07_08	SP51075	0.135	0.670	-0.586			
SP07_09	SP51065	0.084	0.870	-0.215	0.333		
SP07_10	SP51191	0.051	1.342	0.578	0.205		
SP07_11	SP51099	0.044	0.868	0.332	0.216		
SP07_12	SP51175	0.024	0.978	0.968			
SP09_01	SP61135	0.102	0.758	-0.598	0.268		
SP09_02	SP61069	0.120	0.400	-0.481			
SP09_03	SP61134	0.086	0.651	0.181	0.126		
SP09_04	SP61140	0.040	1.039	0.601	0.296		
SP09_05	SP61019	0.031	0.887	0.943			
SP09_06	SP61022	0.085	0.656	0.183	0.241		
SP09_07	SP61036	0.095	0.951	0.903			
SP09_08	SP61160	0.108	0.761	-0.954			
SP09_09	SP61159	0.114	0.826	-0.788			
SP09_10	SP61091	0.036	0.452	1.170		-0.176	0.176
SP09_11	SP61118	0.034	1.001	0.542	0.217		
SP09_12	SP61097	0.036	0.798	0.517	0.275		
SP11_01	SP61132	0.090	0.710	0.539	0.213		
SP11_02	SP61120	0.048	0.884	0.333	0.197		
SP11_03	SP61025	0.079	0.531	-0.366			

* Item parameters for trend items were fixed from the paperTIMSS fourth grade science concurrent calibration.

Item		RMSD	Slope (a_i)	Location (b_i)	Guessing (c_i)	Step 1 (d_{i1})	Step 2 (d_{i2})
Trend Items*:							
SP11_04A	SP61133A	0.061	1.370	0.245	0.326		
SP11_04B	SP61133B	0.046	1.701	0.792	0.114		
SP11_05	SP61074	0.075	0.772	0.219			
SP11_06	SP61093	0.142	0.761	-0.057		0.937	-0.937
SP11_07	SP61161	0.086	0.614	0.664			
SP11_08A	SP61042A	0.031	1.366	0.806	0.239		
SP11_08B	SP61042B	0.040	0.791	0.640	0.150		
SP11_09A	SP61041A	0.055	0.871	0.116			
SP11_09B	SP61041B	0.066	0.719	0.167			
SP11_10	SP61155	0.097	0.735	-0.488	0.286		
SP13_02	SP61014	0.085	0.495	0.425			
SP13_03	SP61056	0.104	0.853	-0.738			
SP13_04	SP61015	0.110	0.692	-0.395			
SP13_05	SP61113	0.101	0.760	0.954			
SP13_06	SP61107	0.075	1.001	0.641	0.180		
SP13_07	SP61046	0.029	1.164	0.804	0.227		
SP13_08	SP61047	0.095	0.751	-0.518	0.313		
SP13_09	SP61048	0.045	1.300	0.509	0.221		
SP13_10	SP61096	0.054	1.100	0.730	0.257		
SP13_11	SP61124	0.031	0.590	1.242			
SP13_12	SP61116	0.092	0.681	0.159			
New Items:							
SP02_01	SP71002	0.103	0.516 (0.047)	-0.414 (0.099)			
SP02_02	SP71402	0.049	1.200 (0.183)	-0.140 (0.086)	0.240 (0.027)		
SP02_03	SP71017	0.048	0.598 (0.065)	0.571 (0.142)			
SP02_04	SP71077	0.038	0.970 (0.089)	0.243 (0.076)			
SP02_05	SP71072	0.030	0.959 (0.240)	0.673 (0.150)	0.246 (0.027)		
SP02_06	SP71054	0.053	0.954 (0.082)	-0.045 (0.067)			
SP02_07	SP71115	0.046	0.703 (0.197)	0.728 (0.202)	0.249 (0.034)		
SP02_08	SP71140	0.046	0.850 (0.180)	0.366 (0.131)	0.231 (0.030)		
SP02_09	SP71128	0.084	0.478 (0.122)	-0.242 (0.285)	0.281 (0.063)		
SP02_10	SP71147	0.086	0.639 (0.125)	-0.285 (0.171)	0.235 (0.045)		
SP02_11A	SP71920A	0.049	0.862 (0.078)	0.113 (0.079)			
SP02_11B	SP71920B	0.029	0.955 (0.096)	0.458 (0.091)			
SP02_12	SP71268	0.024	1.089 (0.425)	1.318 (0.292)	0.213 (0.022)		
SP04_01	SP71013	0.086	0.959 (0.140)	-0.850 (0.124)	0.272 (0.038)		
SP04_02	SP71902	0.058	0.343 (0.043)	0.537 (0.215)			
SP04_03	SP71076	0.050	1.053 (0.155)	-0.254 (0.092)	0.210 (0.029)		

* Item parameters for trend items were fixed from the paperTIMSS fourth grade science concurrent calibration.

Item		RMSD	Slope (a_i)	Location (b_i)	Guessing (c_i)	Step 1 (d_{i1})	Step 2 (d_{i2})
New Items:							
SP04_04	SP71041	0.030	0.659 (0.063)	1.056 (0.125)		-0.010 (0.105)	0.010 (0.183)
SP04_05	SP71046	0.039	0.645 (0.069)	0.627 (0.137)			
SP04_06	SP71095	0.048	0.558 (0.060)	0.567 (0.147)			
SP04_07	SP71129	0.091	0.818 (0.134)	-0.904 (0.165)	0.308 (0.045)		
SP04_08	SP71102	0.031	0.811 (0.088)	0.656 (0.122)			
SP04_09	SP71124	0.031	0.900 (0.232)	0.762 (0.167)	0.223 (0.027)		
SP04_10	SP71112	0.138	0.686 (0.099)	-1.453 (0.211)	0.218 (0.058)		
SP04_11	SP71265	0.053	0.209 (0.099)	1.461 (0.883)	0.273 (0.097)		
SP04_12	SP71223	0.118	0.482 (0.078)	-1.707 (0.350)	0.238 (0.080)		
SP08_02	SP71033	0.059	0.320 (0.131)	0.812 (0.461)	0.275 (0.080)		
SP08_03	SP71065	0.092	0.428 (0.042)	-0.391 (0.119)			
SP08_04	SP71025	0.081	0.353 (0.094)	-0.043 (0.366)	0.215 (0.072)		
SP08_05	SP71081	0.023	0.937 (0.323)	1.328 (0.300)	0.167 (0.022)		
SP08_06	SP71056	0.025	0.610 (0.082)	1.382 (0.243)			
SP08_07	SP71145	0.075	0.493 (0.114)	0.010 (0.214)	0.198 (0.051)		
SP08_08	SP71104	0.115	0.741 (0.057)	-0.780 (0.071)			
SP08_09	SP71144	0.065	0.492 (0.131)	0.547 (0.222)	0.180 (0.045)		
SP08_10	SP71150	0.065	0.742 (0.065)	-0.104 (0.081)			
SP08_11	SP71201	0.042	1.069 (0.180)	-0.046 (0.098)	0.248 (0.029)		
SP08_12	SP71237	0.044	1.097 (0.097)	0.096 (0.065)			
SP08_13	SP71260	0.031	0.664 (0.237)	1.404 (0.381)	0.170 (0.028)		
SP10_01	SP71009	0.126	0.521 (0.036)	-0.386 (0.073)		1.209 (0.101)	-1.209 (0.126)
SP10_02	SP71093	0.081	0.731 (0.059)	-0.493 (0.073)			
SP10_03	SP71069	0.038	0.842 (0.281)	0.955 (0.240)	0.288 (0.029)		
SP10_04	SP71051	0.036	0.687 (0.073)	0.630 (0.134)			
SP10_05	SP71039	0.045	0.985 (0.161)	0.083 (0.096)	0.173 (0.026)		
SP10_06	SP71080	0.028	0.819 (0.473)	1.799 (0.682)	0.236 (0.026)		
SP10_07	SP71137	0.066	0.720 (0.062)	-0.213 (0.080)			
SP10_08	SP71103	0.043	0.833 (0.189)	0.323 (0.142)	0.271 (0.032)		
SP10_09	SP71106	0.057	0.422 (0.054)	1.021 (0.242)			
SP10_10	SP71100	0.067	0.697 (0.146)	-0.203 (0.167)	0.288 (0.042)		
SP10_12	SP71220	0.034	0.783 (0.221)	0.832 (0.206)	0.222 (0.030)		
SP10_13	SP71254	0.041	0.546 (0.067)	0.967 (0.200)			
SP12_01	SP71031	0.066	0.320 (0.044)	1.046 (0.295)			
SP12_02	SP71090	0.061	0.726 (0.065)	0.024 (0.088)			
SP12_03	SP71048	0.027	2.262 (0.784)	1.004 (0.127)	0.224 (0.017)		
SP12_04	SP71071	0.025	0.732 (0.093)	1.110 (0.186)			
SP12_05	SP71011	0.070	1.081 (0.154)	-0.350 (0.089)	0.203 (0.028)		
SP12_06	SP71142	0.095	0.387 (0.101)	-0.138 (0.331)	0.221 (0.069)		

Item		RMSD	Slope (a_i)	Location (b_i)	Guessing (c_i)	Step 1 (d_{i1})	Step 2 (d_{i2})
New Items:							
SP12_07	SP71138	0.113	0.702 (0.055)	-0.752 (0.074)			
SP12_08	SP71127	0.068	0.711 (0.153)	-0.064 (0.157)	0.285 (0.039)		
SP12_10	SP71500	0.049	0.816 (0.153)	0.232 (0.120)	0.170 (0.028)		
SP12_11	SP71257	0.034	1.649 (0.762)	1.030 (0.207)	0.429 (0.022)		
SP12_12	SP71222	0.044	0.985 (0.092)	0.194 (0.076)			
SP12_13	SP71252	0.043	0.968 (0.200)	0.200 (0.119)	0.266 (0.030)		
SP14_01	SP71063	0.075	0.409 (0.045)	0.160 (0.153)			
SP14_02	SP71900	0.043	0.965 (0.206)	0.083 (0.127)	0.351 (0.032)		
SP14_04	SP71043	0.026	0.742 (0.096)	1.179 (0.193)			
SP14_05	SP71005	0.101	0.845 (0.065)	-0.691 (0.063)			
SP14_06	SP71118	0.033	1.178 (0.233)	0.473 (0.101)	0.185 (0.023)		
SP14_07	SP71139	0.106	0.538 (0.106)	-0.701 (0.243)	0.236 (0.059)		
SP14_08	SP71114	0.086	0.713 (0.059)	-0.481 (0.074)			
SP14_09	SP71131	0.077	0.566 (0.053)	-0.097 (0.102)			
SP14_10	SP71152	0.040	0.862 (0.197)	0.361 (0.138)	0.271 (0.031)		
SP14_11	SP71218	0.120	0.600 (0.102)	-0.922 (0.212)	0.211 (0.054)		
SP14_12	SP71214	0.040	0.923 (0.169)	0.218 (0.108)	0.185 (0.027)		
SP14_13	SP71213	0.030	0.939 (0.106)	0.721 (0.116)			

Appendix 12G: Mathematics Item Parameters from the eTIMSS 2019 Non-Invariant Model Calibration—Grade 4

Item		RMSD	Slope (a_i)	Location (b_i)	Guessing (c_i)	Step 1 (d_{i1})	Step 2 (d_{i2})
ME01_01	ME51043	0.030	0.445 (0.035)	0.016 (0.064)			
ME01_02	ME51040	0.017	1.224 (0.134)	-0.026 (0.097)	0.415 (0.040)		
ME01_03	ME51008	0.088	1.309 (0.075)	1.185 (0.041)			
ME01_04A	ME51031A	0.067	1.565 (0.073)	0.257 (0.023)			
ME01_04B	ME51031B	0.058	1.787 (0.083)	0.290 (0.021)			
ME01_05	ME51508	0.084	1.262 (0.061)	0.324 (0.027)			
ME01_06A	ME51216A	0.038	1.199 (0.136)	0.649 (0.066)	0.290 (0.028)		
ME01_06B	ME51216B	0.103	0.741 (0.090)	-0.089 (0.168)	0.280 (0.060)		
ME01_07	ME51221	0.030	0.645 (0.071)	-0.717 (0.223)	0.251 (0.077)		
ME01_08	ME51115	0.037	0.641 (0.114)	1.749 (0.138)	0.118 (0.028)		
ME01_09A	ME51507A	0.040	0.759 (0.044)	-0.487 (0.049)			
ME01_09B	ME51507B	0.029	1.114 (0.061)	0.851 (0.037)			
ME02_01	ME71219	0.028	0.751 (0.067)	-0.865 (0.157)	0.186 (0.064)		
ME02_02	ME71021	0.034	1.106 (0.087)	0.103 (0.061)	0.132 (0.030)		
ME02_03	ME71167	0.100	1.565 (0.084)	1.052 (0.032)			
ME02_04	ME71041	0.039	1.145 (0.086)	-0.267 (0.070)	0.147 (0.037)		
ME02_05	ME71162	0.030	0.558 (0.027)	1.359 (0.055)		-0.492 (0.070)	0.492 (0.093)
ME02_06	ME71078	0.124	0.449 (0.036)	-0.884 (0.098)			
ME02_07	ME71090	0.034	1.197 (0.112)	0.338 (0.064)	0.226 (0.031)		
ME02_08	ME71151	0.038	0.743 (0.027)	0.783 (0.029)		-0.785 (0.062)	0.785 (0.069)
ME02_09	ME71119	0.072	0.666 (0.043)	-0.880 (0.070)			
ME02_10A	ME71217A	0.075	0.934 (0.053)	-0.921 (0.055)			
ME02_11	ME71142	0.030	1.114 (0.057)	-0.411 (0.036)			
ME02_12	ME71204	0.029	1.483 (0.072)	0.442 (0.025)			
ME03_01	ME61026	0.038	0.924 (0.075)	-0.637 (0.108)	0.166 (0.051)		
ME03_02	ME61273	0.031	0.793 (0.085)	0.374 (0.099)	0.174 (0.039)		
ME03_03	ME61034	0.030	1.202 (0.061)	0.661 (0.031)			
ME03_04	ME61040	0.049	1.636 (0.147)	0.737 (0.039)	0.176 (0.018)		
ME03_05	ME61228	0.080	0.739 (0.034)	1.210 (0.042)		-0.164 (0.053)	0.164 (0.072)
ME03_06	ME61166	0.031	1.182 (0.058)	-0.425 (0.033)			
ME03_07	ME61171	0.054	1.210 (0.109)	-0.143 (0.081)	0.269 (0.040)		
ME03_08	ME61080	0.039	0.686 (0.042)	0.505 (0.047)			
ME03_09	ME61222	0.060	0.828 (0.107)	0.295 (0.132)	0.319 (0.047)		
ME03_10	ME61076	0.073	0.443 (0.037)	-1.207 (0.116)			
ME03_11	ME61084	0.035	1.058 (0.056)	0.632 (0.034)			
ME04_01	ME71013	0.035	1.028 (0.100)	-0.210 (0.105)	0.275 (0.047)		
ME04_02	ME71026	0.027	1.177 (0.057)	0.142 (0.028)			
ME04_03	ME71036	0.019	0.923 (0.049)	-0.574 (0.042)			

Item		RMSD	Slope (a_i)	Location (b_i)	Guessing (c_i)	Step 1 (d_{i1})	Step 2 (d_{i2})
ME04_04	ME71040	0.058	1.496 (0.111)	0.483 (0.036)	0.100 (0.017)		
ME04_05	ME71068	0.046	0.491 (0.072)	0.735 (0.170)	0.148 (0.051)		
ME04_06A	ME71075A	0.034	1.266 (0.061)	0.353 (0.027)			
ME04_06B	ME71075B	0.067	1.360 (0.070)	0.823 (0.031)			
ME04_07	ME71080	0.038	1.534 (0.149)	0.508 (0.050)	0.271 (0.024)		
ME04_08	ME71211	0.035	0.625 (0.040)	0.139 (0.047)			
ME04_09	ME71178	0.040	0.848 (0.048)	0.576 (0.041)			
ME04_10B	ME71135B	0.080	0.790 (0.045)	-0.220 (0.042)			
ME04_11	ME71201	0.128	0.743 (0.055)	1.599 (0.092)			
ME04_12	ME71175	0.039	0.790 (0.037)	-0.097 (0.030)		0.675 (0.050)	-0.675 (0.044)
ME05_01	ME51206	0.028	0.567 (0.039)	-0.819 (0.074)			
ME05_02	ME51052	0.045	0.775 (0.091)	0.041 (0.144)	0.262 (0.053)		
ME05_03	ME51049	0.051	1.491 (0.118)	0.218 (0.046)	0.175 (0.025)		
ME05_04	ME51045	0.071	1.148 (0.056)	0.084 (0.029)			
ME05_05	ME51098	0.033	1.065 (0.106)	0.818 (0.056)	0.136 (0.023)		
ME05_06	ME51030	0.029	1.006 (0.060)	1.165 (0.050)			
ME05_07	ME51502	0.043	0.997 (0.119)	1.215 (0.066)	0.130 (0.020)		
ME05_08	ME51224	0.031	0.837 (0.092)	0.003 (0.128)	0.256 (0.050)		
ME05_09	ME51207	0.035	0.786 (0.129)	0.860 (0.124)	0.333 (0.040)		
ME05_10	ME51427	0.020	1.144 (0.112)	0.728 (0.055)	0.160 (0.024)		
ME05_11	ME51533	0.038	1.085 (0.054)	0.181 (0.030)			
ME05_12	ME51080	0.121	1.104 (0.057)	0.231 (0.031)			
ME06_01	ME61018	0.029	0.944 (0.049)	0.106 (0.034)			
ME06_02	ME61274	0.028	0.743 (0.081)	-0.456 (0.180)	0.267 (0.067)		
ME06_03	ME61248	0.032	0.910 (0.040)	0.408 (0.025)		0.443 (0.038)	-0.443 (0.042)
ME06_04	ME61039	0.021	1.103 (0.055)	0.238 (0.030)			
ME06_05	ME61079	0.100	1.253 (0.066)	0.917 (0.035)			
ME06_06	ME61179	0.055	1.284 (0.107)	0.197 (0.057)	0.191 (0.029)		
ME06_07	ME61052	0.048	1.101 (0.086)	0.215 (0.057)	0.116 (0.027)		
ME06_08	ME61207	0.048	1.595 (0.115)	0.428 (0.035)	0.103 (0.017)		
ME06_09	ME61236	0.070	0.789 (0.045)	0.432 (0.040)			
ME06_10	ME61266	0.033	0.494 (0.020)	0.716 (0.040)		-0.892 (0.081)	0.892 (0.090)
ME06_11	ME61106	0.043	1.040 (0.106)	0.095 (0.094)	0.276 (0.041)		
ME07_01	ME51401	0.046	0.786 (0.045)	0.583 (0.042)			
ME07_02	ME51075	0.058	1.318 (0.187)	1.202 (0.065)	0.295 (0.020)		
ME07_03	ME51402	0.013	0.922 (0.049)	0.398 (0.035)			
ME07_04	ME51226	0.039	1.362 (0.142)	0.715 (0.054)	0.257 (0.023)		
ME07_05	ME51131	0.027	0.716 (0.042)	0.098 (0.042)			
ME07_06	ME51103	0.019	1.279 (0.120)	0.180 (0.068)	0.277 (0.032)		
ME07_07	ME51217	0.020	1.202 (0.061)	0.625 (0.031)			
ME07_08	ME51079	0.119	0.839 (0.048)	0.683 (0.042)			

Item		RMSD	Slope (a_i)	Location (b_i)	Guessing (c_i)	Step 1 (d_{i1})	Step 2 (d_{i2})
ME07_09	ME51211	0.031	0.811 (0.096)	-0.234 (0.168)	0.333 (0.060)		
ME07_10	ME51102	0.031	1.038 (0.105)	0.793 (0.059)	0.146 (0.024)		
ME07_11	ME51009	0.022	0.829 (0.045)	-0.017 (0.038)			
ME07_12	ME51100	0.033	0.853 (0.109)	0.345 (0.124)	0.318 (0.045)		
ME08_01	ME71018	0.036	1.311 (0.109)	0.250 (0.052)	0.177 (0.026)		
ME08_02	ME71009	0.023	1.153 (0.056)	0.145 (0.029)			
ME08_03	ME71037	0.068	0.742 (0.042)	-0.031 (0.041)			
ME08_04	ME71051	0.030	1.220 (0.066)	0.955 (0.037)			
ME08_05	ME71064	0.040	0.697 (0.083)	0.630 (0.103)	0.148 (0.038)		
* ME08_06	ME71176	—	0.719 (0.068)	-1.067 (0.190)	0.223 (0.075)		
ME08_07	ME71169	0.062	1.197 (0.061)	0.662 (0.032)			
ME08_08	ME71083	0.045	1.177 (0.111)	0.396 (0.062)	0.213 (0.029)		
ME08_10	ME71184	0.036	2.115 (0.240)	1.037 (0.038)	0.238 (0.015)		
ME08_11	ME71141	0.148	0.871 (0.047)	0.271 (0.036)			
ME08_12	ME71194	0.050	0.732 (0.046)	-1.189 (0.074)			
ME08_13	ME71193	0.032	0.679 (0.024)	0.383 (0.028)		-0.779 (0.065)	0.779 (0.068)
ME08_14	ME71192	0.051	0.598 (0.023)	1.060 (0.040)		-1.329 (0.090)	1.329 (0.101)
ME09_01	ME61275	0.022	0.765 (0.077)	-0.543 (0.161)	0.234 (0.063)		
ME09_02	ME61027	0.037	0.795 (0.044)	-0.483 (0.046)			
ME09_03	ME61255	0.028	0.838 (0.034)	0.560 (0.026)		-0.131 (0.045)	0.131 (0.051)
ME09_04	ME61021	0.181	0.829 (0.055)	1.365 (0.069)			
ME09_05	ME61043	0.019	1.215 (0.059)	0.321 (0.028)			
ME09_06	ME61151	0.045	1.293 (0.100)	0.015 (0.055)	0.158 (0.029)		
ME09_07	ME61172	0.026	1.643 (0.140)	0.771 (0.036)	0.130 (0.016)		
ME09_08	ME61223	0.068	0.771 (0.072)	-0.299 (0.125)	0.170 (0.050)		
ME09_09	ME61269	0.037	0.816 (0.082)	-0.358 (0.141)	0.233 (0.057)		
ME09_10A	ME61081A	0.026	1.010 (0.056)	0.828 (0.040)			
ME09_10B	ME61081B	0.061	0.975 (0.059)	1.165 (0.053)			
ME10_02	ME71016	0.031	0.856 (0.046)	-0.119 (0.038)			
ME10_03	ME71163	0.018	1.875 (0.157)	0.956 (0.032)	0.084 (0.011)		
ME10_04	ME71045	0.028	1.288 (0.116)	0.383 (0.055)	0.207 (0.027)		
ME10_05	ME71213	0.030	0.835 (0.047)	0.423 (0.038)			
ME10_06	ME71070	0.036	0.431 (0.076)	0.228 (0.324)	0.251 (0.079)		
ME10_07	ME71181	0.042	0.892 (0.049)	0.506 (0.037)			
ME10_08	ME71179	0.051	1.079 (0.063)	1.052 (0.045)			
ME10_09	ME71067	0.031	0.561 (0.021)	1.046 (0.041)		-1.606 (0.100)	1.606 (0.110)
ME10_10A	ME71147A	0.017	1.327 (0.066)	-0.471 (0.032)			
ME10_10B	ME71147B	0.063	1.039 (0.053)	0.129 (0.031)			
ME10_11	ME71189	0.023	0.903 (0.055)	-1.301 (0.070)			

* eTIMSS items without a paperTIMSS counterpart

Item		RMSD	Slope (a_i)	Location (b_i)	Guessing (c_i)	Step 1 (d_{i1})	Step 2 (d_{i2})
ME10_12A	ME71187A	0.073	0.720 (0.044)	-0.692 (0.058)			
ME10_12B	ME71187B	0.085	0.660 (0.042)	-0.042 (0.047)			
ME11_01	ME61178	0.033	0.952 (0.050)	-0.015 (0.034)			
ME11_02	ME61246	0.047	1.166 (0.094)	0.237 (0.054)	0.138 (0.027)		
ME11_03	ME61271	0.039	0.623 (0.040)	-0.549 (0.058)			
ME11_04	ME61256	0.035	0.953 (0.050)	0.168 (0.033)			
ME11_05	ME61182	0.044	1.180 (0.070)	1.216 (0.047)			
ME11_06	ME61049	0.030	1.029 (0.108)	-0.420 (0.129)	0.354 (0.053)		
ME11_07	ME61232	0.031	0.840 (0.125)	0.774 (0.108)	0.312 (0.037)		
ME11_08	ME61095	0.039	0.908 (0.048)	-0.005 (0.035)			
ME11_09	ME61264	0.031	0.568 (0.026)	0.447 (0.034)		-0.177 (0.063)	0.177 (0.068)
ME11_10	ME61108	0.048	0.587 (0.097)	0.871 (0.152)	0.210 (0.049)		
ME11_11A	ME61211A	0.071	1.234 (0.061)	0.340 (0.028)			
ME11_11B	ME61211B	0.052	1.376 (0.156)	0.794 (0.055)	0.273 (0.023)		
ME12_01	ME71001	0.029	0.815 (0.076)	-0.897 (0.164)	0.234 (0.069)		
ME12_02	ME71010	0.037	0.585 (0.038)	-0.299 (0.054)			
ME12_03	ME71062	0.039	1.412 (0.179)	1.248 (0.056)	0.179 (0.017)		
ME12_04A	ME71216A	0.099	1.422 (0.066)	-0.113 (0.026)			
ME12_04B	ME71216B	0.076	1.024 (0.053)	0.460 (0.033)			
ME12_05	ME71117	0.083	0.673 (0.040)	-0.066 (0.045)			
ME12_06	ME71071	0.043	0.883 (0.113)	0.480 (0.106)	0.296 (0.039)		
ME12_07	ME71098	0.045	0.698 (0.035)	0.928 (0.038)		0.178 (0.049)	-0.178 (0.065)
* ME12_08	ME71069	—	1.096 (0.057)	0.565 (0.032)			
ME12_09A	ME71134A	0.104	1.785 (0.124)	0.218 (0.033)	0.115 (0.019)		
ME12_09B	ME71134B	0.125	1.486 (0.073)	0.533 (0.025)			
ME12_10	ME71202	0.044	0.558 (0.038)	-0.527 (0.065)			
ME12_11	ME71190	0.028	1.011 (0.052)	-0.141 (0.034)			
ME12_12	ME71218	0.032	1.322 (0.078)	1.177 (0.042)			
ME13_01	ME61240	0.056	0.724 (0.044)	0.735 (0.049)			
ME13_02	ME61254	0.055	0.926 (0.048)	0.169 (0.034)			
ME13_03	ME61244	0.026	0.994 (0.097)	-0.084 (0.101)	0.258 (0.044)		
ME13_04	ME61041	0.021	1.261 (0.148)	0.935 (0.057)	0.243 (0.022)		
ME13_05	ME61173	0.033	0.633 (0.039)	-0.390 (0.053)			
ME13_06	ME61252	0.029	1.184 (0.102)	0.676 (0.046)	0.113 (0.020)		
ME13_07	ME61261	0.070	1.336 (0.063)	0.289 (0.026)			
ME13_08	ME61224	0.107	0.973 (0.055)	0.884 (0.042)			
ME13_09	ME61077	0.039	0.881 (0.079)	-0.190 (0.104)	0.179 (0.045)		
ME13_10A	ME61069A	0.034	0.737 (0.043)	-0.659 (0.054)			
ME13_10B	ME61069B	0.039	0.712 (0.042)	0.040 (0.043)			

* eTIMSS items without a paperTIMSS counterpart

Item		RMSD	Slope (a_i)	Location (b_i)	Guessing (c_i)	Step 1 (d_{i1})	Step 2 (d_{i2})
ME14_01	ME71024	0.035	0.877 (0.047)	0.266 (0.036)			
ME14_02	ME71008	0.028	1.132 (0.085)	-0.182 (0.065)	0.137 (0.033)		
ME14_03	ME71165	0.050	1.212 (0.103)	0.309 (0.055)	0.167 (0.026)		
ME14_04	ME71049	0.106	0.749 (0.042)	0.007 (0.041)			
ME14_05	ME71063	0.042	0.845 (0.046)	0.239 (0.037)			
ME14_06	ME71079	0.050	1.303 (0.142)	0.887 (0.053)	0.216 (0.021)		
ME14_07	ME71081	0.032	1.012 (0.051)	-0.036 (0.032)			
ME14_08	ME71094	0.048	0.697 (0.097)	0.563 (0.133)	0.238 (0.046)		
ME14_09	ME71177	0.057	0.521 (0.037)	0.201 (0.055)			
ME14_10	ME71206	0.049	0.592 (0.066)	-0.329 (0.193)	0.195 (0.064)		
ME14_11A	ME71138A	0.025	0.753 (0.043)	0.007 (0.041)			
ME14_11B	ME71138B	0.079	1.013 (0.058)	0.994 (0.045)			
ME14_12	ME71203	0.044	0.911 (0.135)	1.242 (0.084)	0.207 (0.026)		
ME14_13	ME71205	0.064	1.201 (0.061)	0.531 (0.030)			

Appendix 12H: Science Item Parameters from the eTIMSS 2019 Non-Invariant Model Calibration— Grade 4

Item		RMSD	Slope (a_i)	Location (b_i)	Guessing (c_i)	Step 1 (d_{i1})	Step 2 (d_{i2})
SE01_01	SE51054	0.022	0.899 (0.090)	-0.467 (0.136)	0.276 (0.057)		
SE01_02	SE51024	0.032	0.503 (0.041)	0.711 (0.066)			
SE01_03A	SE51132A	0.025	0.723 (0.057)	1.451 (0.088)			
SE01_03B	SE51132B	0.024	0.844 (0.058)	1.171 (0.060)			
SE01_04	SE51040	0.024	0.458 (0.039)	0.688 (0.072)			
SE01_05	SE51193	0.023	0.976 (0.096)	-0.125 (0.105)	0.257 (0.047)		
SE01_06	SE51063	0.040	1.095 (0.135)	0.847 (0.063)	0.217 (0.028)		
SE01_07	SE51012	0.033	1.212 (0.121)	0.301 (0.070)	0.268 (0.034)		
SE01_08	SE51115	0.036	1.113 (0.058)	0.239 (0.029)			
SE01_09	SE51180	0.039	0.795 (0.094)	-0.070 (0.147)	0.279 (0.055)		
SE01_10	SE51106	0.031	1.066 (0.122)	0.743 (0.063)	0.192 (0.029)		
SE01_11	SE51148	0.023	1.147 (0.104)	-0.011 (0.079)	0.231 (0.039)		
SE02_01	SE71002	0.079	0.615 (0.042)	0.352 (0.047)			
SE02_02	SE71402	0.035	1.133 (0.107)	-0.188 (0.093)	0.293 (0.044)		
SE02_03	SE71017	0.030	0.671 (0.043)	0.153 (0.044)			
SE02_04	SE71077	0.031	1.005 (0.053)	0.155 (0.031)			
SE02_05	SE71072	0.073	0.895 (0.120)	0.679 (0.092)	0.264 (0.037)		
SE02_06	SE71054	0.053	0.808 (0.047)	0.024 (0.039)			
SE02_07	SE71115	0.019	0.993 (0.134)	0.783 (0.079)	0.273 (0.032)		
SE02_08	SE71140	0.045	0.925 (0.090)	-0.100 (0.104)	0.226 (0.046)		
SE02_09	SE71128	0.035	0.978 (0.119)	0.183 (0.113)	0.360 (0.044)		
SE02_10	SE71147	0.029	1.069 (0.100)	-0.194 (0.096)	0.260 (0.045)		
SE02_11A	SE71920A	0.124	0.535 (0.043)	0.877 (0.070)			
SE02_11B	SE71920B	0.041	0.811 (0.051)	0.709 (0.043)			
SE02_12	SE71268	0.081	0.904 (0.114)	0.834 (0.075)	0.179 (0.031)		
SE03_01	SE61141	0.026	1.281 (0.136)	0.509 (0.062)	0.284 (0.030)		
SE03_02	SE61023	0.094	0.745 (0.045)	-0.353 (0.049)			
SE03_03	SE61054	0.039	0.508 (0.021)	0.825 (0.046)		1.507 (0.062)	-1.507 (0.087)
SE03_04	SE61007	0.021	0.722 (0.081)	-0.081 (0.146)	0.218 (0.055)		
SE03_05	SE61006	0.022	0.761 (0.046)	-0.701 (0.059)			
SE03_06	SE61108	0.038	0.928 (0.114)	0.265 (0.113)	0.318 (0.044)		
SE03_07	SE61109	0.030	0.614 (0.100)	0.727 (0.150)	0.220 (0.051)		
SE03_08	SE61080	0.035	1.161 (0.121)	0.391 (0.071)	0.264 (0.034)		
SE03_09	SE61088	0.027	0.711 (0.057)	1.517 (0.092)			
SE03_10	SE61151	0.031	0.940 (0.054)	0.516 (0.035)			
SE03_11	SE61150	0.017	0.590 (0.042)	0.385 (0.050)			
SE03_12	SE61169	0.074	1.234 (0.128)	0.331 (0.071)	0.285 (0.034)		

Item		RMSD	Slope (a_i)	Location (b_i)	Guessing (c_i)	Step 1 (d_{i1})	Step 2 (d_{i2})
SE04_01	SE71013	0.037	1.128 (0.104)	-0.646 (0.116)	0.305 (0.056)		
SE04_02	SE71902	0.090	0.338 (0.041)	1.971 (0.220)			
SE04_03	SE71076	0.046	1.022 (0.086)	-0.605 (0.105)	0.207 (0.051)		
SE04_04	SE71041	0.068	0.862 (0.042)	0.827 (0.029)		0.288 (0.039)	-0.288 (0.051)
SE04_05	SE71046	0.051	0.907 (0.051)	0.272 (0.034)			
SE04_06	SE71095	0.036	0.555 (0.040)	0.142 (0.052)			
SE04_07	SE71129	0.028	0.806 (0.090)	-0.581 (0.181)	0.322 (0.067)		
SE04_08	SE71102	0.069	1.019 (0.058)	0.685 (0.035)			
SE04_09	SE71124	0.038	0.963 (0.107)	0.398 (0.086)	0.234 (0.038)		
SE04_10	SE71112	0.044	0.703 (0.074)	-0.915 (0.207)	0.257 (0.074)		
SE04_11	SE71265	0.080	0.355 (0.082)	0.211 (0.502)	0.317 (0.095)		
SE04_12	SE71223	0.059	0.423 (0.056)	-2.841 (0.458)	0.234 (0.092)		
SE05_01	SE51044	0.062	0.427 (0.038)	0.516 (0.071)			
SE05_03	SE51003	0.099	0.616 (0.073)	0.403 (0.119)	0.133 (0.042)		
SE05_04	SE51168	0.022	0.699 (0.044)	-0.686 (0.062)			
SE05_05	SE51010	0.022	0.785 (0.047)	0.098 (0.039)			
SE05_06	SE51035	0.028	1.335 (0.191)	1.175 (0.060)	0.233 (0.021)		
SE05_07	SE51059	0.033	0.488 (0.039)	0.130 (0.058)			
SE05_08	SE51142	0.044	0.669 (0.102)	0.605 (0.141)	0.235 (0.050)		
SE05_09A	SE51131A	0.041	0.964 (0.091)	0.064 (0.088)	0.193 (0.040)		
SE05_09B	SE51131B	0.060	0.848 (0.099)	0.697 (0.077)	0.151 (0.033)		
SE05_10	SE51151	0.045	0.849 (0.052)	-0.949 (0.065)			
SE05_11	SE51157	0.022	0.816 (0.130)	1.035 (0.093)	0.214 (0.035)		
SE06_01	SE61071	0.033	0.245 (0.047)	-1.669 (0.687)	0.248 (0.095)		
SE06_02	SE61138	0.026	0.558 (0.040)	0.079 (0.052)			
SE06_03A	SE61016A	0.054	0.949 (0.104)	0.535 (0.076)	0.191 (0.034)		
SE06_03B	SE61016B	0.048	0.996 (0.056)	0.669 (0.035)			
SE06_04	SE61011	0.027	0.735 (0.045)	-0.463 (0.052)			
SE06_06	SE61083	0.021	0.730 (0.047)	-0.980 (0.073)			
SE06_07	SE61034	0.028	0.733 (0.053)	1.219 (0.070)			
SE06_08	SE61044	0.023	0.759 (0.048)	0.545 (0.042)			
SE06_09A	SE61142A	0.050	0.662 (0.045)	0.518 (0.047)			
SE06_09B	SE61142B	0.047	0.811 (0.057)	1.203 (0.064)			
SE06_10A	SE61115A	0.037	1.583 (0.153)	0.482 (0.049)	0.270 (0.026)		
SE06_10B	SE61115B	0.082	1.292 (0.145)	0.736 (0.055)	0.237 (0.026)		
SE07_01	SE51161	0.023	0.494 (0.108)	1.148 (0.197)	0.224 (0.059)		
SE07_02	SE51051	0.025	1.336 (0.264)	1.505 (0.088)	0.281 (0.020)		
SE07_03Z	SE51138Z	0.030	0.516 (0.040)	0.378 (0.056)			
SE07_04	SE51194	0.078	1.038 (0.059)	0.771 (0.035)			
SE07_05	SE51029	0.026	0.654 (0.126)	1.161 (0.129)	0.234 (0.044)		
SE07_06	SE51077	0.030	0.750 (0.045)	-0.267 (0.047)			

Item		RMSD	Slope (a_i)	Location (b_i)	Guessing (c_i)	Step 1 (d_{i1})	Step 2 (d_{i2})
SE07_07	SE51200	0.064	0.827 (0.061)	1.353 (0.072)			
SE07_08	SE51075	0.045	0.551 (0.040)	-0.511 (0.070)			
SE07_09	SE51065	0.023	0.835 (0.092)	-0.363 (0.158)	0.299 (0.061)		
SE07_10	SE51191	0.036	1.383 (0.145)	0.668 (0.052)	0.241 (0.026)		
SE07_11	SE51099	0.020	0.914 (0.102)	0.379 (0.093)	0.218 (0.040)		
SE07_12	SE51175	0.097	1.047 (0.070)	1.288 (0.055)			
SE08_02	SE71033	0.039	0.471 (0.094)	0.490 (0.291)	0.287 (0.074)		
SE08_03	SE71065	0.101	0.623 (0.041)	-0.236 (0.053)			
SE08_04	SE71025	0.035	0.474 (0.102)	0.708 (0.271)	0.285 (0.071)		
SE08_05	SE71081	0.065	0.956 (0.138)	1.005 (0.077)	0.231 (0.030)		
SE08_06	SE71056	0.038	0.511 (0.043)	1.064 (0.083)			
SE08_07	SE71145	0.051	0.563 (0.079)	-0.294 (0.261)	0.284 (0.076)		
SE08_08	SE71104	0.092	0.618 (0.042)	-0.621 (0.066)			
SE08_09	SE71144	0.038	0.641 (0.075)	0.199 (0.137)	0.166 (0.049)		
SE08_10	SE71150	0.043	1.051 (0.055)	-0.295 (0.036)			
SE08_11	SE71201	0.038	0.972 (0.103)	-0.088 (0.116)	0.306 (0.049)		
SE08_12	SE71237	0.040	1.061 (0.056)	0.280 (0.030)			
SE08_13	SE71260	0.035	0.707 (0.098)	1.089 (0.090)	0.122 (0.032)		
SE09_01	SE61135	0.040	0.831 (0.082)	-0.411 (0.135)	0.231 (0.055)		
SE09_02	SE61069	0.022	0.361 (0.035)	-0.550 (0.101)			
SE09_03	SE61134	0.037	0.743 (0.075)	0.226 (0.099)	0.138 (0.039)		
SE09_04	SE61140	0.029	1.131 (0.144)	0.714 (0.072)	0.299 (0.031)		
SE09_05	SE61019	0.047	0.798 (0.051)	0.835 (0.047)			
SE09_06	SE61022	0.024	0.618 (0.080)	0.045 (0.180)	0.225 (0.060)		
SE09_07	SE61036	0.027	0.993 (0.061)	0.984 (0.044)			
SE09_08	SE61160	0.028	0.871 (0.052)	-0.909 (0.061)			
SE09_09	SE61159	0.078	0.662 (0.045)	-1.239 (0.092)			
SE09_10	SE61091	0.021	0.479 (0.028)	1.134 (0.058)		-0.190 (0.071)	0.190 (0.092)
SE09_11	SE61118	0.047	1.171 (0.130)	0.665 (0.061)	0.225 (0.029)		
SE09_12	SE61097	0.029	0.766 (0.097)	0.436 (0.116)	0.216 (0.045)		
SE10_01	SE71009	0.025	0.572 (0.026)	-0.508 (0.041)		1.156 (0.078)	-1.156 (0.054)
SE10_02	SE71093	0.050	0.591 (0.041)	-0.661 (0.070)			
SE10_03	SE71069	0.049	1.534 (0.223)	1.107 (0.055)	0.306 (0.020)		
SE10_04	SE71051	0.052	0.705 (0.048)	0.822 (0.053)			
SE10_05	SE71039	0.036	0.837 (0.078)	0.178 (0.085)	0.137 (0.037)		
SE10_06	SE71080	0.034	0.703 (0.110)	0.886 (0.113)	0.209 (0.042)		
SE10_07	SE71137	0.035	0.742 (0.045)	-0.355 (0.049)			
SE10_08	SE71103	0.058	1.130 (0.116)	0.329 (0.074)	0.257 (0.035)		
SE10_09	SE71106	0.047	0.706 (0.046)	0.546 (0.045)			
SE10_10	SE71100	0.055	0.801 (0.102)	-0.089 (0.165)	0.346 (0.057)		

Item		RMSD	Slope (a_i)	Location (b_i)	Guessing (c_i)	Step 1 (d_{i1})	Step 2 (d_{i2})
* SE10_11	SE71921	—	1.641 (0.279)	1.361 (0.064)	0.262 (0.018)		
SE10_12	SE71220	0.040	0.852 (0.122)	0.815 (0.093)	0.238 (0.037)		
SE10_13	SE71254	0.091	0.673 (0.044)	0.290 (0.044)			
SE11_01	SE61132	0.053	0.785 (0.121)	0.605 (0.127)	0.312 (0.045)		
SE11_02	SE61120	0.028	0.896 (0.099)	0.430 (0.086)	0.198 (0.037)		
SE11_03	SE61025	0.056	0.668 (0.043)	-0.037 (0.046)			
SE11_04A	SE61133A	0.051	1.625 (0.147)	0.286 (0.050)	0.284 (0.028)		
SE11_04B	SE61133B	0.072	1.492 (0.130)	0.947 (0.036)	0.074 (0.013)		
SE11_05	SE61074	0.033	0.719 (0.045)	0.359 (0.042)			
SE11_06	SE61093	0.016	0.764 (0.032)	-0.054 (0.031)		0.935 (0.053)	-0.935 (0.044)
SE11_07	SE61161	0.034	0.508 (0.041)	0.626 (0.063)			
SE11_08A	SE61042A	0.034	1.399 (0.155)	0.843 (0.048)	0.213 (0.022)		
SE11_08B	SE61042B	0.042	0.931 (0.116)	0.808 (0.074)	0.187 (0.031)		
SE11_09A	SE61041A	0.021	0.869 (0.050)	0.171 (0.036)			
SE11_09B	SE61041B	0.041	0.678 (0.045)	0.328 (0.044)			
SE11_10	SE61155	0.035	0.830 (0.092)	-0.348 (0.155)	0.289 (0.060)		
SE12_01	SE71031	0.024	0.617 (0.041)	-0.027 (0.049)			
SE12_02	SE71090	0.063	0.784 (0.047)	0.207 (0.038)			
SE12_03	SE71048	0.033	1.564 (0.196)	1.094 (0.047)	0.219 (0.018)		
SE12_04	SE71071	0.063	1.055 (0.065)	1.054 (0.044)			
SE12_05	SE71011	0.025	1.109 (0.093)	-0.464 (0.093)	0.218 (0.047)		
SE12_06	SE71142	0.035	0.949 (0.126)	0.423 (0.108)	0.349 (0.041)		
SE12_07	SE71138	0.031	0.640 (0.043)	-0.778 (0.071)			
SE12_08	SE71127	0.062	1.156 (0.114)	0.173 (0.078)	0.272 (0.037)		
SE12_10	SE71500	0.059	1.090 (0.114)	0.569 (0.064)	0.199 (0.030)		
SE12_11	SE71257	0.046	1.824 (0.325)	1.224 (0.060)	0.411 (0.018)		
SE12_12	SE71222	0.035	1.040 (0.056)	0.267 (0.030)			
SE12_13	SE71252	0.030	0.989 (0.115)	0.296 (0.098)	0.296 (0.041)		
SE13_02	SE61014	0.047	0.493 (0.040)	0.639 (0.065)			
SE13_03	SE61056	0.031	0.726 (0.046)	-0.837 (0.069)			
SE13_04	SE61015	0.051	0.519 (0.038)	-0.408 (0.068)			
SE13_05	SE61113	0.020	0.798 (0.054)	1.052 (0.056)			
SE13_06	SE61107	0.027	1.035 (0.123)	0.701 (0.070)	0.228 (0.031)		
SE13_07	SE61046	0.058	1.515 (0.173)	0.923 (0.046)	0.231 (0.021)		
SE13_08	SE61047	0.029	0.726 (0.091)	-0.333 (0.198)	0.331 (0.066)		
SE13_09	SE61048	0.031	1.556 (0.156)	0.564 (0.049)	0.278 (0.025)		
SE13_10	SE61096	0.041	1.172 (0.142)	0.681 (0.068)	0.288 (0.030)		
SE13_11	SE61124	0.037	0.606 (0.050)	1.376 (0.093)			
SE13_12	SE61116	0.037	0.718 (0.046)	0.307 (0.042)			

* eTIMSS items without a paperTIMSS counterpart

Item		RMSD	Slope (a_i)	Location (b_i)	Guessing (c_i)	Step 1 (d_{i1})	Step 2 (d_{i2})
SE14_01	SE71063	0.071	0.420 (0.036)	0.078 (0.067)			
SE14_02	SE71900	0.072	0.517 (0.078)	-0.138 (0.271)	0.269 (0.074)		
SE14_04	SE71043	0.030	0.693 (0.054)	1.435 (0.088)			
SE14_05	SE71005	0.038	0.818 (0.047)	-0.588 (0.052)			
SE14_06	SE71118	0.057	1.170 (0.142)	0.992 (0.056)	0.187 (0.023)		
SE14_07	SE71139	0.030	1.011 (0.114)	0.020 (0.112)	0.354 (0.045)		
SE14_08	SE71114	0.044	0.711 (0.044)	-0.596 (0.058)			
SE14_09	SE71131	0.051	0.454 (0.037)	0.090 (0.062)			
SE14_10	SE71152	0.034	1.080 (0.130)	0.534 (0.079)	0.302 (0.034)		
SE14_11	SE71218	0.062	0.742 (0.076)	-1.147 (0.208)	0.265 (0.077)		
SE14_12	SE71214	0.021	1.078 (0.100)	0.163 (0.075)	0.209 (0.036)		
SE14_13	SE71213	0.068	0.769 (0.055)	1.179 (0.065)			

Appendix 12I: Mathematics Item Parameters from the eTIMSS 2019 Non-Invariant Model Calibration—Grade 8

Item		RMSD	Slope (a_i)	Location (b_i)	Guessing (c_i)	Step 1 (d_{i1})	Step 2 (d_{i2})
ME01_01	ME52024	0.059	1.440 (0.157)	0.620 (0.062)	0.231 (0.029)		
ME01_02A	ME52058A	0.050	1.181 (0.071)	-0.248 (0.039)			
ME01_02B	ME52058B	0.059	1.368 (0.084)	1.044 (0.039)			
ME01_03	ME52125	0.045	1.166 (0.118)	0.772 (0.061)	0.124 (0.025)		
ME01_04	ME52229	0.129	1.224 (0.070)	0.379 (0.034)			
ME01_05	ME52063	0.043	1.674 (0.170)	0.634 (0.049)	0.196 (0.024)		
ME01_06	ME52072	0.050	1.229 (0.116)	0.170 (0.072)	0.165 (0.037)		
ME01_07A	ME52146A	0.068	0.865 (0.055)	0.437 (0.045)			
ME01_07B	ME52146B	0.070	1.625 (0.110)	1.364 (0.043)			
ME01_08	ME52092	0.042	1.379 (0.226)	1.661 (0.077)	0.186 (0.018)		
ME01_09	ME52046	0.071	0.946 (0.162)	1.762 (0.106)	0.143 (0.023)		
ME01_10	ME52083	0.044	1.328 (0.163)	1.046 (0.063)	0.200 (0.024)		
ME01_11	ME52082	0.031	1.207 (0.124)	0.285 (0.078)	0.203 (0.038)		
ME01_12	ME52161	0.037	1.034 (0.104)	-0.147 (0.108)	0.200 (0.052)		
ME01_13A	ME52418A	0.063	1.636 (0.161)	0.809 (0.045)	0.139 (0.020)		
ME01_13B	ME52418B	0.071	1.487 (0.172)	0.773 (0.061)	0.245 (0.027)		
ME02_01	ME72007	0.049	0.760 (0.038)	1.016 (0.040)		-0.143 (0.061)	0.143 (0.075)
ME02_02	ME72025	0.038	1.636 (0.175)	0.678 (0.053)	0.223 (0.025)		
ME02_03	ME72017	0.080	1.377 (0.091)	1.223 (0.044)			
ME02_04	ME72190	0.057	0.969 (0.059)	-0.005 (0.042)			
ME02_05	ME72068	0.039	1.357 (0.140)	0.131 (0.078)	0.250 (0.039)		
ME02_06	ME72076	0.052	1.297 (0.140)	0.766 (0.061)	0.175 (0.026)		
ME02_07	ME72056	0.033	1.288 (0.074)	0.555 (0.034)			
ME02_08	ME72098	0.038	1.906 (0.111)	0.765 (0.028)			
ME02_09	ME72103	0.025	1.280 (0.135)	0.688 (0.062)	0.170 (0.027)		
ME02_10	ME72121	0.073	1.141 (0.067)	-0.092 (0.038)			
ME02_11	ME72180	0.103	0.505 (0.043)	0.313 (0.070)			
ME02_12	ME72198	0.026	1.353 (0.078)	0.621 (0.034)			
ME02_13	ME72227	0.037	1.371 (0.078)	0.499 (0.033)			
ME02_14	ME72170	0.042	0.785 (0.052)	0.129 (0.049)			
ME02_15	ME72209	0.040	0.976 (0.073)	1.541 (0.072)			
ME03_01	ME62005	0.082	1.000 (0.146)	0.824 (0.104)	0.294 (0.037)		
ME03_02	ME62139	0.065	0.977 (0.061)	0.803 (0.045)			
ME03_03	ME62164	0.073	1.514 (0.143)	0.320 (0.057)	0.183 (0.030)		
ME03_04	ME62142	0.037	0.859 (0.055)	-0.160 (0.048)			
ME03_05	ME62084	0.026	1.715 (0.236)	1.486 (0.055)	0.142 (0.015)		
ME03_06	ME62351	0.034	0.843 (0.171)	1.541 (0.120)	0.251 (0.033)		
ME03_07	ME62223	0.048	1.633 (0.154)	0.028 (0.061)	0.212 (0.035)		

Item		RMSD	Slope (a_i)	Location (b_i)	Guessing (c_i)	Step 1 (d_{i1})	Step 2 (d_{i2})
ME03_08	ME62027	0.037	0.739 (0.051)	0.722 (0.055)			
ME03_09	ME62174	0.034	1.733 (0.239)	0.976 (0.061)	0.342 (0.023)		
ME03_10	ME62244	0.050	1.131 (0.066)	0.575 (0.038)			
ME03_11	ME62261	0.028	2.219 (0.315)	1.516 (0.046)	0.140 (0.013)		
ME03_12	ME62300	0.033	0.748 (0.033)	0.443 (0.032)		-0.368 (0.066)	0.368 (0.069)
ME03_13	ME62254	0.032	0.852 (0.063)	1.461 (0.075)			
ME03_14A	ME62132A	0.045	1.084 (0.066)	-0.180 (0.041)			
ME03_14B	ME62132B	0.054	0.896 (0.140)	0.927 (0.115)	0.270 (0.040)		
ME04_01	ME72178	0.070	1.230 (0.073)	0.805 (0.038)			
ME04_02	ME72234	0.087	1.454 (0.186)	1.065 (0.061)	0.240 (0.023)		
ME04_03	ME72020	0.039	0.751 (0.035)	0.059 (0.033)		-0.188 (0.066)	0.188 (0.062)
ME04_04	ME72027	0.027	1.325 (0.129)	0.224 (0.070)	0.199 (0.036)		
ME04_05	ME72052	0.039	1.291 (0.086)	1.334 (0.049)			
ME04_06	ME72067	0.084	1.665 (0.180)	0.355 (0.062)	0.292 (0.032)		
ME04_07A	ME72083A	0.029	1.173 (0.069)	-0.101 (0.038)			
ME04_07B	ME72083B	0.089	0.873 (0.098)	0.883 (0.080)	0.111 (0.030)		
ME04_08A	ME72108A	0.094	0.797 (0.052)	0.324 (0.048)			
ME04_08B	ME72108B	0.148	1.128 (0.070)	0.967 (0.044)			
ME04_09	ME72181	0.120	0.984 (0.064)	1.047 (0.051)			
ME04_10	ME72126	0.036	0.742 (0.032)	0.967 (0.037)		-0.744 (0.078)	0.744 (0.087)
ME04_11	ME72164	0.092	0.657 (0.054)	1.488 (0.094)			
ME04_12A	ME72185A	0.138	1.421 (0.084)	0.813 (0.035)			
ME04_12B	ME72185B	0.119	1.289 (0.077)	0.742 (0.037)			
ME05_01	ME52413	0.145	1.322 (0.131)	0.369 (0.067)	0.193 (0.033)		
ME05_02	ME52134	0.027	1.348 (0.122)	-0.136 (0.074)	0.176 (0.041)		
ME05_03	ME52078	0.044	0.910 (0.126)	0.987 (0.094)	0.196 (0.035)		
ME05_04	ME52034	0.052	1.120 (0.136)	0.625 (0.086)	0.250 (0.036)		
ME05_05A	ME52174A	0.041	0.964 (0.059)	0.317 (0.041)			
ME05_05B	ME52174B	0.047	1.066 (0.070)	1.184 (0.051)			
ME05_06	ME52130	0.035	1.415 (0.155)	0.973 (0.054)	0.159 (0.022)		
ME05_07	ME52073	0.080	1.417 (0.141)	0.706 (0.054)	0.157 (0.025)		
ME05_08	ME52110	0.050	1.586 (0.092)	0.785 (0.031)			
ME05_09	ME52105	0.023	1.154 (0.082)	1.482 (0.059)			
ME05_10	ME52407	0.061	1.143 (0.138)	0.358 (0.099)	0.297 (0.043)		
ME05_11	ME52036	0.121	0.815 (0.056)	0.926 (0.055)			
ME05_12	ME52502	0.072	1.047 (0.063)	-0.036 (0.040)			
ME05_13	ME52117	0.060	0.638 (0.065)	2.338 (0.174)			
ME05_14	ME52426	0.058	0.862 (0.094)	-0.342 (0.154)	0.227 (0.066)		
ME06_01	ME62150	0.033	1.062 (0.065)	-0.231 (0.042)			
ME06_02	ME62335	0.030	1.439 (0.133)	-0.025 (0.069)	0.192 (0.039)		
ME06_03	ME62219	0.030	2.183 (0.237)	0.888 (0.040)	0.198 (0.018)		

Item		RMSD	Slope (a_i)	Location (b_i)	Guessing (c_i)	Step 1 (d_{i1})	Step 2 (d_{i2})
ME06_04	ME62002	0.072	0.454 (0.043)	0.839 (0.089)			
ME06_05	ME62149	0.085	1.263 (0.125)	0.760 (0.055)	0.121 (0.024)		
ME06_06	ME62241	0.037	1.568 (0.090)	0.729 (0.031)			
ME06_08	ME62105	0.026	0.765 (0.031)	0.842 (0.033)		-1.536 (0.112)	1.536 (0.117)
ME06_09	ME62040	0.051	0.680 (0.134)	1.270 (0.148)	0.235 (0.047)		
ME06_10	ME62288	0.022	0.804 (0.036)	1.172 (0.038)		-0.914 (0.085)	0.914 (0.095)
ME06_11	ME62173	0.030	1.231 (0.075)	0.904 (0.040)			
ME06_12	ME62133	0.045	1.219 (0.140)	0.749 (0.069)	0.197 (0.030)		
ME06_13A	ME62123A	0.041	1.531 (0.165)	0.406 (0.065)	0.264 (0.032)		
ME06_13B	ME62123B	0.040	1.472 (0.160)	0.831 (0.054)	0.178 (0.024)		
ME07_01	ME52079	0.032	1.140 (0.161)	0.671 (0.099)	0.352 (0.037)		
ME07_02	ME52204	0.025	1.100 (0.129)	0.541 (0.086)	0.229 (0.037)		
ME07_03	ME52364	0.049	1.256 (0.074)	-0.219 (0.037)			
ME07_04	ME52215	0.111	0.938 (0.058)	0.133 (0.042)			
ME07_05	ME52147	0.038	1.580 (0.197)	0.890 (0.059)	0.277 (0.024)		
ME07_06	ME52067	0.063	1.340 (0.139)	0.204 (0.076)	0.243 (0.038)		
ME07_07	ME52068	0.034	1.400 (0.160)	1.269 (0.054)	0.105 (0.016)		
ME07_08	ME52087	0.018	1.774 (0.115)	1.163 (0.035)			
ME07_09	ME52048	0.169	0.779 (0.053)	0.660 (0.052)			
ME07_10	ME52039	0.055	1.323 (0.075)	0.431 (0.033)			
ME07_11	ME52208	0.047	2.078 (0.195)	1.179 (0.035)	0.050 (0.009)		
ME07_12A	ME52419A	0.088	0.882 (0.079)	0.028 (0.088)	0.106 (0.037)		
ME07_12B	ME52419B	0.069	1.289 (0.117)	-0.397 (0.085)	0.178 (0.048)		
ME07_13	ME52115	0.037	1.637 (0.139)	0.475 (0.042)	0.103 (0.021)		
ME07_14	ME52421	0.045	0.736 (0.052)	0.729 (0.056)			
ME08_01	ME72002	0.096	1.378 (0.081)	0.792 (0.035)			
ME08_02	ME72188	0.035	1.141 (0.120)	0.808 (0.062)	0.129 (0.026)		
ME08_03	ME72035	0.080	1.198 (0.072)	0.752 (0.038)			
ME08_04	ME72055	0.087	1.306 (0.080)	0.957 (0.039)			
ME08_05	ME72222	0.073	1.133 (0.128)	0.623 (0.075)	0.197 (0.033)		
ME08_06	ME72090	0.049	1.931 (0.230)	0.946 (0.047)	0.243 (0.020)		
ME08_07	ME72233	0.050	1.117 (0.178)	0.917 (0.099)	0.369 (0.034)		
ME08_08A	ME72106A	0.096	0.967 (0.059)	-0.030 (0.042)			
ME08_08B	ME72106B	0.130	1.588 (0.095)	0.879 (0.033)			
ME08_08C	ME72106C	0.129	1.839 (0.119)	1.140 (0.034)			
ME08_09A	ME72128A	0.045	1.008 (0.062)	0.664 (0.042)			
ME08_09B	ME72128B	0.060	0.900 (0.045)	0.886 (0.033)		-0.022 (0.052)	0.022 (0.062)
ME08_10	ME72119	0.053	1.075 (0.064)	0.352 (0.038)			
ME08_11A	ME72153A	0.041	1.327 (0.076)	0.352 (0.033)			
ME08_11B	ME72153B	0.043	1.457 (0.101)	1.359 (0.046)			
ME08_12	ME72172	0.042	1.065 (0.098)	0.292 (0.072)	0.117 (0.032)		

Item		RMSD	Slope (a_i)	Location (b_i)	Guessing (c_i)	Step 1 (d_{i1})	Step 2 (d_{i2})
ME09_01	ME62329	0.045	0.683 (0.077)	-0.925 (0.223)	0.233 (0.082)		
ME09_02	ME62151	0.047	1.256 (0.075)	0.848 (0.038)			
ME09_03	ME62346	0.079	0.997 (0.063)	0.868 (0.046)			
ME09_04	ME62212	0.047	1.379 (0.172)	1.262 (0.056)	0.139 (0.018)		
ME09_05	ME62056	0.022	1.366 (0.088)	1.170 (0.042)			
ME09_06	ME62317	0.090	1.378 (0.086)	1.070 (0.039)			
ME09_07	ME62350	0.027	1.380 (0.199)	1.575 (0.068)	0.120 (0.016)		
ME09_08	ME62078	0.034	1.568 (0.089)	0.683 (0.030)			
ME09_09	ME62284	0.060	0.724 (0.127)	0.750 (0.170)	0.300 (0.054)		
ME09_10	ME62245	0.065	1.449 (0.158)	0.795 (0.055)	0.191 (0.024)		
ME09_11	ME62287	0.045	1.369 (0.101)	1.528 (0.055)			
ME09_12A	ME62345A	0.059	0.731 (0.041)	0.669 (0.037)		0.400 (0.057)	-0.400 (0.066)
ME09_13	ME62115	0.023	1.572 (0.223)	1.382 (0.058)	0.186 (0.018)		
ME10_01	ME72187	0.117	0.923 (0.057)	0.014 (0.043)			
ME10_02	ME72022	0.055	1.508 (0.213)	1.210 (0.062)	0.253 (0.021)		
ME10_04	ME72045	0.042	1.294 (0.073)	0.525 (0.034)			
ME10_05	ME72049	0.121	0.797 (0.053)	-0.347 (0.055)			
ME10_06	ME72069	0.119	1.640 (0.091)	0.178 (0.028)			
ME10_07	ME72074	0.065	1.543 (0.094)	0.984 (0.035)			
ME10_08	ME72013	0.064	1.325 (0.126)	0.731 (0.052)	0.111 (0.022)		
ME10_09	ME72095	0.079	1.258 (0.074)	0.740 (0.037)			
ME10_10	ME72109	0.080	1.664 (0.112)	1.286 (0.040)			
ME10_11	ME72125	0.038	2.069 (0.183)	0.718 (0.035)	0.099 (0.015)		
ME10_12	ME72196	0.057	1.311 (0.076)	0.679 (0.035)			
ME10_13	ME72237	0.051	0.729 (0.095)	0.081 (0.178)	0.237 (0.064)		
ME10_14	ME72232	0.057	0.592 (0.046)	-0.101 (0.065)			
ME10_15	ME72206	0.040	1.307 (0.090)	1.360 (0.050)			
ME11_01	ME62271	0.063	1.526 (0.150)	0.573 (0.053)	0.171 (0.025)		
ME11_02	ME62152	0.049	1.116 (0.065)	0.459 (0.037)			
ME11_03	ME62215	0.042	0.889 (0.041)	0.721 (0.031)		-0.129 (0.054)	0.129 (0.061)
ME11_04	ME62143	0.026	1.545 (0.091)	0.851 (0.033)			
ME11_05	ME62230	0.033	1.506 (0.236)	1.430 (0.067)	0.240 (0.019)		
ME11_06	ME62095	0.029	1.620 (0.167)	0.597 (0.053)	0.207 (0.025)		
ME11_07	ME62076	0.027	1.703 (0.186)	0.292 (0.063)	0.301 (0.032)		
ME11_08	ME62030	0.041	0.516 (0.043)	0.227 (0.069)			
ME11_09	ME62171	0.078	0.887 (0.097)	0.313 (0.106)	0.169 (0.044)		
ME11_10	ME62301	0.034	1.031 (0.067)	1.125 (0.052)			
ME11_11	ME62194	0.041	0.864 (0.103)	-0.352 (0.175)	0.287 (0.072)		
ME11_12	ME62344	0.025	0.966 (0.064)	1.114 (0.055)			
ME11_13	ME62320	0.056	1.771 (0.153)	0.626 (0.039)	0.097 (0.018)		
ME11_14	ME62296	0.037	1.144 (0.067)	0.113 (0.037)			

Item		RMSD	Slope (a_i)	Location (b_i)	Guessing (c_i)	Step 1 (d_{i1})	Step 2 (d_{i2})
ME12_01	ME72001	0.058	1.774 (0.102)	0.723 (0.029)			
ME12_02	ME72019	0.053	1.489 (0.084)	0.522 (0.031)			
ME12_03	ME72189	0.109	1.408 (0.152)	0.507 (0.065)	0.236 (0.030)		
ME12_04	ME72024	0.089	1.222 (0.072)	0.722 (0.037)			
ME12_05	ME72043	0.045	2.027 (0.208)	0.702 (0.042)	0.197 (0.020)		
ME12_06	ME72221	0.082	1.695 (0.189)	0.635 (0.055)	0.263 (0.026)		
ME12_07	ME72220	0.078	1.500 (0.160)	1.061 (0.049)	0.120 (0.018)		
ME12_08	ME72225	0.034	1.250 (0.072)	0.521 (0.035)			
ME12_09A	ME72110A	0.079	1.377 (0.081)	0.788 (0.035)			
ME12_09B	ME72110B	0.102	1.837 (0.118)	1.132 (0.034)			
ME12_10	ME72150	0.063	1.561 (0.197)	0.404 (0.078)	0.391 (0.033)		
ME12_11	ME72139	0.031	1.255 (0.079)	1.050 (0.043)			
ME12_12	ME72229	0.018	0.973 (0.048)	1.444 (0.039)		-1.088 (0.104)	1.088 (0.114)
ME12_13	ME72171	0.033	1.282 (0.074)	0.435 (0.034)			
ME12_14A	ME72211A	0.076	1.656 (0.178)	0.325 (0.063)	0.276 (0.032)		
ME13_01	ME62001	0.090	0.964 (0.146)	1.043 (0.097)	0.257 (0.035)		
ME13_02	ME62214	0.052	1.028 (0.062)	0.551 (0.040)			
ME13_03	ME62146	0.038	1.408 (0.141)	0.832 (0.051)	0.133 (0.022)		
ME13_04	ME62154	0.044	1.395 (0.079)	0.033 (0.032)			
ME13_05	ME62067	0.042	0.992 (0.122)	0.129 (0.130)	0.303 (0.053)		
ME13_06	ME62341	0.036	0.892 (0.172)	1.619 (0.113)	0.225 (0.029)		
ME13_07	ME62242	0.025	1.204 (0.119)	0.269 (0.076)	0.185 (0.037)		
ME13_08A	ME62250A	0.057	1.103 (0.064)	0.303 (0.037)			
ME13_08B	ME62250B	0.056	1.399 (0.085)	0.978 (0.037)			
ME13_09	ME62170	0.051	0.582 (0.037)	0.978 (0.050)		0.644 (0.066)	-0.644 (0.087)
ME13_10	ME62192	0.031	1.129 (0.073)	1.145 (0.048)			
ME13_11	ME62072	0.035	0.980 (0.059)	0.189 (0.041)			
ME13_13	ME62120	0.067	1.284 (0.146)	0.765 (0.066)	0.206 (0.028)		
ME14_01	ME72005	0.052	0.927 (0.103)	0.424 (0.099)	0.174 (0.042)		
ME14_02	ME72021	0.106	1.200 (0.070)	0.470 (0.035)			
ME14_03	ME72026	0.027	0.788 (0.053)	0.627 (0.050)			
ME14_04A	ME72041A	0.094	1.129 (0.066)	0.330 (0.036)			
ME14_04B	ME72041B	0.097	1.099 (0.066)	0.608 (0.038)			
ME14_05	ME72223	0.052	2.059 (0.221)	0.582 (0.046)	0.265 (0.024)		
ME14_06	ME72094	0.035	1.255 (0.073)	-0.103 (0.036)			
ME14_07	ME72059	0.033	1.419 (0.081)	0.537 (0.031)			
ME14_08	ME72080	0.050	2.159 (0.212)	0.909 (0.036)	0.132 (0.016)		
ME14_09	ME72081	0.091	1.106 (0.071)	1.119 (0.048)			
ME14_10	ME72140	0.066	0.769 (0.052)	0.149 (0.049)			
ME14_11	ME72120	0.118	1.440 (0.089)	1.085 (0.038)			
ME14_12	ME72131	0.033	1.610 (0.107)	1.332 (0.041)			

Item		RMSD	Slope (a_i)	Location (b_i)	Guessing (c_i)	Step 1 (d_{i1})	Step 2 (d_{i2})
ME14_13	ME72147	0.031	1.398 (0.090)	1.214 (0.042)			
ME14_14	ME72154	0.041	1.166 (0.123)	0.098 (0.094)	0.235 (0.046)		
ME14_15	ME72192	0.034	0.899 (0.110)	0.418 (0.117)	0.220 (0.047)		
ME14_16	ME72161	0.064	1.083 (0.067)	0.814 (0.042)			

Appendix 12J:Science Item Parameters from the eTIMSS 2019 Non-Invariant Model Calibration Grade 8

Item		RMSD	Slope (a_i)	Location (b_i)	Guessing (c_i)	Step 1 (d_{i1})	Step 2 (d_{i2})
SE01_01	SE52006	0.034	0.585 (0.036)	-0.234 (0.047)		0.706 (0.084)	-0.706 (0.066)
SE01_02	SE52069	0.047	1.004 (0.173)	0.846 (0.110)	0.359 (0.040)		
SE01_03	SE52012	0.034	1.025 (0.120)	0.360 (0.095)	0.223 (0.042)		
SE01_04	SE52021	0.033	0.998 (0.066)	0.713 (0.042)			
SE01_05Z	SE52095Z	0.037	0.462 (0.044)	-0.059 (0.080)			
SE01_07	SE52054	0.037	0.739 (0.053)	-0.250 (0.059)			
SE01_08	SE52150	0.030	0.937 (0.158)	1.170 (0.091)	0.213 (0.033)		
SE01_09A	SE52243A	0.061	0.664 (0.052)	0.612 (0.057)			
SE01_09B	SE52243B	0.049	0.781 (0.056)	0.602 (0.049)			
SE01_09C	SE52243C	0.064	0.615 (0.111)	1.215 (0.134)	0.149 (0.043)		
SE01_10	SE52206	0.050	1.077 (0.110)	0.319 (0.078)	0.162 (0.036)		
SE01_11A	SE52112A	0.038	0.761 (0.096)	0.058 (0.153)	0.221 (0.057)		
SE01_11B	SE52112B	0.022	1.020 (0.068)	0.760 (0.042)			
SE01_12	SE52294	0.025	1.032 (0.109)	-0.048 (0.107)	0.221 (0.049)		
SE02_01	SE72072	0.027	0.909 (0.119)	0.517 (0.106)	0.222 (0.044)		
SE02_02	SE72029	0.051	1.336 (0.192)	0.802 (0.076)	0.339 (0.032)		
SE02_03	SE72902	0.067	1.230 (0.073)	0.236 (0.033)			
SE02_04	SE72077	0.067	0.709 (0.104)	0.441 (0.154)	0.224 (0.055)		
SE02_05A	SE72900A	0.045	0.865 (0.062)	0.875 (0.051)			
SE02_05B	SE72900B	0.094	0.678 (0.070)	1.953 (0.147)			
SE02_06	SE72103	0.081	0.715 (0.052)	0.160 (0.052)			
SE02_07	SE72110	0.037	0.883 (0.062)	0.800 (0.048)			
SE02_08	SE72130	0.066	0.752 (0.058)	0.963 (0.061)			
SE02_09	SE72148	0.069	1.290 (0.159)	0.939 (0.059)	0.179 (0.026)		
SE02_10	SE72200	0.029	0.906 (0.118)	0.786 (0.087)	0.164 (0.036)		
SE02_11	SE72232	0.040	1.517 (0.086)	0.303 (0.029)			
SE02_12	SE72275	0.034	1.064 (0.101)	-0.333 (0.101)	0.182 (0.049)		
SE02_13	SE72244	0.030	1.010 (0.065)	0.513 (0.039)			
SE02_14	SE72301	0.068	0.646 (0.128)	1.091 (0.151)	0.220 (0.050)		
SE02_15	SE72721	0.068	1.186 (0.116)	0.097 (0.080)	0.190 (0.040)		
SE02_16	SE72335	0.038	1.145 (0.164)	0.747 (0.087)	0.301 (0.036)		
SE03_01	SE62055	0.045	1.071 (0.141)	0.026 (0.135)	0.394 (0.052)		
SE03_02	SE62007	0.023	1.335 (0.138)	0.450 (0.063)	0.194 (0.031)		
SE03_03	SE62275	0.053	0.937 (0.068)	1.026 (0.053)			
SE03_04	SE62225	0.033	1.255 (0.257)	1.424 (0.088)	0.290 (0.025)		
SE03_05	SE62111	0.024	0.545 (0.033)	0.533 (0.042)		-0.040 (0.078)	0.040 (0.082)
SE03_06A	SE62116A	0.026	1.256 (0.076)	0.588 (0.033)			
SE03_06B	SE62116B	0.082	1.309 (0.088)	1.068 (0.041)			

Item		RMSD	Slope (a_i)	Location (b_i)	Guessing (c_i)	Step 1 (d_{i1})	Step 2 (d_{i2})
SE03_06C	SE62116C	0.040	1.059 (0.080)	1.308 (0.060)			
SE03_07	SE62262	0.040	1.052 (0.182)	1.124 (0.087)	0.270 (0.032)		
SE03_08	SE62035	0.035	1.064 (0.156)	1.038 (0.076)	0.200 (0.030)		
SE03_09	SE62144	0.045	0.878 (0.093)	-0.312 (0.133)	0.205 (0.056)		
SE03_10	SE62162	0.032	0.717 (0.056)	0.909 (0.062)			
SE03_11	SE62233	0.045	1.072 (0.178)	0.904 (0.095)	0.327 (0.036)		
SE03_13	SE62171	0.035	0.427 (0.109)	1.157 (0.285)	0.232 (0.072)		
SE04_01	SE72002	0.046	1.019 (0.105)	0.127 (0.093)	0.188 (0.042)		
* SE04_02	SE72403	—	0.615 (0.048)	0.088 (0.060)			
SE04_03	SE72021	0.046	1.289 (0.144)	0.372 (0.076)	0.262 (0.036)		
SE04_04	SE72082	0.068	0.695 (0.051)	0.091 (0.054)			
SE04_05	SE72066	0.071	1.048 (0.119)	0.458 (0.083)	0.196 (0.037)		
SE04_06	SE72063	0.039	0.731 (0.190)	1.811 (0.176)	0.194 (0.035)		
SE04_07	SE72102	0.078	0.760 (0.054)	0.370 (0.049)			
SE04_08A	SE72141A	0.040	1.010 (0.070)	0.985 (0.048)			
SE04_08B	SE72141B	0.095	0.712 (0.036)	0.907 (0.038)		-0.336 (0.066)	0.336 (0.076)
SE04_09	SE72921	0.073	1.209 (0.090)	1.315 (0.054)			
SE04_10	SE72234	0.063	1.325 (0.175)	1.159 (0.057)	0.151 (0.021)		
SE04_11	SE72251	0.055	1.099 (0.172)	1.081 (0.078)	0.238 (0.030)		
SE04_12	SE72284	0.060	0.587 (0.047)	-0.037 (0.065)			
SE04_13	SE72345	0.038	0.803 (0.045)	0.485 (0.034)		0.638 (0.053)	-0.638 (0.056)
SE04_14	SE72349	0.025	1.125 (0.116)	0.145 (0.087)	0.210 (0.041)		
SE04_15	SE72363	0.051	0.740 (0.103)	0.224 (0.159)	0.245 (0.057)		
SE05_01	SE52076	0.045	0.865 (0.132)	0.509 (0.135)	0.311 (0.049)		
SE05_02	SE52272	0.017	1.059 (0.065)	-0.079 (0.041)			
SE05_03A	SE52085A	0.044	1.058 (0.079)	1.280 (0.058)			
SE05_03B	SE52085B	0.008	0.974 (0.062)	-0.077 (0.044)			
SE05_04	SE52094	0.030	0.648 (0.053)	0.927 (0.068)			
SE05_05	SE52248	0.034	0.947 (0.256)	1.631 (0.142)	0.329 (0.032)		
SE05_06	SE52146	0.022	1.161 (0.070)	0.402 (0.035)			
SE05_07	SE52282	0.052	0.701 (0.123)	0.822 (0.148)	0.244 (0.051)		
SE05_08	SE52299	0.047	1.111 (0.149)	0.323 (0.111)	0.364 (0.045)		
SE05_09	SE52144	0.037	1.301 (0.155)	0.680 (0.066)	0.234 (0.031)		
SE05_10	SE52214	0.028	1.033 (0.065)	0.375 (0.038)			
SE05_12	SE52101	0.031	0.538 (0.050)	1.010 (0.086)			
SE05_13	SE52113	0.062	1.515 (0.181)	0.706 (0.059)	0.265 (0.029)		
SE05_14	SE52107	0.045	0.769 (0.174)	1.482 (0.133)	0.233 (0.039)		
SE06_01	SE62090	0.047	1.084 (0.129)	0.265 (0.100)	0.272 (0.044)		
SE06_02	SE62274	0.031	0.575 (0.029)	0.794 (0.050)		1.266 (0.069)	-1.266 (0.089)

* eTIMSS items without a paperTIMSS counterpart

Item		RMSD	Slope (a_i)	Location (b_i)	Guessing (c_i)	Step 1 (d_{i1})	Step 2 (d_{i2})
SE06_03	SE62284	0.040	0.384 (0.081)	0.394 (0.381)	0.242 (0.084)		
SE06_04A	SE62098A	0.019	0.626 (0.036)	0.477 (0.037)		0.011 (0.069)	-0.011 (0.072)
SE06_04B	SE62098B	0.027	0.956 (0.056)	1.309 (0.042)		0.016 (0.050)	-0.016 (0.071)
SE06_05	SE62032	0.030	1.610 (0.261)	1.305 (0.061)	0.251 (0.021)		
SE06_06	SE62043	0.042	0.962 (0.069)	1.075 (0.054)			
SE06_07	SE62158	0.050	0.696 (0.134)	0.845 (0.165)	0.290 (0.054)		
SE06_08	SE62159	0.061	1.086 (0.132)	0.593 (0.082)	0.218 (0.036)		
SE06_09	SE62005	0.055	1.258 (0.078)	0.741 (0.035)			
SE06_10	SE62075	0.039	0.966 (0.157)	0.852 (0.106)	0.302 (0.040)		
SE06_11	SE62004	0.021	2.042 (0.220)	0.848 (0.040)	0.195 (0.020)		
SE06_12	SE62175	0.039	0.625 (0.051)	0.605 (0.060)			
SE06_13A	SE62173A	0.027	0.631 (0.050)	0.247 (0.057)			
SE06_13B	SE62173B	0.044	0.847 (0.279)	2.133 (0.254)	0.217 (0.029)		
SE07_01A	SE52090A	0.042	0.396 (0.080)	-0.015 (0.431)	0.280 (0.092)		
SE07_01B	SE52090B	0.023	0.644 (0.068)	1.975 (0.153)			
SE07_02	SE52262	0.031	0.647 (0.129)	1.028 (0.159)	0.242 (0.052)		
SE07_03	SE52267	0.023	0.959 (0.139)	0.772 (0.098)	0.249 (0.039)		
SE07_04	SE52273	0.027	0.578 (0.038)	0.956 (0.050)		0.160 (0.070)	-0.160 (0.087)
SE07_05Z	SE52015Z	0.041	0.833 (0.057)	-0.427 (0.059)			
SE07_06	SE52051	0.048	0.924 (0.062)	0.651 (0.043)			
SE07_07	SE52026	0.030	0.774 (0.134)	0.489 (0.175)	0.353 (0.056)		
SE07_08	SE52130	0.027	0.953 (0.159)	1.167 (0.090)	0.215 (0.033)		
SE07_09	SE52028	0.029	0.770 (0.124)	0.642 (0.142)	0.266 (0.051)		
SE07_10	SE52189	0.043	0.995 (0.064)	0.476 (0.039)			
SE07_11	SE52217	0.026	0.643 (0.122)	0.842 (0.172)	0.254 (0.056)		
SE07_12	SE52038	0.046	1.262 (0.202)	1.077 (0.075)	0.299 (0.029)		
SE07_13	SE52099	0.023	0.953 (0.066)	0.899 (0.048)			
SE07_14	SE52118	0.017	0.785 (0.063)	1.250 (0.073)			
SE08_01	SE72070	0.079	0.905 (0.147)	0.541 (0.138)	0.363 (0.048)		
SE08_02	SE72400	0.045	0.864 (0.057)	-0.180 (0.050)			
SE08_03	SE72024	0.041	1.207 (0.126)	0.107 (0.086)	0.239 (0.042)		
SE08_04	SE72462	0.045	0.596 (0.114)	0.911 (0.174)	0.220 (0.056)		
SE08_05	SE72443	0.121	0.965 (0.119)	0.304 (0.110)	0.251 (0.046)		
SE08_06	SE72903	0.046	0.662 (0.036)	0.875 (0.040)		-0.216 (0.067)	0.216 (0.078)
SE08_07	SE72145	0.023	1.035 (0.078)	1.313 (0.061)			
SE08_08	SE72100	0.051	0.814 (0.181)	1.070 (0.145)	0.376 (0.045)		
SE08_10	SE72137	0.059	0.976 (0.099)	0.158 (0.090)	0.160 (0.040)		
SE08_11	SE72298	0.034	0.889 (0.059)	0.440 (0.043)			
SE08_12	SE72215	0.051	0.450 (0.022)	0.922 (0.052)		-1.332 (0.116)	1.332 (0.127)
SE08_13	SE72260	0.029	0.656 (0.050)	0.335 (0.055)			
SE08_14	SE72265	0.032	0.684 (0.051)	0.167 (0.054)			

Item		RMSD	Slope (a_i)	Location (b_i)	Guessing (c_i)	Step 1 (d_{i1})	Step 2 (d_{i2})
SE08_15	SE72347	0.046	0.862 (0.166)	1.337 (0.106)	0.216 (0.035)		
SE08_16	SE72351	0.048	0.738 (0.060)	1.146 (0.071)			
SE08_17	SE72367	0.050	0.998 (0.131)	0.821 (0.080)	0.183 (0.034)		
SE09_01	SE62099	0.023	0.947 (0.108)	0.342 (0.098)	0.192 (0.042)		
SE09_02	SE62095	0.033	0.480 (0.031)	0.790 (0.052)		-0.064 (0.085)	0.064 (0.098)
SE09_03	SE62106	0.025	0.785 (0.085)	-0.450 (0.151)	0.185 (0.059)		
SE09_04	SE62064	0.027	0.829 (0.056)	-0.331 (0.055)			
SE09_05	SE62132	0.031	0.886 (0.109)	0.263 (0.120)	0.229 (0.049)		
SE09_06	SE62163	0.019	1.139 (0.085)	1.356 (0.059)			
SE09_07	SE62153	0.032	1.424 (0.209)	0.958 (0.068)	0.316 (0.028)		
SE09_08	SE62018	0.021	0.573 (0.034)	1.448 (0.066)		-0.568 (0.086)	0.568 (0.112)
SE09_09	SE62143	0.061	0.910 (0.093)	2.025 (0.132)			
SE09_10	SE62276	0.024	0.776 (0.059)	0.960 (0.060)			
SE09_11	SE62050	0.047	0.905 (0.069)	1.242 (0.064)			
SE09_12	SE62205	0.035	1.252 (0.143)	0.884 (0.057)	0.144 (0.025)		
SE09_13	SE62190	0.032	0.921 (0.095)	0.146 (0.096)	0.155 (0.042)		
SE09_14A	SE62024A	0.025	0.659 (0.118)	0.882 (0.152)	0.219 (0.052)		
SE09_14B	SE62024B	0.047	0.692 (0.068)	1.772 (0.125)			
SE10_01	SE72033	0.043	0.786 (0.034)	0.303 (0.030)		-0.463 (0.066)	0.463 (0.065)
SE10_02	SE72440	0.046	0.647 (0.049)	-0.231 (0.064)			
SE10_03	SE72032	0.032	1.284 (0.192)	0.950 (0.073)	0.299 (0.029)		
SE10_04	SE72031	0.056	0.857 (0.134)	1.131 (0.092)	0.164 (0.033)		
SE10_05	SE72086	0.114	0.622 (0.049)	-0.700 (0.085)			
SE10_06	SE72005	0.024	0.917 (0.050)	0.707 (0.031)		0.230 (0.047)	-0.230 (0.055)
SE10_08	SE72123	0.069	0.724 (0.114)	0.411 (0.169)	0.276 (0.058)		
SE10_09	SE72116	0.029	0.563 (0.121)	1.151 (0.179)	0.213 (0.055)		
SE10_10	SE72920	0.062	0.534 (0.032)	0.967 (0.054)		1.002 (0.071)	-1.002 (0.097)
SE10_11	SE72294	0.099	0.725 (0.053)	0.526 (0.052)			
SE10_12	SE72231	0.075	0.868 (0.146)	1.140 (0.098)	0.203 (0.035)		
SE10_13	SE72261	0.063	0.856 (0.057)	-0.204 (0.050)			
SE10_14	SE72220	0.060	1.429 (0.231)	1.435 (0.069)	0.169 (0.019)		
SE10_15	SE72348	0.065	0.589 (0.049)	-0.876 (0.098)			
SE10_16	SE72720	0.032	0.426 (0.126)	2.036 (0.290)	0.166 (0.055)		
SE11_01	SE62279	0.036	1.172 (0.125)	0.061 (0.091)	0.248 (0.044)		
SE11_02	SE62112	0.022	0.512 (0.046)	0.294 (0.068)			
SE11_03	SE62119	0.032	1.042 (0.117)	0.131 (0.102)	0.242 (0.046)		
SE11_04	SE62093	0.038	0.554 (0.034)	-0.010 (0.044)		0.206 (0.082)	-0.206 (0.074)
SE11_05	SE62089	0.033	1.627 (0.189)	0.962 (0.047)	0.171 (0.021)		
SE11_06	SE62006	0.021	1.069 (0.066)	0.405 (0.037)			
SE11_07	SE62067	0.040	0.755 (0.055)	0.499 (0.050)			
SE11_08	SE62247	0.030	0.881 (0.177)	1.236 (0.112)	0.273 (0.037)		

Item		RMSD	Slope (a_i)	Location (b_i)	Guessing (c_i)	Step 1 (d_{i1})	Step 2 (d_{i2})
SE11_09	SE62177	0.036	0.859 (0.134)	0.978 (0.098)	0.198 (0.037)		
SE11_10	SE62186	0.031	1.462 (0.237)	1.262 (0.065)	0.243 (0.022)		
SE11_11A	SE62211A	0.022	0.789 (0.055)	0.402 (0.047)			
SE11_11B	SE62211B	0.014	0.938 (0.098)	2.053 (0.138)			
SE11_13	SE62033	0.024	1.263 (0.078)	0.724 (0.036)			
SE11_14	SE62037	0.041	0.745 (0.142)	0.798 (0.158)	0.315 (0.052)		
SE11_15	SE62242	0.025	0.864 (0.063)	-1.050 (0.082)			
SE12_01	SE72078	0.025	0.943 (0.061)	0.385 (0.041)			
SE12_02	SE72460	0.049	0.861 (0.140)	0.708 (0.128)	0.298 (0.046)		
SE12_03	SE72000	0.047	0.640 (0.031)	0.313 (0.035)		-0.347 (0.073)	0.347 (0.073)
SE12_05	SE72901	0.042	0.438 (0.105)	1.004 (0.290)	0.239 (0.074)		
SE12_06	SE72038	0.082	0.858 (0.124)	0.769 (0.105)	0.208 (0.041)		
SE12_07	SE72120	0.085	0.723 (0.122)	0.772 (0.144)	0.239 (0.051)		
SE12_08	SE72143	0.149	0.894 (0.062)	0.783 (0.048)			
SE12_09	SE72523	0.029	0.598 (0.037)	0.353 (0.040)		0.386 (0.070)	-0.386 (0.071)
SE12_10	SE72168	0.094	1.265 (0.137)	0.591 (0.063)	0.181 (0.030)		
SE12_11	SE72205	0.076	0.763 (0.114)	0.634 (0.131)	0.219 (0.049)		
SE12_12	SE72293	0.028	1.096 (0.071)	0.821 (0.041)			
SE12_13A	SE72280A	0.062	1.174 (0.076)	0.925 (0.041)			
SE12_13B	SE72280B	0.044	1.155 (0.122)	-0.309 (0.113)	0.276 (0.055)		
SE12_14	SE72370	0.049	1.288 (0.142)	0.234 (0.082)	0.269 (0.040)		
SE13_01A	SE62091A	0.051	1.112 (0.117)	-0.484 (0.126)	0.279 (0.061)		
SE13_01B	SE62091B	0.082	0.678 (0.082)	-0.500 (0.207)	0.229 (0.073)		
SE13_02	SE62100	0.056	0.985 (0.063)	0.526 (0.040)			
SE13_03	SE62097	0.037	0.934 (0.116)	0.396 (0.108)	0.226 (0.045)		
SE13_04	SE62101	0.048	0.562 (0.035)	0.033 (0.043)		0.305 (0.079)	-0.305 (0.072)
SE13_06	SE62128	0.041	0.929 (0.059)	0.117 (0.042)			
SE13_07	SE62047	0.048	0.466 (0.044)	0.368 (0.075)			
SE13_08	SE62042	0.061	0.551 (0.049)	0.861 (0.076)			
SE13_09	SE62250	0.029	0.601 (0.055)	1.366 (0.100)			
SE13_10	SE62246	0.033	1.214 (0.204)	1.163 (0.079)	0.292 (0.028)		
SE13_11	SE62056	0.033	1.263 (0.075)	0.505 (0.033)			
SE13_12	SE62235	0.033	0.780 (0.117)	0.853 (0.112)	0.186 (0.042)		
SE13_13	SE62180	0.028	1.182 (0.121)	0.264 (0.077)	0.192 (0.038)		
SE13_14	SE62022	0.044	0.584 (0.050)	0.771 (0.069)			
SE13_15	SE62243	0.050	0.647 (0.033)	-0.129 (0.039)		-0.227 (0.078)	0.227 (0.069)
SE14_01	SE72011	0.097	1.238 (0.127)	-0.090 (0.093)	0.253 (0.047)		
SE14_02	SE72905	0.090	0.482 (0.044)	-0.097 (0.078)			
SE14_03	SE72049	0.056	0.629 (0.108)	0.434 (0.207)	0.266 (0.065)		
SE14_04	SE72016	0.069	1.031 (0.051)	0.690 (0.027)		0.033 (0.045)	-0.033 (0.050)
SE14_05	SE72451	0.053	0.868 (0.057)	-0.137 (0.049)			

Item		RMSD	Slope (a_i)	Location (b_i)	Guessing (c_i)	Step 1 (d_{i1})	Step 2 (d_{i2})
SE14_06	SE72074	0.094	0.878 (0.060)	0.608 (0.045)			
SE14_07	SE72091	0.038	1.150 (0.160)	0.821 (0.079)	0.264 (0.033)		
SE14_08	SE72109	0.062	0.693 (0.052)	0.487 (0.053)			
SE14_09	SE72140	0.036	0.808 (0.141)	0.915 (0.124)	0.262 (0.045)		
SE14_10	SE72132	0.036	1.007 (0.083)	1.540 (0.077)			
SE14_11	SE72209	0.038	0.940 (0.118)	0.548 (0.097)	0.202 (0.041)		
SE14_12	SE72210	0.043	0.479 (0.035)	1.126 (0.065)		0.604 (0.079)	-0.604 (0.107)
SE14_13	SE72249	0.039	0.788 (0.116)	0.998 (0.098)	0.149 (0.036)		
SE14_14	SE72323	0.051	0.687 (0.115)	0.690 (0.157)	0.234 (0.054)		
SE14_15	SE72368	0.138	0.744 (0.088)	-0.236 (0.167)	0.214 (0.063)		
SE14_16	SE72303	0.078	0.786 (0.144)	1.364 (0.109)	0.165 (0.035)		

Appendix 12K: Mathematics Item Parameters from the Final eTIMSS 2019 Adjusted Model Calibration—Grade 4

Item		RMSD	Slope (a_i)	Location (b_i)	Guessing (c_i)	Step 1 (d_{i1})	Step 2 (d_{i2})
ME01_01	ME51043	0.045	0.450 (0.035)	0.011 (0.063)			
* ME01_02	ME51040	0.033	1.162	0.051	0.422		
* ME01_03	ME51008	0.050	1.270	1.010			
* ME01_04A	ME51031A	0.032	1.449	0.178			
* ME01_04B	ME51031B	0.029	1.619	0.252			
* ME01_05	ME51508	0.039	1.256	0.190			
* ME01_06A	ME51216A	0.038	1.272	0.592	0.237		
ME01_06B	ME51216B	0.029	0.749 (0.090)	-0.099 (0.167)	0.278 (0.060)		
* ME01_07	ME51221	0.038	0.571	-0.907	0.168		
* ME01_08	ME51115	0.030	0.591	1.706	0.113		
* ME01_09A	ME51507A	0.040	0.704	-0.564			
* ME01_09B	ME51507B	0.024	1.101	0.862			
* ME02_01	ME71219	0.042	0.709	-1.072	0.032		
* ME02_02	ME71021	0.056	1.146	0.191	0.089		
ME02_03	ME71167	0.025	1.557 (0.084)	1.073 (0.032)			
* ME02_04	ME71041	0.026	1.375	-0.220	0.143		
* ME02_05	ME71162	0.050	0.479	1.545		-0.840	0.840
ME02_06	ME71078	0.040	0.456 (0.037)	-0.848 (0.096)			
* ME02_07	ME71090	0.021	1.102	0.277	0.164		
* ME02_08	ME71151	0.057	0.593	0.990		-1.236	1.236
ME02_09	ME71119	0.033	0.675 (0.043)	-0.847 (0.069)			
ME02_10A	ME71217A	0.041	0.946 (0.054)	-0.888 (0.054)			
ME02_11	ME71142	0.030	1.132 (0.058)	-0.385 (0.035)			
* ME02_12	ME71204	0.063	1.334	0.569			
* ME03_01	ME61026	0.041	0.904	-0.740	0.098		
* ME03_02	ME61273	0.025	0.779	0.335	0.138		
* ME03_03	ME61034	0.027	1.187	0.694			
* ME03_04	ME61040	0.030	1.504	0.683	0.174		
* ME03_05	ME61228	0.058	0.734	0.965		-0.255	0.255
* ME03_06	ME61166	0.071	1.106	-0.263			
* ME03_07	ME61171	0.018	1.310	-0.249	0.231		
ME03_08	ME61080	0.024	0.700 (0.043)	0.525 (0.046)			
* ME03_09	ME61222	0.055	0.853	0.576	0.323		
ME03_10	ME61076	0.029	0.454 (0.038)	-1.144 (0.113)			
ME03_11	ME61084	0.019	1.076 (0.057)	0.648 (0.034)			

* Invariant item—item parameters for invariant items were fixed from the paperTIMSS concurrent calibration; location parameters are transformations of the fixed paperTIMSS value.

Item		RMSD	Slope (a_i)	Location (b_i)	Guessing (c_i)	Step 1 (d_{i1})	Step 2 (d_{i2})
* ME04_01	ME71013	0.036	1.155	-0.166	0.234		
* ME04_02	ME71026	0.056	1.118	0.255			
ME04_03	ME71036	0.044	0.949 (0.051)	-0.543 (0.041)			
* ME04_04	ME71040	0.031	1.391	0.432	0.103		
* ME04_05	ME71068	0.034	0.492	0.513	0.113		
* ME04_06A	ME71075A	0.026	1.256	0.360			
* ME04_06B	ME71075B	0.019	1.471	0.740			
* ME04_07	ME71080	0.063	1.595	0.731	0.303		
ME04_08	ME71211	0.026	0.640 (0.040)	0.153 (0.046)			
ME04_09	ME71178	0.022	0.862 (0.048)	0.582 (0.040)			
ME04_10B	ME71135B	0.025	0.807 (0.046)	-0.199 (0.041)			
ME04_11	ME71201	0.026	0.753 (0.056)	1.592 (0.090)			
* ME04_12	ME71175	0.054	0.801	0.008		0.560	-0.560
* ME05_01	ME51206	0.044	0.591	-0.793			
* ME05_02	ME51052	0.028	0.824	0.084	0.297		
* ME05_03	ME51049	0.021	1.341	0.131	0.143		
* ME05_04	ME51045	0.037	1.066	-0.015			
* ME05_05	ME51098	0.026	0.990	0.753	0.121		
* ME05_06	ME51030	0.034	0.945	1.187			
* ME05_07	ME51502	0.034	0.961	1.192	0.153		
* ME05_08	ME51224	0.032	0.938	0.080	0.301		
* ME05_09	ME51207	0.018	0.799	0.887	0.341		
* ME05_10	ME51427	0.030	1.053	0.752	0.136		
* ME05_11	ME51533	0.022	1.056	0.168			
ME05_12	ME51080	0.026	1.090 (0.056)	0.227 (0.031)			
ME06_01	ME61018	0.025	0.934 (0.048)	0.104 (0.034)			
* ME06_02	ME61274	0.048	0.665	-0.592	0.197		
* ME06_03	ME61248	0.048	0.828	0.439		0.401	-0.401
* ME06_04	ME61039	0.049	1.068	0.327			
ME06_05	ME61079	0.022	1.225 (0.065)	0.932 (0.036)			
* ME06_06	ME61179	0.023	1.141	0.070	0.157		
* ME06_07	ME61052	0.032	0.945	0.116	0.091		
* ME06_08	ME61207	0.034	1.429	0.376	0.113		
ME06_09	ME61236	0.041	0.783 (0.044)	0.435 (0.041)			
* ME06_10	ME61266	0.030	0.466	0.765		-0.844	0.844
* ME06_11	ME61106	0.023	0.974	-0.032	0.219		
* ME07_01	ME51401	0.028	0.784	0.540			
* ME07_02	ME51075	0.045	1.297	1.137	0.326		
* ME07_03	ME51402	0.040	0.917	0.471			

* Invariant item—item parameters for invariant items were fixed from the paperTIMSS concurrent calibration; location parameters are transformations of the fixed paperTIMSS value.

Item		RMSD	Slope (a_i)	Location (b_i)	Guessing (c_i)	Step 1 (d_{i1})	Step 2 (d_{i2})
* ME07_04	ME51226	0.031	1.302	0.681	0.270		
* ME07_05	ME51131	0.030	0.731	0.062			
* ME07_06	ME51103	0.033	1.258	0.267	0.280		
* ME07_07	ME51217	0.028	1.153	0.670			
ME07_08	ME51079	0.023	0.843 (0.048)	0.712 (0.042)			
* ME07_09	ME51211	0.054	0.783	-0.105	0.274		
* ME07_10	ME51102	0.031	0.948	0.792	0.159		
* ME07_11	ME51009	0.050	0.777	0.061			
* ME07_12	ME51100	0.044	0.642	0.217	0.195		
* ME08_01	ME71018	0.019	1.371	0.271	0.160		
* ME08_02	ME71009	0.066	1.248	0.303			
ME08_03	ME71037	0.047	0.751 (0.043)	0.019 (0.040)			
* ME08_04	ME71051	0.020	1.170	1.006			
* ME08_05	ME71064	0.051	0.724	0.850	0.155		
ME08_06	ME71176	0.044	0.728 (0.069)	-1.007 (0.188)	0.221 (0.075)		
* ME08_07	ME71169	0.021	1.317	0.600			
* ME08_08	ME71083	0.060	1.202	0.600	0.209		
* ME08_10	ME71184	0.037	1.635	1.153	0.244		
ME08_11	ME71141	0.031	0.877 (0.047)	0.317 (0.036)			
ME08_12	ME71194	0.046	0.743 (0.047)	-1.122 (0.073)			
ME08_13	ME71193	0.024	0.684 (0.024)	0.427 (0.027)		-0.773 (0.065)	0.773 (0.067)
ME08_14	ME71192	0.020	0.599 (0.023)	1.103 (0.040)		-1.327 (0.090)	1.327 (0.101)
* ME09_01	ME61275	0.043	0.709	-0.476	0.212		
* ME09_02	ME61027	0.048	0.893	-0.484			
* ME09_03	ME61255	0.029	0.812	0.576		-0.182	0.182
ME09_04	ME61021	0.025	0.827 (0.054)	1.414 (0.069)			
* ME09_05	ME61043	0.032	1.232	0.394			
* ME09_06	ME61151	0.027	1.203	-0.065	0.132		
* ME09_07	ME61172	0.033	1.520	0.849	0.123		
* ME09_08	ME61223	0.064	0.725	-0.633	0.119		
* ME09_09	ME61269	0.039	0.851	-0.370	0.130		
ME09_10A	ME61081A	0.028	1.013 (0.056)	0.873 (0.040)			
ME09_10B	ME61081B	0.027	0.978 (0.059)	1.210 (0.052)			
* ME10_02	ME71016	0.046	0.949	0.044			
* ME10_03	ME71163	0.040	1.762	1.060	0.076		
* ME10_04	ME71045	0.024	1.087	0.351	0.163		
ME10_05	ME71213	0.020	0.838 (0.047)	0.465 (0.038)			
* ME10_06	ME71070	0.023	0.354	-0.516	0.021		
ME10_07	ME71181	0.026	0.892 (0.049)	0.548 (0.037)			

* Invariant item—item parameters for invariant items were fixed from the paperTIMSS concurrent calibration; location parameters are transformations of the fixed paperTIMSS value.

Item		RMSD	Slope (a_i)	Location (b_i)	Guessing (c_i)	Step 1 (d_{i1})	Step 2 (d_{i2})
ME10_08	ME71179	0.021	1.080 (0.063)	1.095 (0.045)			
* ME10_09	ME71067	0.035	0.543	1.054		-1.542	1.542
* ME10_10A	ME71147A	0.054	1.302	-0.335			
* ME10_10B	ME71147B	0.091	0.886	0.392			
ME10_11	ME71189	0.050	0.910 (0.056)	-1.247 (0.069)			
ME10_12A	ME71187A	0.035	0.724 (0.044)	-0.645 (0.057)			
* ME10_12B	ME71187B	0.069	0.676	-0.261			
* ME11_01	ME61178	0.064	0.829	0.142			
* ME11_02	ME61246	0.029	0.953	0.145	0.090		
* ME11_03	ME61271	0.035	0.618	-0.626			
* ME11_04	ME61256	0.046	0.835	0.218			
* ME11_05	ME61182	0.025	1.210	1.173			
* ME11_06	ME61049	0.040	0.910	-0.389	0.310		
* ME11_07	ME61232	0.019	0.970	0.753	0.321		
ME11_08	ME61095	0.025	0.904 (0.048)	0.009 (0.035)			
ME11_09	ME61264	0.029	0.560 (0.026)	0.465 (0.034)		-0.183 (0.063)	0.183 (0.069)
* ME11_10	ME61108	0.035	0.520	0.647	0.182		
* ME11_11A	ME61211A	0.038	1.222	0.241			
* ME11_11B	ME61211B	0.024	1.512	0.719	0.276		
* ME12_01	ME71001	0.045	0.857	-0.986	0.087		
* ME12_02	ME71010	0.068	0.694	-0.093			
* ME12_03	ME71062	0.045	1.337	1.262	0.129		
* ME12_04A	ME71216A	0.057	1.253	-0.288			
* ME12_04B	ME71216B	0.044	0.831	0.388			
ME12_05	ME71117	0.027	0.676 (0.040)	-0.064 (0.045)			
* ME12_06	ME71071	0.031	1.248	0.610	0.332		
* ME12_07	ME71098	0.035	0.729	0.855		0.060	-0.060
ME12_08	ME71069	0.034	1.088 (0.056)	0.568 (0.033)			
ME12_09A	ME71134A	0.024	1.785 (0.124)	0.215 (0.033)	0.114 (0.019)		
ME12_09B	ME71134B	0.025	1.483 (0.072)	0.535 (0.026)			
ME12_10	ME71202	0.030	0.562 (0.038)	-0.521 (0.064)			
ME12_11	ME71190	0.031	1.009 (0.051)	-0.142 (0.034)			
* ME12_12	ME71218	0.036	1.098	1.289			
ME13_01	ME61240	0.026	0.732 (0.044)	0.739 (0.049)			
ME13_02	ME61254	0.034	0.935 (0.048)	0.176 (0.033)			
* ME13_03	ME61244	0.036	0.931	-0.068	0.220		
* ME13_04	ME61041	0.044	1.209	1.090	0.242		
* ME13_05	ME61173	0.059	0.706	-0.210			
* ME13_06	ME61252	0.026	1.157	0.684	0.113		

* Invariant item—item parameters for invariant items were fixed from the paperTIMSS concurrent calibration; location parameters are transformations of the fixed paperTIMSS value.

Item		RMSD	Slope (a_i)	Location (b_i)	Guessing (c_i)	Step 1 (d_{i1})	Step 2 (d_{i2})
* ME13_07	ME61261	0.033	1.261	0.208			
ME13_08	ME61224	0.024	0.974 (0.055)	0.890 (0.042)			
* ME13_09	ME61077	0.080	0.830	-0.068	0.093		
* ME13_10A	ME61069A	0.040	0.725	-0.698			
* ME13_10B	ME61069B	0.032	0.732	-0.021			
* ME14_01	ME71024	0.023	0.921	0.254			
* ME14_02	ME71008	0.053	1.118	-0.105	0.128		
* ME14_03	ME71165	0.025	1.277	0.294	0.190		
ME14_04	ME71049	0.030	0.770 (0.043)	0.006 (0.039)			
* ME14_05	ME71063	0.054	1.050	0.314			
* ME14_06	ME71079	0.023	1.179	0.790	0.192		
* ME14_07	ME71081	0.034	1.007	-0.012			
* ME14_08	ME71094	0.045	1.007	0.741	0.280		
ME14_09	ME71177	0.025	0.531 (0.038)	0.196 (0.054)			
* ME14_10	ME71206	0.038	0.681	-0.526	0.125		
ME14_11A	ME71138A	0.025	0.770 (0.044)	0.004 (0.040)			
* ME14_11B	ME71138B	0.037	0.984	0.841			
* ME14_12	ME71203	0.055	0.653	1.272	0.106		
* ME14_13	ME71205	0.030	1.108	0.460			

* Invariant item—item parameters for invariant items were fixed from the paperTIMSS concurrent calibration; location parameters are transformations of the fixed paperTIMSS value.

Appendix 12L: Science Item Parameters from the Final eTIMSS 2019 Adjusted Model Calibration—Grade 4

Item		RMSD	Slope (a_i)	Location (b_i)	Guessing (c_i)	Step 1 (d_{i1})	Step 2 (d_{i2})
* SE01_01	SE51054	0.039	0.934	-0.360	0.261		
* SE01_02	SE51024	0.038	0.612	0.733			
* SE01_03A	SE51132A	0.016	0.881	1.313			
* SE01_03B	SE51132B	0.026	0.810	1.124			
* SE01_04	SE51040	0.032	0.453	0.665			
* SE01_05	SE51193	0.036	0.940	-0.067	0.274		
* SE01_06	SE51063	0.022	1.148	0.812	0.222		
* SE01_07	SE51012	0.042	0.989	0.327	0.253		
* SE01_08	SE51115	0.036	1.090	0.205			
* SE01_09	SE51180	0.033	0.880	0.116	0.360		
* SE01_10	SE51106	0.034	1.024	0.780	0.215		
* SE01_11	SE51148	0.047	1.049	0.102	0.241		
* SE02_01	SE71002	0.065	0.572	0.102			
* SE02_02	SE71402	0.025	1.119	-0.194	0.299		
SE02_03	SE71017	0.028	0.683 (0.044)	0.193 (0.043)			
* SE02_04	SE71077	0.054	1.100	0.285			
* SE02_05	SE71072	0.079	1.212	0.845	0.232		
* SE02_06	SE71054	0.081	0.941	0.272			
* SE02_07	SE71115	0.034	0.848	0.856	0.249		
* SE02_08	SE71140	0.055	0.703	-0.012	0.240		
* SE02_09	SE71128	0.023	0.852	0.075	0.330		
* SE02_10	SE71147	0.045	0.883	-0.165	0.241		
SE02_11A	SE71920A	0.033	0.551 (0.043)	0.899 (0.068)			
* SE02_11B	SE71920B	0.018	0.956	0.671			
SE02_12	SE71268	0.020	0.923 (0.117)	0.866 (0.073)	0.180 (0.031)		
* SE03_01	SE61141	0.029	1.235	0.577	0.300		
SE03_02	SE61023	0.030	0.759 (0.046)	-0.304 (0.048)			
* SE03_03	SE61054	0.040	0.479	0.702		1.489	-1.489
* SE03_04	SE61007	0.035	0.647	-0.150	0.163		
* SE03_05	SE61006	0.040	0.785	-0.591			
* SE03_06	SE61108	0.022	1.050	0.292	0.352		
* SE03_07	SE61109	0.032	0.583	0.769	0.235		
* SE03_08	SE61080	0.034	0.968	0.356	0.264		
* SE03_09	SE61088	0.026	0.672	1.476			
* SE03_10	SE61151	0.024	0.952	0.499			
* SE03_11	SE61150	0.041	0.624	0.467			
* SE03_12	SE61169	0.050	1.077	0.138	0.268		

* Invariant item—item parameters for invariant items were fixed from the paperTIMSS concurrent calibration; location parameters are transformations of the fixed paperTIMSS value.

Item		RMSD	Slope (a_i)	Location (b_i)	Guessing (c_i)	Step 1 (d_{i1})	Step 2 (d_{i2})
* SE04_01	SE71013	0.048	0.852	-0.707	0.278		
SE04_02	SE71902	0.023	0.346 (0.042)	1.980 (0.215)			
* SE04_03	SE71076	0.069	0.860	-0.505	0.134		
* SE04_04	SE71041	0.090	0.778	1.036		0.021	-0.021
SE04_05	SE71046	0.032	0.933 (0.052)	0.318 (0.033)			
* SE04_06	SE71095	0.051	0.654	0.284			
* SE04_07	SE71129	0.029	0.855	-0.559	0.346		
* SE04_08	SE71102	0.062	0.751	0.727			
* SE04_09	SE71124	0.040	1.132	0.569	0.252		
* SE04_10	SE71112	0.052	0.743	-1.124	0.216		
* SE04_11	SE71265	0.071	0.708	0.687	0.341		
* SE04_12	SE71223	0.062	0.548	-1.514	0.298		
* SE05_01	SE51044	0.045	0.503	0.259			
* SE05_03	SE51003	0.083	0.711	-0.063	0.104		
* SE05_04	SE51168	0.080	0.704	-0.416			
* SE05_05	SE51010	0.044	0.766	0.135			
* SE05_06	SE51035	0.048	1.249	1.357	0.236		
* SE05_07	SE51059	0.024	0.584	0.163			
* SE05_08	SE51142	0.052	0.802	0.657	0.199		
* SE05_09A	SE51131A	0.037	1.014	-0.030	0.193		
* SE05_09B	SE51131B	0.036	0.988	0.635	0.197		
SE05_10	SE51151	0.041	0.874 (0.053)	-0.905 (0.062)			
* SE05_11	SE51157	0.031	0.739	1.058	0.190		
* SE06_01	SE61071	0.032	0.335	-1.313	0.197		
* SE06_02	SE61138	0.034	0.616	0.061			
* SE06_03A	SE61016A	0.038	0.926	0.424	0.216		
* SE06_03B	SE61016B	0.035	0.990	0.568			
* SE06_04	SE61011	0.056	0.733	-0.477			
SE06_06	SE61083	0.047	0.762 (0.048)	-0.967 (0.069)			
* SE06_07	SE61034	0.032	0.788	1.147			
* SE06_08	SE61044	0.056	0.740	0.610			
SE06_09A	SE61142A	0.032	0.679 (0.046)	0.477 (0.046)			
* SE06_09B	SE61142B	0.027	0.788	1.093			
* SE06_10A	SE61115A	0.030	1.468	0.405	0.264		
* SE06_10B	SE61115B	0.062	1.345	0.721	0.328		
* SE07_01	SE51161	0.031	0.488	1.066	0.217		
* SE07_02	SE51051	0.024	1.391	1.429	0.281		
SE07_03Z	SE51138Z	0.034	0.528 (0.040)	0.350 (0.055)			
SE07_04	SE51194	0.037	1.049 (0.059)	0.737 (0.035)			

* Invariant item—item parameters for invariant items were fixed from the paperTIMSS concurrent calibration; location parameters are transformations of the fixed paperTIMSS value.

Item		RMSD	Slope (a_i)	Location (b_i)	Guessing (c_i)	Step 1 (d_{i1})	Step 2 (d_{i2})
* SE07_05	SE51029	0.037	0.518	1.279	0.202		
* SE07_06	SE51077	0.077	0.747	-0.108			
* SE07_07	SE51200	0.050	0.679	1.255			
* SE07_08	SE51075	0.039	0.670	-0.527			
* SE07_09	SE51065	0.050	0.870	-0.156	0.333		
* SE07_10	SE51191	0.045	1.342	0.637	0.205		
* SE07_11	SE51099	0.040	0.868	0.391	0.216		
* SE07_12	SE51175	0.060	0.978	1.026			
* SE08_02	SE71033	0.022	0.544	0.335	0.289		
SE08_03	SE71065	0.033	0.636 (0.042)	-0.218 (0.052)			
* SE08_04	SE71025	0.040	0.270	-0.270			
* SE08_05	SE71081	0.085	0.949	1.110	0.157		
* SE08_06	SE71056	0.021	0.635	0.911			
* SE08_07	SE71145	0.067	0.516	-0.231	0.181		
* SE08_08	SE71104	0.074	0.795	-0.791			
* SE08_09	SE71144	0.041	0.515	-0.028	0.081		
* SE08_10	SE71150	0.044	1.055	-0.343			
* SE08_11	SE71201	0.046	1.048	0.033	0.285		
* SE08_12	SE71237	0.039	1.086	0.272			
* SE08_13	SE71260	0.032	0.735	1.164	0.151		
* SE09_01	SE61135	0.057	0.758	-0.539	0.268		
* SE09_02	SE61069	0.030	0.400	-0.422			
* SE09_03	SE61134	0.044	0.651	0.240	0.126		
* SE09_04	SE61140	0.029	1.039	0.660	0.296		
* SE09_05	SE61019	0.069	0.887	1.002			
* SE09_06	SE61022	0.037	0.656	0.241	0.241		
* SE09_07	SE61036	0.029	0.951	0.962			
SE09_08	SE61160	0.041	0.909 (0.054)	-0.828 (0.058)			
* SE09_09	SE61159	0.076	0.826	-0.729			
* SE09_10	SE61091	0.035	0.452	1.229		-0.176	0.176
* SE09_11	SE61118	0.039	1.001	0.601	0.217		
* SE09_12	SE61097	0.036	0.798	0.576	0.275		
SE10_01	SE71009	0.044	0.594 (0.027)	-0.451 (0.040)		1.114 (0.075)	-1.114 (0.052)
* SE10_02	SE71093	0.059	0.727	-0.350			
* SE10_03	SE71069	0.039	0.946	1.199	0.295		
* SE10_04	SE71051	0.029	0.748	0.681			
* SE10_05	SE71039	0.044	0.766	0.209	0.147		
* SE10_06	SE71080	0.037	0.929	0.987	0.235		
* SE10_07	SE71137	0.062	0.705	-0.224			

* Invariant item—item parameters for invariant items were fixed from the paperTIMSS concurrent calibration; location parameters are transformations of the fixed paperTIMSS value.

Item		RMSD	Slope (a_i)	Location (b_i)	Guessing (c_i)	Step 1 (d_{i1})	Step 2 (d_{i2})
* SE10_08	SE71103	0.049	0.815	0.333	0.259		
SE10_09	SE71106	0.030	0.720 (0.047)	0.568 (0.044)			
* SE10_10	SE71100	0.070	0.910	0.334	0.374		
SE10_11	SE71921	0.026	1.639 (0.279)	1.373 (0.064)	0.262 (0.018)		
* SE10_12	SE71220	0.023	0.998	0.791	0.232		
SE10_13	SE71254	0.031	0.688 (0.045)	0.317 (0.043)			
* SE11_01	SE61132	0.066	0.710	0.598	0.213		
* SE11_02	SE61120	0.025	0.884	0.392	0.197		
* SE11_03	SE61025	0.065	0.531	-0.307			
* SE11_04A	SE61133A	0.045	1.370	0.303	0.326		
* SE11_04B	SE61133B	0.043	1.701	0.851	0.114		
* SE11_05	SE61074	0.032	0.772	0.278			
* SE11_06	SE61093	0.054	0.761	0.002		0.937	-0.937
* SE11_07	SE61161	0.054	0.614	0.723			
* SE11_08A	SE61042A	0.031	1.366	0.865	0.239		
* SE11_08B	SE61042B	0.023	0.791	0.699	0.150		
* SE11_09A	SE61041A	0.031	0.871	0.175			
* SE11_09B	SE61041B	0.031	0.719	0.226			
* SE11_10	SE61155	0.042	0.735	-0.429	0.286		
SE12_01	SE71031	0.037	0.620 (0.042)	-0.025 (0.049)			
* SE12_02	SE71090	0.040	0.767	0.070			
* SE12_03	SE71048	0.048	1.433	1.250	0.220		
* SE12_04	SE71071	0.034	0.990	0.934			
* SE12_05	SE71011	0.053	1.209	-0.362	0.193		
* SE12_06	SE71142	0.055	0.826	0.552	0.323		
* SE12_07	SE71138	0.049	0.771	-0.560			
* SE12_08	SE71127	0.047	0.920	0.093	0.288		
* SE12_10	SE71500	0.036	0.792	0.392	0.140		
* SE12_11	SE71257	0.037	1.395	1.443	0.431		
* SE12_12	SE71222	0.056	0.906	0.290			
* SE12_13	SE71252	0.049	0.988	0.411	0.290		
* SE13_02	SE61014	0.039	0.495	0.484			
* SE13_03	SE61056	0.050	0.853	-0.679			
* SE13_04	SE61015	0.040	0.692	-0.336			
* SE13_05	SE61113	0.026	0.760	1.013			
* SE13_06	SE61107	0.046	1.001	0.700	0.180		
* SE13_07	SE61046	0.040	1.164	0.863	0.227		
* SE13_08	SE61047	0.032	0.751	-0.459	0.313		
* SE13_09	SE61048	0.053	1.300	0.568	0.221		

* Invariant item—item parameters for invariant items were fixed from the paperTIMSS concurrent calibration; location parameters are transformations of the fixed paperTIMSS value.

Item		RMSD	Slope (a_i)	Location (b_i)	Guessing (c_i)	Step 1 (d_{i1})	Step 2 (d_{i2})
* SE13_10	SE61096	0.061	1.100	0.789	0.257		
SE13_11	SE61124	0.024	0.620 (0.051)	1.359 (0.091)			
SE13_12	SE61116	0.033	0.743 (0.048)	0.313 (0.041)			
SE14_01	SE71063	0.032	0.445 (0.039)	0.099 (0.063)			
* SE14_02	SE71900	0.037	1.029	0.037	0.373		
* SE14_04	SE71043	0.031	0.644	1.440			
* SE14_05	SE71005	0.045	1.021	-0.525			
* SE14_06	SE71118	0.034	1.130	0.886	0.188		
* SE14_07	SE71139	0.033	0.952	0.066	0.359		
SE14_08	SE71114	0.049	0.756 (0.047)	-0.534 (0.054)			
* SE14_09	SE71131	0.030	0.577	0.030			
* SE14_10	SE71152	0.027	1.235	0.538	0.300		
* SE14_11	SE71218	0.079	0.795	-0.567	0.309		
* SE14_12	SE71214	0.046	1.098	0.178	0.167		
* SE14_13	SE71213	0.022	1.005	1.009			

* Invariant item—item parameters for invariant items were fixed from the paperTIMSS concurrent calibration; location parameters are transformations of the fixed paperTIMSS value.

Appendix 12M: Mathematics Item Parameters from the Final eTIMSS 2019 Adjusted Model Calibration—Grade 8

Item		RMSD	Slope (a_i)	Location (b_i)	Guessing (c_i)	Step 1 (d_{i1})	Step 2 (d_{i2})
* ME01_01	ME52024	0.018	1.646	0.551	0.232		
* ME01_02A	ME52058A	0.033	1.281	-0.255			
* ME01_02B	ME52058B	0.013	1.504	0.992			
* ME01_03	ME52125	0.028	1.196	0.684	0.098		
ME01_04	ME52229	0.021	1.237 (0.071)	0.391 (0.034)			
* ME01_05	ME52063	0.037	1.320	0.672	0.196		
* ME01_06	ME52072	0.042	1.009	0.107	0.146		
* ME01_07A	ME52146A	0.046	0.859	0.292			
* ME01_07B	ME52146B	0.035	1.533	1.263			
* ME01_08	ME52092	0.030	1.244	1.624	0.151		
* ME01_09	ME52046	0.053	1.125	1.586	0.188		
* ME01_10	ME52083	0.033	1.501	0.991	0.169		
* ME01_11	ME52082	0.027	1.202	0.271	0.174		
* ME01_12	ME52161	0.037	1.187	-0.100	0.189		
* ME01_13A	ME52418A	0.022	1.908	0.758	0.147		
* ME01_13B	ME52418B	0.036	1.916	0.663	0.250		
ME02_01	ME72007	0.033	0.743 (0.037)	1.042 (0.040)		-0.151 (0.063)	0.151 (0.077)
* ME02_02	ME72025	0.044	1.492	0.739	0.195		
* ME02_03	ME72017	0.043	1.319	1.127			
* ME02_04	ME72190	0.060	0.740	0.072			
* ME02_05	ME72068	0.039	1.285	0.089	0.185		
* ME02_06	ME72076	0.036	0.859	0.660	0.092		
* ME02_07	ME72056	0.055	1.159	0.661			
* ME02_08	ME72098	0.076	1.597	0.923			
* ME02_09	ME72103	0.037	1.249	0.754	0.150		
* ME02_10	ME72121	0.031	1.309	-0.154			
ME02_11	ME72180	0.042	0.499 (0.042)	0.327 (0.071)			
* ME02_12	ME72198	0.042	1.233	0.720			
* ME02_13	ME72227	0.094	1.507	0.688			
ME02_14	ME72170	0.034	0.774 (0.051)	0.140 (0.050)			
* ME02_15	ME72209	0.025	1.057	1.470			
* ME03_01	ME62005	0.058	0.871	0.588	0.304		
* ME03_02	ME62139	0.031	0.986	0.693			
* ME03_03	ME62164	0.032	1.357	0.185	0.172		
ME03_04	ME62142	0.038	0.837 (0.054)	-0.176 (0.049)			
* ME03_05	ME62084	0.039	1.393	1.663	0.144		

* Invariant item—item parameters for invariant items were fixed from the paperTIMSS concurrent calibration; location parameters are transformations of the fixed paperTIMSS value.

Item		RMSD	Slope (a_i)	Location (b_i)	Guessing (c_i)	Step 1 (d_{i1})	Step 2 (d_{i2})
* ME03_06	ME62351	0.035	0.804	1.515	0.207		
* ME03_07	ME62223	0.033	1.420	-0.054	0.188		
* ME03_08	ME62027	0.021	0.772	0.666			
* ME03_09	ME62174	0.028	1.403	0.972	0.319		
* ME03_10	ME62244	0.034	0.971	0.572			
* ME03_11	ME62261	0.027	1.889	1.570	0.132		
ME03_12	ME62300	0.036	0.721 (0.032)	0.442 (0.034)		-0.386 (0.069)	0.386 (0.072)
* ME03_13	ME62254	0.029	0.744	1.600			
* ME03_14A	ME62132A	0.047	1.185	-0.186			
* ME03_14B	ME62132B	0.032	1.049	0.887	0.263		
ME04_01	ME72178	0.018	1.184 (0.070)	0.793 (0.040)			
* ME04_02	ME72234	0.059	0.959	1.052	0.258		
ME04_03	ME72020	0.032	0.739 (0.035)	0.029 (0.033)		-0.192 (0.067)	0.192 (0.063)
* ME04_04	ME72027	0.076	1.225	0.321	0.154		
* ME04_05	ME72052	0.078	0.814	1.664			
* ME04_06	ME72067	0.034	1.318	0.106	0.218		
* ME04_07A	ME72083A	0.085	1.406	0.019			
* ME04_07B	ME72083B	0.054	0.776	0.579	0.076		
* ME04_08A	ME72108A	0.053	0.728	0.099			
ME04_08B	ME72108B	0.017	1.085 (0.067)	0.963 (0.046)			
ME04_09	ME72181	0.032	0.956 (0.062)	1.043 (0.052)			
* ME04_10	ME72126	0.043	0.679	1.010		-0.811	0.811
ME04_11	ME72164	0.026	0.639 (0.052)	1.498 (0.096)			
ME04_12A	ME72185A	0.022	1.376 (0.081)	0.799 (0.036)			
ME04_12B	ME72185B	0.018	1.251 (0.075)	0.726 (0.038)			
ME05_01	ME52413	0.027	1.276 (0.126)	0.346 (0.069)	0.189 (0.034)		
* ME05_02	ME52134	0.048	1.261	-0.161	0.130		
* ME05_03	ME52078	0.035	0.990	0.993	0.183		
* ME05_04	ME52034	0.029	1.216	0.659	0.279		
* ME05_05A	ME52174A	0.045	1.088	0.323			
* ME05_05B	ME52174B	0.017	1.118	1.130			
* ME05_06	ME52130	0.044	1.232	1.080	0.173		
* ME05_07	ME52073	0.039	1.385	0.583	0.174		
* ME05_08	ME52110	0.022	1.464	0.763			
* ME05_09	ME52105	0.030	1.172	1.538			
* ME05_10	ME52407	0.028	1.344	0.469	0.378		
ME05_11	ME52036	0.031	0.799 (0.054)	0.922 (0.056)			
* ME05_12	ME52502	0.035	1.165	-0.139			

* Invariant item—item parameters for invariant items were fixed from the paperTIMSS concurrent calibration; location parameters are transformations of the fixed paperTIMSS value.

Item		RMSD	Slope (a_i)	Location (b_i)	Guessing (c_i)	Step 1 (d_{i1})	Step 2 (d_{i2})
* ME05_13	ME52117	0.033	0.625	2.205			
* ME05_14	ME52426	0.056	0.785	-0.687	0.142		
* ME06_01	ME62150	0.045	1.111	-0.193			
* ME06_02	ME62335	0.045	1.377	0.004	0.175		
* ME06_03	ME62219	0.034	2.050	0.961	0.218		
ME06_04	ME62002	0.030	0.447 (0.042)	0.846 (0.091)			
* ME06_05	ME62149	0.043	1.089	0.617	0.111		
* ME06_06	ME62241	0.024	1.708	0.743			
* ME06_08	ME62105	0.058	0.757	0.960		-1.718	1.718
* ME06_09	ME62040	0.039	0.769	1.057	0.224		
* ME06_10	ME62288	0.030	0.776	1.250		-0.880	0.880
* ME06_11	ME62173	0.027	1.119	0.922			
* ME06_12	ME62133	0.018	1.315	0.726	0.214		
* ME06_13A	ME62123A	0.028	1.562	0.464	0.306		
* ME06_13B	ME62123B	0.031	1.444	0.814	0.138		
* ME07_01	ME52079	0.037	0.966	0.534	0.271		
* ME07_02	ME52204	0.038	0.871	0.506	0.180		
ME07_03	ME52364	0.047	1.228 (0.072)	-0.235 (0.038)			
ME07_04	ME52215	0.026	0.911 (0.056)	0.126 (0.043)			
* ME07_05	ME52147	0.021	1.572	0.872	0.275		
* ME07_06	ME52067	0.043	1.063	0.176	0.263		
* ME07_07	ME52068	0.035	1.417	1.374	0.132		
* ME07_08	ME52087	0.031	1.622	1.249			
ME07_09	ME52048	0.033	0.757 (0.051)	0.669 (0.053)			
* ME07_10	ME52039	0.022	1.235	0.382			
* ME07_11	ME52208	0.031	2.264	1.221	0.081		
* ME07_12A	ME52419A	0.053	0.888	-0.264	0.050		
* ME07_12B	ME52419B	0.035	1.372	-0.562	0.104		
* ME07_13	ME52115	0.030	1.738	0.457	0.080		
* ME07_14	ME52421	0.050	0.824	0.751			
* ME08_01	ME72002	0.039	1.517	0.652			
* ME08_02	ME72188	0.044	1.280	0.880	0.138		
* ME08_03	ME72035	0.033	1.132	0.661			
ME08_04	ME72055	0.020	1.260 (0.077)	0.968 (0.040)			
* ME08_05	ME72222	0.093	0.603	0.761	0.098		
* ME08_06	ME72090	0.044	1.211	0.987	0.198		
* ME08_07	ME72233	0.025	1.075	0.802	0.367		
* ME08_08A	ME72106A	0.047	1.068	-0.188			
ME08_08B	ME72106B	0.020	1.537 (0.091)	0.887 (0.034)			

* Invariant item—item parameters for invariant items were fixed from the paperTIMSS concurrent calibration; location parameters are transformations of the fixed paperTIMSS value.

Item		RMSD	Slope (a_i)	Location (b_i)	Guessing (c_i)	Step 1 (d_{i1})	Step 2 (d_{i2})
ME08_08C	ME72106C	0.014	1.770 (0.114)	1.160 (0.035)			
* ME08_09A	ME72128A	0.025	0.999	0.654			
* ME08_09B	ME72128B	0.082	0.892	1.144		0.042	-0.042
ME08_10	ME72119	0.022	1.038 (0.062)	0.342 (0.039)			
* ME08_11A	ME72153A	0.072	1.021	0.488			
* ME08_11B	ME72153B	0.021	1.548	1.340			
* ME08_12	ME72172	0.037	1.048	0.204	0.060		
ME09_01	ME62329	0.081	0.675 (0.075)	-0.964 (0.224)	0.231 (0.082)		
* ME09_02	ME62151	0.027	1.247	0.826			
* ME09_03	ME62346	0.040	1.185	0.756			
* ME09_04	ME62212	0.013	1.397	1.199	0.124		
* ME09_05	ME62056	0.036	1.244	1.237			
* ME09_06	ME62317	0.033	1.328	0.933			
* ME09_07	ME62350	0.024	1.389	1.648	0.129		
* ME09_08	ME62078	0.047	1.441	0.721			
* ME09_09	ME62284	0.047	0.676	0.522	0.290		
* ME09_10	ME62245	0.031	1.273	0.752	0.204		
ME09_11	ME62287	0.029	1.321 (0.097)	1.545 (0.057)			
* ME09_12A	ME62345A	0.058	0.589	0.557		0.267	-0.267
* ME09_13	ME62115	0.031	1.507	1.468	0.202		
ME10_01	ME72187	0.041	0.909 (0.056)	-0.001 (0.044)			
* ME10_02	ME72022	0.024	1.631	1.180	0.279		
* ME10_04	ME72045	0.038	1.307	0.571			
ME10_05	ME72049	0.051	0.794 (0.053)	-0.361 (0.055)			
ME10_06	ME72069	0.045	1.615 (0.089)	0.163 (0.029)			
* ME10_07	ME72074	0.041	1.162	1.036			
* ME10_08	ME72013	0.032	1.126	0.704	0.120		
* ME10_09	ME72095	0.038	1.416	0.623			
* ME10_10	ME72109	0.039	1.467	1.194			
* ME10_11	ME72125	0.098	2.017	0.930	0.107		
* ME10_12	ME72196	0.021	1.376	0.653			
* ME10_13	ME72237	0.061	0.963	0.065	0.194		
ME10_14	ME72232	0.050	0.593 (0.046)	-0.112 (0.065)			
* ME10_15	ME72206	0.025	1.330	1.399			
* ME11_01	ME62271	0.057	1.536	0.635	0.252		
* ME11_02	ME62152	0.030	1.197	0.458			
* ME11_03	ME62215	0.040	0.889	0.765		-0.188	0.188
* ME11_04	ME62143	0.033	1.655	0.914			
* ME11_05	ME62230	0.030	1.555	1.468	0.224		

* Invariant item—item parameters for invariant items were fixed from the paperTIMSS concurrent calibration; location parameters are transformations of the fixed paperTIMSS value.

Item		RMSD	Slope (a_i)	Location (b_i)	Guessing (c_i)	Step 1 (d_{i1})	Step 2 (d_{i2})
* ME11_06	ME62095	0.029	1.586	0.660	0.219		
* ME11_07	ME62076	0.041	1.745	0.341	0.291		
* ME11_08	ME62030	0.056	0.536	0.168			
* ME11_09	ME62171	0.063	0.832	-0.035	0.128		
* ME11_10	ME62301	0.020	1.080	1.108			
* ME11_11	ME62194	0.064	1.025	-0.164	0.290		
* ME11_12	ME62344	0.038	0.874	1.202			
* ME11_13	ME62320	0.014	1.899	0.579	0.092		
ME11_14	ME62296	0.038	1.137 (0.067)	0.117 (0.037)			
* ME12_01	ME72001	0.024	1.523	0.721			
ME12_02	ME72019	0.030	1.459 (0.082)	0.529 (0.032)			
ME12_03	ME72189	0.023	1.340 (0.145)	0.510 (0.069)	0.234 (0.031)		
* ME12_04	ME72024	0.042	0.899	0.726			
* ME12_05	ME72043	0.085	2.286	0.869	0.171		
* ME12_06	ME72221	0.047	1.207	0.440	0.219		
* ME12_07	ME72220	0.066	1.330	1.263	0.202		
* ME12_08	ME72225	0.032	1.263	0.559			
* ME12_09A	ME72110A	0.040	1.493	0.696			
ME12_09B	ME72110B	0.016	1.794 (0.115)	1.155 (0.035)			
* ME12_10	ME72150	0.033	1.827	0.523	0.481		
* ME12_11	ME72139	0.021	1.155	1.104			
* ME12_12	ME72229	0.026	0.966	1.543		-1.025	1.025
* ME12_13	ME72171	0.056	1.437	0.515			
ME12_14A	ME72211A	0.029	1.607 (0.172)	0.321 (0.065)	0.273 (0.032)		
* ME13_01	ME62001	0.071	1.007	0.956	0.339		
* ME13_02	ME62214	0.026	1.151	0.499			
* ME13_03	ME62146	0.015	1.444	0.815	0.124		
* ME13_04	ME62154	0.031	1.359	0.024			
* ME13_05	ME62067	0.038	1.159	0.206	0.335		
* ME13_06	ME62341	0.039	0.932	1.753	0.218		
* ME13_07	ME62242	0.036	1.269	0.285	0.171		
* ME13_08A	ME62250A	0.029	1.207	0.248			
* ME13_08B	ME62250B	0.016	1.403	0.927			
* ME13_09	ME62170	0.085	0.535	1.031		0.551	-0.551
* ME13_10	ME62192	0.039	1.044	1.230			
* ME13_11	ME62072	0.059	1.024	0.220			
* ME13_13	ME62120	0.037	1.250	0.575	0.166		
* ME14_01	ME72005	0.038	0.704	0.234	0.100		
ME14_02	ME72021	0.022	1.220 (0.071)	0.485 (0.034)			

* Invariant item—item parameters for invariant items were fixed from the paperTIMSS concurrent calibration; location parameters are transformations of the fixed paperTIMSS value.

Item		RMSD	Slope (a_i)	Location (b_i)	Guessing (c_i)	Step 1 (d_{i1})	Step 2 (d_{i2})
ME14_03	ME72026	0.045	0.800 (0.054)	0.640 (0.049)			
* ME14_04A	ME72041A	0.045	1.268	0.214			
* ME14_04B	ME72041B	0.052	1.471	0.474			
* ME14_05	ME72223	0.083	1.948	0.773	0.250		
* ME14_06	ME72094	0.085	1.172	0.077			
* ME14_07	ME72059	0.084	1.363	0.726			
* ME14_08	ME72080	0.050	1.587	0.984	0.118		
ME14_09	ME72081	0.033	1.119 (0.072)	1.124 (0.047)			
ME14_10	ME72140	0.029	0.784 (0.053)	0.170 (0.048)			
ME14_11	ME72120	0.018	1.453 (0.090)	1.091 (0.038)			
* ME14_12	ME72131	0.033	1.349	1.395			
* ME14_13	ME72147	0.051	1.697	1.282			
* ME14_14	ME72154	0.065	1.325	0.216	0.189		
* ME14_15	ME72192	0.049	1.009	0.554	0.209		
* ME14_16	ME72161	0.030	1.164	0.728			

* Invariant item—item parameters for invariant items were fixed from the paperTIMSS concurrent calibration; location parameters are transformations of the fixed paperTIMSS value.

Appendix 12N: Science Item Parameters from the Final eTIMSS 2019 Adjusted Model Calibration—Grade 8

Item		RMSD	Slope (a_i)	Location (b_i)	Guessing (c_i)	Step 1 (d_{i1})	Step 2 (d_{i2})
* SE01_01	SE52006	0.054	0.635	-0.030		0.620	-0.620
* SE01_02	SE52069	0.029	0.984	0.668	0.325		
* SE01_03	SE52012	0.055	0.947	0.410	0.163		
* SE01_04	SE52021	0.018	1.029	0.706			
SE01_05Z	SE52095Z	0.031	0.466 (0.044)	-0.044 (0.080)			
* SE01_07	SE52054	0.042	0.749	-0.312			
* SE01_08	SE52150	0.033	0.787	1.237	0.181		
* SE01_09A	SE52243A	0.046	0.624	0.441			
* SE01_09B	SE52243B	0.037	0.769	0.461			
* SE01_09C	SE52243C	0.052	0.671	1.093	0.200		
* SE01_10	SE52206	0.063	1.127	0.545	0.207		
* SE01_11A	SE52112A	0.036	0.672	0.026	0.221		
* SE01_11B	SE52112B	0.051	0.992	0.832			
* SE01_12	SE52294	0.029	1.085	-0.017	0.206		
* SE02_01	SE72072	0.035	0.824	0.585	0.216		
* SE02_02	SE72029	0.065	1.324	1.125	0.364		
* SE02_03	SE72902	0.040	1.017	0.213			
* SE02_04	SE72077	0.046	0.685	0.463	0.300		
* SE02_05A	SE72900A	0.042	0.959	0.951			
* SE02_05B	SE72900B	0.067	0.954	1.428			
* SE02_06	SE72103	0.068	0.500	-0.011			
SE02_07	SE72110	0.024	0.868 (0.061)	0.817 (0.049)			
SE02_08	SE72130	0.031	0.720 (0.056)	0.995 (0.064)			
* SE02_09	SE72148	0.074	0.679	1.226	0.132		
* SE02_10	SE72200	0.034	0.854	0.739	0.103		
SE02_11	SE72232	0.030	1.479 (0.084)	0.311 (0.029)			
* SE02_12	SE72275	0.038	1.016	-0.454	0.117		
* SE02_13	SE72244	0.032	0.950	0.565			
* SE02_14	SE72301	0.076	0.936	1.267	0.220		
SE02_15	SE72721	0.029	1.153 (0.113)	0.095 (0.083)	0.189 (0.040)		
* SE02_16	SE72335	0.036	0.859	0.620	0.199		
* SE03_01	SE62055	0.031	0.962	-0.020	0.438		
* SE03_02	SE62007	0.046	1.176	0.525	0.205		
* SE03_03	SE62275	0.042	0.888	0.853			
* SE03_04	SE62225	0.025	1.004	1.402	0.259		
* SE03_05	SE62111	0.039	0.587	0.584		0.033	-0.033
* SE03_06A	SE62116A	0.036	1.164	0.597			
* SE03_06B	SE62116B	0.035	1.319	0.926			

* Invariant item—item parameters for invariant items were fixed from the paperTIMSS concurrent calibration; location parameters are transformations of the fixed paperTIMSS value.

Item		RMSD	Slope (a_i)	Location (b_i)	Guessing (c_i)	Step 1 (d_{i1})	Step 2 (d_{i2})
* SE03_06C	SE62116C	0.023	0.946	1.315			
* SE03_07	SE62262	0.025	0.891	1.130	0.277		
* SE03_08	SE62035	0.031	1.076	1.097	0.199		
* SE03_09	SE62144	0.054	0.725	-0.533	0.163		
* SE03_10	SE62162	0.030	0.777	0.881			
* SE03_11	SE62233	0.035	0.927	0.820	0.343		
* SE03_13	SE62171	0.035	0.384	0.893	0.185		
* SE04_01	SE72002	0.060	1.393	0.307	0.212		
SE04_02	SE72403	0.033	0.618 (0.048)	0.086 (0.060)			
* SE04_03	SE72021	0.058	0.896	0.404	0.221		
SE04_04	SE72082	0.057	0.704 (0.051)	0.089 (0.053)			
SE04_05	SE72066	0.028	1.053 (0.119)	0.446 (0.083)	0.194 (0.037)		
* SE04_06	SE72063	0.035	0.582	2.063	0.200		
* SE04_07	SE72102	0.087	0.482	0.612			
* SE04_08A	SE72141A	0.026	1.069	0.944			
* SE04_08B	SE72141B	0.065	0.731	0.669		-0.141	0.141
* SE04_09	SE72921	0.053	0.766	1.439			
* SE04_10	SE72234	0.085	1.141	1.540	0.167		
* SE04_11	SE72251	0.024	1.064	0.922	0.208		
* SE04_12	SE72284	0.050	0.786	0.009			
SE04_13	SE72345	0.035	0.823 (0.045)	0.478 (0.033)		0.632 (0.052)	-0.632 (0.055)
* SE04_14	SE72349	0.042	1.086	0.150	0.178		
* SE04_15	SE72363	0.076	0.613	0.140	0.101		
* SE05_01	SE52076	0.035	0.934	0.411	0.257		
* SE05_02	SE52272	0.050	1.130	-0.007			
* SE05_03A	SE52085A	0.016	1.038	1.232			
* SE05_03B	SE52085B	0.054	1.034	0.009			
* SE05_04	SE52094	0.036	0.614	1.030			
* SE05_05	SE52248	0.022	1.188	1.615	0.364		
* SE05_06	SE52146	0.040	1.023	0.411			
* SE05_07	SE52282	0.071	0.828	0.857	0.185		
* SE05_08	SE52299	0.063	1.224	0.392	0.309		
* SE05_09	SE52144	0.032	1.160	0.710	0.249		
* SE05_10	SE52214	0.028	0.996	0.356			
* SE05_12	SE52101	0.033	0.563	1.043			
* SE05_13	SE52113	0.042	1.565	0.597	0.292		
* SE05_14	SE52107	0.044	1.000	1.328	0.197		
* SE06_01	SE62090	0.043	1.011	0.180	0.304		
* SE06_02	SE62274	0.059	0.577	0.879		1.149	-1.149

* Invariant item—item parameters for invariant items were fixed from the paperTIMSS concurrent calibration; location parameters are transformations of the fixed paperTIMSS value.

Item		RMSD	Slope (a_i)	Location (b_i)	Guessing (c_i)	Step 1 (d_{i1})	Step 2 (d_{i2})
* SE06_03	SE62284	0.061	0.375	0.478	0.172		
* SE06_04A	SE62098A	0.040	0.639	0.500		-0.050	0.050
* SE06_04B	SE62098B	0.030	0.798	1.337		-0.091	0.091
* SE06_05	SE62032	0.052	1.742	1.504	0.287		
* SE06_06	SE62043	0.028	0.907	0.981			
* SE06_07	SE62158	0.031	0.697	0.678	0.299		
* SE06_08	SE62159	0.036	0.983	0.400	0.204		
* SE06_09	SE62005	0.020	1.250	0.666			
* SE06_10	SE62075	0.025	0.990	0.770	0.314		
* SE06_11	SE62004	0.049	1.806	0.885	0.173		
* SE06_12	SE62175	0.059	0.739	0.674			
SE06_13A	SE62173A	0.036	0.647 (0.051)	0.253 (0.056)			
* SE06_13B	SE62173B	0.026	0.808	1.862	0.203		
* SE07_01A	SE52090A	0.026	0.494	0.539	0.393		
* SE07_01B	SE52090B	0.027	0.609	1.962			
* SE07_02	SE52262	0.020	0.694	0.910	0.227		
* SE07_03	SE52267	0.034	0.988	0.763	0.216		
* SE07_04	SE52273	0.030	0.638	0.934		0.174	-0.174
SE07_05Z	SE52015Z	0.039	0.847 (0.057)	-0.399 (0.057)			
* SE07_06	SE52051	0.078	1.005	0.815			
* SE07_07	SE52026	0.041	0.587	0.468	0.350		
* SE07_08	SE52130	0.026	0.909	1.202	0.215		
* SE07_09	SE52028	0.027	0.858	0.620	0.282		
* SE07_10	SE52189	0.033	1.041	0.450			
* SE07_11	SE52217	0.041	0.722	1.059	0.283		
* SE07_12	SE52038	0.033	0.994	0.977	0.290		
* SE07_13	SE52099	0.026	0.947	0.884			
* SE07_14	SE52118	0.031	0.766	1.293			
* SE08_01	SE72070	0.063	0.568	-0.193	0.207		
SE08_02	SE72400	0.035	0.878 (0.058)	-0.151 (0.049)			
* SE08_03	SE72024	0.048	0.891	-0.027	0.113		
* SE08_04	SE72462	0.036	0.490	0.792	0.198		
SE08_05	SE72443	0.026	0.969 (0.121)	0.320 (0.111)	0.249 (0.047)		
* SE08_06	SE72903	0.023	0.796	0.821		-0.090	0.090
* SE08_07	SE72145	0.041	0.949	1.441			
* SE08_08	SE72100	0.047	0.560	0.647	0.195		
* SE08_10	SE72137	0.082	0.836	0.435	0.194		
* SE08_11	SE72298	0.069	0.814	0.626			
* SE08_12	SE72215	0.057	0.515	1.031		-0.538	0.538

* Invariant item—item parameters for invariant items were fixed from the paperTIMSS concurrent calibration; location parameters are transformations of the fixed paperTIMSS value.

Item		RMSD	Slope (a_i)	Location (b_i)	Guessing (c_i)	Step 1 (d_{i1})	Step 2 (d_{i2})
SE08_13	SE72260	0.031	0.667 (0.051)	0.356 (0.054)			
SE08_14	SE72265	0.028	0.692 (0.051)	0.191 (0.053)			
* SE08_15	SE72347	0.026	1.061	1.184	0.186		
* SE08_16	SE72351	0.025	0.847	0.997			
* SE08_17	SE72367	0.020	1.114	0.705	0.156		
* SE09_01	SE62099	0.043	0.842	0.324	0.146		
* SE09_02	SE62095	0.028	0.501	0.750		-0.076	0.076
* SE09_03	SE62106	0.041	0.750	-0.654	0.116		
* SE09_04	SE62064	0.032	0.879	-0.289			
* SE09_05	SE62132	0.035	0.992	0.400	0.289		
* SE09_06	SE62163	0.035	1.196	1.375			
* SE09_07	SE62153	0.027	1.278	0.921	0.294		
SE09_08	SE62018	0.029	0.567 (0.033)	1.446 (0.067)		-0.582 (0.087)	0.582 (0.113)
* SE09_09	SE62143	0.047	0.850	1.772			
* SE09_10	SE62276	0.042	0.718	1.062			
* SE09_11	SE62050	0.032	0.920	1.074			
* SE09_12	SE62205	0.033	1.100	0.892	0.158		
* SE09_13	SE62190	0.034	0.883	0.091	0.140		
* SE09_14A	SE62024A	0.035	0.605	0.944	0.226		
* SE09_14B	SE62024B	0.025	0.801	1.514			
SE10_01	SE72033	0.029	0.789 (0.034)	0.298 (0.029)		-0.465 (0.065)	0.465 (0.065)
* SE10_02	SE72440	0.037	0.670	-0.280			
* SE10_03	SE72032	0.046	1.540	1.069	0.315		
* SE10_04	SE72031	0.037	0.655	1.009	0.137		
SE10_05	SE72086	0.028	0.637 (0.050)	-0.680 (0.082)			
* SE10_06	SE72005	0.057	1.030	0.797		0.248	-0.248
* SE10_08	SE72123	0.052	0.551	0.064	0.249		
* SE10_09	SE72116	0.042	0.574	1.240	0.198		
SE10_10	SE72920	0.083	0.544 (0.033)	0.954 (0.053)		0.985 (0.069)	-0.985 (0.095)
* SE10_11	SE72294	0.056	0.914	0.274			
* SE10_12	SE72231	0.043	1.257	0.990	0.265		
SE10_13	SE72261	0.031	0.868 (0.058)	-0.200 (0.049)			
* SE10_14	SE72220	0.081	1.761	1.800	0.210		
* SE10_15	SE72348	0.037	0.805	-0.777			
* SE10_16	SE72720	0.023	0.412	1.812	0.135		
* SE11_01	SE62279	0.042	1.185	0.075	0.187		
* SE11_02	SE62112	0.027	0.534	0.284			
* SE11_03	SE62119	0.033	1.214	0.226	0.249		
* SE11_04	SE62093	0.046	0.630	0.131		0.306	-0.306

* Invariant item—item parameters for invariant items were fixed from the paperTIMSS concurrent calibration; location parameters are transformations of the fixed paperTIMSS value.

Item		RMSD	Slope (a_i)	Location (b_i)	Guessing (c_i)	Step 1 (d_{i1})	Step 2 (d_{i2})
* SE11_05	SE62089	0.039	1.347	1.002	0.153		
* SE11_06	SE62006	0.041	0.953	0.430			
* SE11_07	SE62067	0.029	0.823	0.433			
* SE11_08	SE62247	0.035	0.977	1.300	0.268		
* SE11_09	SE62177	0.037	0.711	1.076	0.207		
* SE11_10	SE62186	0.026	1.545	1.245	0.263		
* SE11_11A	SE62211A	0.024	0.814	0.413			
* SE11_11B	SE62211B	0.019	0.868	2.149			
* SE11_13	SE62033	0.039	1.106	0.762			
* SE11_14	SE62037	0.034	0.747	0.631	0.305		
SE11_15	SE62242	0.049	0.885 (0.064)	-1.001 (0.079)			
* SE12_01	SE72078	0.061	1.019	0.526			
* SE12_02	SE72460	0.058	0.962	0.778	0.254		
SE12_03	SE72000	0.029	0.639 (0.031)	0.329 (0.035)		-0.348 (0.074)	0.348 (0.073)
* SE12_05	SE72901	0.041	0.612	1.189	0.273		
* SE12_06	SE72038	0.057	0.487	0.364	0.103		
* SE12_07	SE72120	0.066	0.441	0.022	0.092		
SE12_08	SE72143	0.023	0.892 (0.062)	0.800 (0.048)			
* SE12_09	SE72523	0.042	0.663	0.387		0.309	-0.309
* SE12_10	SE72168	0.057	1.195	0.387	0.176		
* SE12_11	SE72205	0.088	1.159	0.948	0.244		
* SE12_12	SE72293	0.045	0.959	0.926			
* SE12_13A	SE72280A	0.025	1.309	0.823			
* SE12_13B	SE72280B	0.045	1.433	0.005	0.387		
* SE12_14	SE72370	0.072	1.461	0.487	0.289		
* SE13_01A	SE62091A	0.043	0.958	-0.639	0.304		
* SE13_01B	SE62091B	0.071	0.587	-1.118	0.167		
* SE13_02	SE62100	0.035	0.898	0.403			
* SE13_03	SE62097	0.044	0.909	0.334	0.147		
SE13_04	SE62101	0.025	0.549 (0.034)	0.014 (0.044)		0.311 (0.081)	-0.311 (0.074)
* SE13_06	SE62128	0.027	0.867	0.043			
SE13_07	SE62047	0.052	0.457 (0.043)	0.356 (0.076)			
SE13_08	SE62042	0.040	0.539 (0.048)	0.859 (0.078)			
* SE13_09	SE62250	0.033	0.580	1.268			
* SE13_10	SE62246	0.033	0.924	1.256	0.288		
* SE13_11	SE62056	0.031	1.147	0.495			
* SE13_12	SE62235	0.030	0.765	0.922	0.195		
* SE13_13	SE62180	0.035	1.210	0.326	0.211		

* Invariant item—item parameters for invariant items were fixed from the paperTIMSS concurrent calibration; location parameters are transformations of the fixed paperTIMSS value.

Item		RMSD	Slope (a_i)	Location (b_i)	Guessing (c_i)	Step 1 (d_{i1})	Step 2 (d_{i2})
SE13_14	SE62022	0.030	0.577 (0.049)	0.764 (0.070)			
SE13_15	SE62243	0.042	0.631 (0.032)	-0.153 (0.040)		-0.233 (0.080)	0.233 (0.071)
SE14_01	SE72011	0.025	1.239 (0.128)	-0.106 (0.093)	0.253 (0.046)		
SE14_02	SE72905	0.042	0.481 (0.044)	-0.112 (0.078)			
* SE14_03	SE72049	0.067	0.805	0.684	0.270		
* SE14_04	SE72016	0.046	0.782	0.627		-0.167	0.167
* SE14_05	SE72451	0.041	1.084	-0.094			
* SE14_06	SE72074	0.054	0.785	0.412			
* SE14_07	SE72091	0.040	1.170	0.830	0.233		
SE14_08	SE72109	0.032	0.685 (0.051)	0.475 (0.054)			
* SE14_09	SE72140	0.038	0.906	1.049	0.279		
* SE14_10	SE72132	0.045	0.853	1.761			
* SE14_11	SE72209	0.036	1.207	0.708	0.268		
SE14_12	SE72210	0.079	0.475 (0.035)	1.120 (0.066)		0.609 (0.079)	-0.609 (0.108)
* SE14_13	SE72249	0.045	1.008	0.997	0.143		
* SE14_14	SE72323	0.032	0.697	0.791	0.295		
SE14_15	SE72368	0.033	0.748 (0.089)	-0.248 (0.170)	0.215 (0.064)		
* SE14_16	SE72303	0.038	1.205	1.133	0.210		

* Invariant item—item parameters for invariant items were fixed from the paperTIMSS concurrent calibration; location parameters are transformations of the fixed paperTIMSS value.