IEA TIMSS 2019

CHAPTER 4

TIMSS 2019 Assessment Design

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TIMSS is designed to provide countries with information about their students' mathematics and science achievement that can be used to inform evidence-based decisions for improving educational policy and practice. At the heart of TIMSS is a wide ranging student assessment of mathematics and science achievement conducted at four year intervals at fourth and eighth grades, together with questionnaires for parents, students, teachers, school principals, and curriculum experts that gather information about the social and educational contexts for learning.

Central to TIMSS' mission is the measurement of student achievement in mathematics and science in a way that does justice to the breadth and richness of these subjects as they are taught in the participating countries, and that monitors countries' improvements or declines by tracking trends in student performance from one assessment cycle to the next. This requires an assessment that is wide ranging in its coverage of mathematics and science and innovative in its measurement approach.

Conducted every four years since 1995, with each assessment linked to the one that preceded it, TIMSS provides regular and timely data for educators and policymakers on trends in students' mathematics and science achievement. As an additional advantage, administering TIMSS at the fourth and eighth grades every four years provides the opportunity to monitor achievement changes within a grade cohort, as the fourth grade students in one TIMSS cycle become the eighth grade students in the next cycle.

The seventh in the TIMSS series of assessments, TIMSS 2019 continues the TIMSS tradition of innovation by beginning the transition to the eTIMSS digital format. For the first time, about half the countries will transition to administering the assessment via computer, while the rest will administer TIMSS in a paper and pencil format as in previous assessments.

Student Populations Assessed

TIMSS assesses the mathematics and science achievement of students in their fourth and eighth years of formal schooling. Participating countries may choose to assess one or both populations, according to their policy priorities and resource availability. Because in TIMSS the number of years of formal

schooling (four or eight) is the basis for comparison among participating countries, the TIMSS assessment is targeted at the grade levels that correspond to these. The TIMSS target populations are defined as follows:

- At the fourth grade, the TIMSS target grade should be the grade that represents four years of schooling, counting from the first year of ISCED Level 1.
- At the eighth grade, the TIMSS target grade should be the grade that represents eight years of schooling, counting from the first year of ISCED Level 1.

ISCED is the International Standard Classification of Education developed by the UNESCO Institute for Statistics and provides an international standard for describing levels of schooling across countries (UNESCO, 2012). The ISCED system describes the full range of schooling, from preprimary (Level 0) to doctoral study (Level 8). ISCED Level 1 corresponds to primary education or the first stage of basic education. Four years after the beginning of Level 1 is the fourth year of formal schooling and is the target grade for the fourth grade TIMSS assessment. This also is the fourth grade in most countries. Similarly, eight years after the first year of ISCED Level 1 is the target grade for eighth grade TIMSS, and is the eighth grade in most countries. However, given the cognitive demands of the assessments, TIMSS wants to avoid assessing very young students. Thus, TIMSS recommends that countries assess the next higher grade (i.e., fifth grade for fourth grade TIMSS, and ninth grade for eighth grade TIMSS) if, for fourth grade students, the average age at the time of testing would be less than 9.5 years, and, for eighth grade students, less than 13.5 years.

To represent the target population with an acceptable margin of error while keeping the assessment burden on schools and students to a minimum, each country selects a nationally representative probability sample of students at each grade. The basic TIMSS sample design consists of at least 150 schools and one or more intact classes per grade, for a student sample of approximately 4,000 students in each country.

Reporting Student Achievement

TIMSS 2019 provides a comprehensive picture of the mathematics and science achievement of fourth and eighth grade students in each participating country. This includes achievement in each of the content and cognitive domains (as defined in Chapters 1 and 2) as well as overall mathematics and science achievement. Consistent with the goal of comprehensive subject coverage, the complete TIMSS 2019 assessment consists of a large pool of mathematics and science questions (known as items) at each grade level. However, to keep the assessment burden on any one student to a minimum, each student is presented with only a sample of the items, as described in the next section. Following data collection, student responses to the items in each assessment are aggregated and converted to the TIMSS mathematics and science scale metrics at each grade level to provide an overall picture of the assessment results for each country.

One of the major strengths of TIMSS is its measurement of trends over time in mathematics and science achievement. The TIMSS achievement scales provide established metrics on which countries can compare students' progress in mathematics and science from assessment to assessment at the fourth and eighth grades. The TIMSS mathematics and science achievement scales were created with the first TIMSS assessment in 1995, separately for each subject and each grade. The scale units were established so that 100 points on the scale was equivalent to one standard deviation of the distribution of achievement across all of the countries that participated in TIMSS 1995, and the scale midpoint of 500 was located at the mean of this international achievement distribution. The TIMSS achievement scales were first used for reporting TIMSS results with TIMSS 1995, and all results from subsequent TIMSS assessments have been reported on the same scale metrics, making it possible to measure growth or decline in countries' achievement distributions from assessment to assessment.

Using items that were administered in both 1995 and 1999 assessments as a basis for linking the two sets of assessment results, the TIMSS 1999 data also were placed on the scales so that countries could gauge changes in students' mathematics and science achievement since 1995. This was done separately for mathematics and science and for fourth and eighth grades. Using similar procedures, the data from TIMSS 2003, TIMSS 2007, TIMSS 2011, and TIMSS 2015 were placed on the TIMSS scales, as will be the data from TIMSS 2019. This will enable TIMSS 2019 countries that have participated in TIMSS since its inception to have comparable achievement data from 1995, 1999, 2003, 2007, 2011, 2015, and 2019, and to plot changes in performance over this 24 year period.

As previously mentioned, in addition to the achievement scales for mathematics and science overall, TIMSS 2019 will construct scales for reporting relative student performance in each of the mathematics and science content and cognitive domains defined in the TIMSS 2019 Assessment Frameworks. More specifically, in mathematics at the fourth grade there will be three content scales, corresponding to the three content domains—number, measurement and geometry, and data display—and four at the eighth grade—number, algebra, geometry, and data and probability. In science, there also will be three content scales at fourth grade—life science, physical science, and Earth science—and four at the eighth grade—biology, chemistry, physics, and Earth science. The TIMSS 2019 Assessment Frameworks also specify three cognitive domains— knowing, applying, and reasoning—which span the mathematics and science content at both grades. Reporting scales will be constructed for each cognitive domain in mathematics and science at each grade level.

TIMSS 2019 Student Booklet Design

A major consequence of TIMSS' ambitious reporting goals is that many more questions are required for the assessment than can be answered by any one student in the amount of testing time available. Accordingly, TIMSS uses a matrix sampling approach that involves packaging the entire assessment pool of mathematics and science items at each grade level into a set of 14 student achievement booklets, with

each student completing just one booklet. Each item appears in two booklets, providing a mechanism for linking together the student responses from the various booklets when data from all booklets are taken together. Booklets are distributed among students in participating classrooms according to assignments predetermined by the TIMSS within-school sampling software, so that the student samples completing each booklet in each country are approximately equivalent in terms of student ability.

After the assessment has been administered and the data collected and processed, TIMSS uses item response theory scaling methods to assemble a comprehensive picture of the achievement of the entire student population of a country from the combined responses of individual students to the booklets that they are assigned.[1] This approach reduces to manageable proportions what otherwise would be an impossible student burden, albeit at the cost of some complexity in booklet assembly, data collection, and data analysis.

To facilitate the process of creating the student achievement booklets, TIMSS groups the assessment items into a series of item blocks, with approximately 10 to 14 items in each block at the fourth grade and 12 to 18 at the eighth grade. As far as possible, within each block the distribution of items across content and cognitive domains matches the distribution across the item pool overall, as described in Chapters 1 and 2. Similar to the TIMSS 2015 assessment, TIMSS 2019 has a total of 28 blocks at each grade, 14 consisting of mathematics items and 14 consisting of science items. Student booklets are assembled from various combinations of these item blocks.

Following the 2015 assessment, eight of the 14 mathematics blocks and eight of the 14 science blocks at each grade were secured for use in 2019 as a basis for measuring trends. The remaining 12 blocks (six mathematics and six science) were available with permission from IEA for use in publications, research, and teaching, and had to be replaced by newly developed items for the TIMSS 2019 assessment. Accordingly, the 28 blocks in the TIMSS 2019 assessment comprise 16 blocks of trend items (eight mathematics and eight science) and 12 blocks of new items to be used for the first time in 2019.

As shown in Exhibit 1, the TIMSS 2019 mathematics blocks are labeled MP01/ME01 through MP14/ME14 and the science blocks SP01/SE01 through SP14/SE14.[2] Mathematics and science blocks ending in odd numbers (01, 03, 05, etc.) contain the trend items from the 2015 assessment, as do blocks ending in 06. The blocks ending in even numbers (except 06) contain the items developed for use for the first time in TIMSS 2019.

1 See Foy and Yin (2016) for a description of the scaling of the TIMSS 2015 achievement data.

2 Each item block exists in both modes of administration, the paper-based version with the letter "P" in its label and the computer-based version with the letter "E" in its label.

Exhibit 4.1: TIMSS 2019 Item Blocks—Fourth and Eighth Grades

Mathematics Blocks	Source of Items	Science Blocks	Source of Items
MP01/ME01	Trend Block M13 from TIMSS 2015	SP01/SE01	Trend Block S13 from TIMSS 2015
MP02/ME02	New items for TIMSS 2019	SP02/SE02	New items for TIMSS 2019
MP03/ME03	Trend Block M08 from TIMSS 2015	SP03/SE03	Trend Block S08 from TIMSS 2015
MP04/ME04	New items for TIMSS 2019	SP04/SE04	New items for TIMSS 2019
MP05/ME05	Trend Block M09 from TIMSS 2015	SP05/SE05	Trend Block S09 from TIMSS 2015
MP06/ME06	Trend Block M10 from TIMSS 2015	SP06/SE06	Trend Block S10 from TIMSS 2015
MP07/ME07	Trend Block M11 from TIMSS 2015	SP07/SE07	Trend Block S11 from TIMSS 2015
MP08/ME08	New items for TIMSS 2019	SP08/SE08	New items for TIMSS 2019
MP09/ME09	Trend Block M04 from TIMSS 2015	SP09/SE09	Trend Block S04 from TIMSS 2015
MP10/ME10	New items for TIMSS 2019	SP10/SE10	New items for TIMSS 2019
MP11/ME11	Trend Block M12 from TIMSS 2015	SP11/SE11	Trend Block S12 from TIMSS 2015
MP12/ME12	New items for TIMSS 2019	SP12/SE12	New items for TIMSS 2019
MP13/ME13	Trend Block M14 from TIMSS 2015	SP13/SE13	Trend Block S14 from TIMSS 2015
MP14/ME14	New items for TIMSS 2019	SP14/SE14	New items for TIMSS 2019

Fourth grade students are expected to spend, on average, 18 minutes on each item block, and eighth grade students, 22½ minutes. Consequently, the 28 blocks of fourth grade items are estimated to contain almost 8½ hours of testing time and the eighth grade blocks about 10½ hours. In previous TIMSS cycles, National Research Coordinators from participating countries agreed that the testing time for any one student should not be increased from previous assessments. Thus, as in the past, the assessment time for each student booklet must fit into 72 minutes for the fourth grade and 90 minutes for the eighth grade. An additional 30 minutes for a student questionnaire also was planned at each grade level.

In choosing how to distribute assessment blocks across student achievement booklets, the major goal was to maximize coverage of the framework while ensuring that every student responded to sufficient items to provide reliable measurement of trends in both mathematics and science. A further goal was to ensure that achievement in the mathematics and science content and cognitive domains could be measured reliably. To enable linking among booklets while keeping the number of booklets to a minimum, each block appears in two booklets. TIMSS has used the same booklet design since 2007.

The TIMSS 2019 booklet design shows how the 28 assessment blocks are distributed across 14 student achievement booklets (see Exhibit 4.2). The fourth and eighth grade booklet designs are identical, although the fourth grade blocks contain 18 minutes of assessment items and the eighth grade blocks 22½ minutes. Each student booklet consists of four blocks of items: two blocks of mathematics

items, and two of science items. In half of the booklets, the two mathematics blocks come first, and then the two science blocks, and in the other half the order is reversed. Additionally, in most booklets two of the blocks contain trend items from TIMSS 2015 and two contain items newly developed for TIMSS 2019. For example, as may be seen from Exhibit 4.2, students assigned the computer-based Booklet 1 complete two blocks of mathematics items, ME01 and ME02, and two blocks of science items, SE01 and SE02. The items in blocks ME01 and SE01 are trend items from TIMSS 2015, while those in ME02 and SE02 are items new for TIMSS 2019. Similarly, students assigned the computer-based Booklet 2 complete two science blocks, SE02 and SE03, followed by two mathematics blocks, ME02 and ME03. SE02 and ME02 contain the new items and SE03 and ME03 the trend items.

Countries participating in TIMSS aim for a sample of at least 4,000 students to ensure that there are enough respondents for each item. The 14 student booklets are distributed among the students in each sampled class according to a predetermined order, so that approximately equal proportions of students respond to each booklet.

Exhibit 4.2: TIMSS 2019 Student Achievement Booklet Design—Fourth and Eighth Grades

	Assessment Blocks			
Student Achievement Booklet	**Part 1**		**Part 2**	
Booklet 1	MP01/ME01	MP02/ME02	SP01/SE01	SP02/SE02
Booklet 2	SP02/SE02	SP03/SE03	MP02/ME02	MP03/ME03
Booklet 3	MP03/ME03	MP04/ME04	SP03/SE03	SP04/SE04
Booklet 4	SP04/SE04	SP05/SE05	MP04/ME04	MP05/ME05
Booklet 5	MP05/ME05	MP06/ME06	SP05/SE05	SP06/SE06
Booklet 6	SP06/SE06	SP07/SE07	MP06/ME06	MP07/ME07
Booklet 7	MP07/ME07	MP08/ME08	SP07/SE07	SP08/SE08
Booklet 8	SP08/SE08	SP09/SE09	MP08/ME08	MP09/ME09
Booklet 9	MP09/ME09	MP10/ME10	SP09/SE09	SP10/SE10
Booklet 10	SP10/SE10	SP11/SE11	MP10/ME10	MP11/ME11
Booklet 11	MP11/ME11	MP12/ME12	SP11/SE11	SP12/SE12
Booklet 12	SP12/SE12	SP13/SE13	MP12/ME12	MP13/ME13
Booklet 13	MP13/ME13	MP14/ME14	SP13/SE13	SP14/SE14
Booklet 14	SP14/SE14	SP01/SE01	MP14/ME14	MP01/ME01

Less Difficult TIMSS Mathematics at Fourth Grade

As described in the introduction to this volume, countries participating in TIMSS 2019 at the fourth grade can choose to administer an assessment with some less difficult blocks than the regular TIMSS fourth grade mathematics assessment. Participants availing of this option administer the fourth grade science assessment as usual, so that student booklets contain a combination of less difficult mathematics items and regular science items. As shown in Exhibit 4.3, the item block design for the less difficult mathematics has the same number of item blocks as the regular mathematics assessment, so that the same block to booklet assignment can be used for both less difficult and regular fourth grade assessments (i.e., the booklet design shown in Exhibit 4.2).

An essential aspect of the less difficult mathematics assessment is that the student achievement results are reported on the same TIMSS achievement scale as the regular mathematics assessment, so that results are comparable regardless of the version of the assessment the students have taken. To support the link between the two versions, the less difficult mathematics assessment includes four blocks of items that also are included in the regular assessment—blocks MN02, MN06, MN08, and MN10 in Exhibit 4.3. These correspond to blocks MP02, MP03, MP08, and MP13 in the regular assessment. The less difficult assessment capitalizes on its origins in the TIMSS 2015 Numeracy assessment by including eight blocks of items from that assessment—blocks MN01, MN03, MN05, MN06, MN07, MN09, MN11, and MN13 in Exhibit 4.3. Block MN06 was in both the fourth grade TIMSS and the TIMSS Numeracy assessments in 2015.

Exhibit 4.3: TIMSS 2019 Fourth Grade Less Difficult Mathematics—Item Blocks

MN01	Trend Block N09 from TIMSS Numeracy 2015
MN02	Block MP02 in TIMSS 2019 – New items for TIMSS 2019
MN03	Trend Block N10 from TIMSS Numeracy 2015
MN04	New less difficult items for TIMSS 2019
MN05	Trend Block N05 from TIMSS Numeracy 2015
MN06	Block MP03 in TIMSS 2019 – TIMSS and TIMSS Numeracy Trend Block M08/N08 from TIMSS 2015
MN07	Trend Block N07 from TIMSS Numeracy 2015
MN08	Block MP08 in TIMSS 2019 – New items for TIMSS 2019
MN09	Trend Block N06 from TIMSS Numeracy 2015
MN10	Block M13 in TIMSS 2019 – TIMSS Trend Block M14 from TIMSS 2015
MN11	Trend Block N02 from TIMSS Numeracy 2015
MN12	New less difficult items for TIMSS 2019
MN13	Trend Block N03 from TIMSS Numeracy 2015
MN14	New less difficult items for TIMSS 2019

Both the regular and less difficult mathematics items will follow the same development guidelines described in the Question Types and Scoring Procedures section with respect to the use of multiple choice and constructed response items.

eTIMSS Assessment Design

The item block design for eTIMSS 2019 (Exhibit 4.4) is similar to the paper and pencil TIMSS design (Exhibit 4.1), with each block in the paperTIMSS design having a counterpart in digital format in the eTIMSS design. The eTIMSS design is more extensive, however, in that it also includes four blocks of problem solving and inquiry (PSI) tasks and items. Blocks ET19DCM01 through ET19DCM14 in Exhibit 4.4 are the digital versions of mathematics blocks M01 through M14 in Exhibit 4.1, and similarly blocks ET19DCS01 through ET19DCS14 are the digital versions of science blocks S01 through S14. Blocks ET19DPSIM1 and ET19DPSIM2 contain mathematics PSIs while blocks ET19DPSIS1 and ET19DPSIS2 contain PSIs for science.

Similar to the paperTIMSS design, eTIMSS blocks ending in the numbers 01, 03, 05, 06, 07, 09, 11, and 13 contain the trend items from the 2015 assessment, although converted to digital format. Blocks ending in numbers 02, 04, 08, 10, 12, and 14 contain items developed for use for the first time in TIMSS 2019. As far as possible these are digital versions of the items in the corresponding paperTIMSS blocks, although adapted to make use of digital components such as "drag and drop," "sorting," etc., as appropriate.

Exhibit 4.4: eTIMSS 2019 Item Blocks—Fourth and Eighth Grades

Mathematics Blocks	Source of Items	Science Blocks	Source of Items
ET19DCM01	Trend Block M13 from TIMSS 2015: digital format	ET19DCS01	Trend Block S13 from TIMSS 2015: digital format
ET19DCM02	New items for TIMSS 2019: digital format	ET19DCS02	New items for TIMSS 2019: digital format
ET19DCM03	Trend Block M08 from TIMSS 2015: digital format	ET19DCS03	Trend Block S08 from TIMSS 2015: digital format
ET19DCM04	New items for TIMSS 2019: digital format	ET19DCS04	New items for TIMSS 2019: digital format
ET19DCM05	Trend Block M09 from TIMSS 2015: digital format	ET19DCS05	Trend Block S09 from TIMSS 2015: digital format
ET19DCM06	Trend Block M10 from TIMSS 2015: digital format	ET19DCS06	Trend Block S10 from TIMSS 2015: digital format
ET19DCM07	Trend Block M11 from TIMSS 2015: digital format	ET19DCS07	Trend Block S11 from TIMSS 2015: digital format
ET19DCM08	New items for TIMSS 2019: digital format	ET19DCS08	New items for TIMSS 2019: digital format

Exhibit 4.4: eTIMSS 2019 Item Blocks—Fourth and Eighth Grades (Continued)

Mathematics Blocks	Source of Items	Science Blocks	Source of Items
ET19DCM09	Trend Block M04 from TIMSS 2015: digital format	ET19DCS09	Trend Block S04 from TIMSS 2015: digital format
ET19DCM10	New items for TIMSS 2019: digital format	ET19DCS10	New items for TIMSS 2019: digital format
ET19DCM11	Trend Block M12 from TIMSS 2015: digital format	ET19DCS11	Trend Block S12 from TIMSS 2015: digital format
ET19DCM12	New items for TIMSS 2019: digital format	ET19DCS12	New items for TIMSS 2019: digital format
ET19DCM13	Trend Block M14 from TIMSS 2015: digital format	ET19DCS13	Trend Block S14 from TIMSS 2015: digital format
ET19DCM14	New items for TIMSS 2019: digital format	ET19DCS14	New items for TIMSS 2019: digital format
ET19DPSIM1	New Math PSI tasks TIMSS 2019: digital format	ET19DPSIS1	New Science PSI tasks TIMSS 2019: digital format
ET19DPSIM2	New Math PSI tasks TIMSS 2019: digital format	ET19DPSIS2	New Science PSI tasks TIMSS 2019: digital format

Exhibit 4.5 shows the eTIMSS block combinations (as student booklets are known in eTIMSS) that are assigned to individual students, and as such is the eTIMSS counterpart to Exhibit 4.2 for paperTIMSS. For example, block combination ET19DCBC01 for eTIMSS includes mathematics blocks ET19DCM01 and ET19DCM02 and science blocks ET19DCS01 and ET19DCS02, just as Booklet 1 contains blocks M01, M02, S01, and S02 for paperTIMSS. The eTIMSS design contains two extra block combinations, ET19DCBC15 and ET19DCBC16, to accommodate the PSI tasks. Similar to paper TIMSS, the 16 eTIMSS block combinations are distributed among students in each sampled classroom according to assignments predetermined by the within-school sampling software.

Exhibit 4.5: eTIMSS 2019 Student Achievement Block Combination (Booklet) Design—Fourth and Eighth Grades

	Assessment Blocks			
Student Block Combination	**Part 1**		**Part 2**	
ET19DCBC01	ET19DCM01	ET19DCM02	ET19DCS01	ET19DCS02
ET19DCBC02	ET19DCS02	ET19DCS03	ET19DCM02	ET19DCM03
ET19DCBC03	ET19DCM03	ET19DCM04	ET19DCS03	ET19DCS04
ET19DCBC04	ET19DCS04	ET19DCS05	ET19DCM04	ET19DCM05
ET19DCBC05	ET19DCM05	ET19DCM06	ET19DCS05	ET19DCS06
ET19DCBC06	ET19DCS06	ET19DCS07	ET19DCM06	ET19DCM07
ET19DCBC07	ET19DCM07	ET19DCM08	ET19DCS07	ET19DCS08
ET19DCBC08	ET19DCS08	ET19DCS09	ET19DCM08	ET19DCM09
ET19DCBC09	ET19DCM09	ET19DCM10	ET19DCS09	ET19DCS10
ET19DCBC10	ET19DCS10	ET19DCS11	ET19DCM10	ET19DCM11
ET19DCBC11	ET19DCM11	ET19DCM12	ET19DCS11	ET19DCS12
ET19DCBC12	ET19DCS12	ET19DCS13	ET19DCM12	ET19DCM13
ET19DCBC13	ET19DCM13	ET19DCM14	ET19DCS13	ET19DCS14
ET19DCBC14	ET19DCS14	ET19DCS01	ET19DCM14	ET19DCM01
ET19DCBC15	ET19DPSIM1	ET19DPSIM2	ET19DPSIS1	ET19DPSIS2
ET19DCBC16	ET19DPSIS2	ET19DPSIS1	ET19DPSIM2	ET19DPSIM1

Student Testing Time

As summarized in Exhibit 4.6, each student completes one student achievement booklet or block combination consisting of two parts, followed by a student questionnaire. The individual student response burden for the TIMSS 2019 assessment is the same as it has been since TIMSS 2007—that is, 72 minutes for the assessment and 30 minutes for the questionnaire at the fourth grade, and 90 minutes and 30 minutes, respectively, at the eighth grade.

Exhibit 4.6: TIMSS 2019 Student Testing Time—Fourth and Eighth Grades

Activity	Fourth Grade	Eighth Grade
Student Achievement Booklet—Part 1	36 minutes	45 minutes
Break		
Student Achievement Booklet—Part 2	36 minutes	45 minutes
Break		
Student Questionnaire	30 minutes	30 minutes

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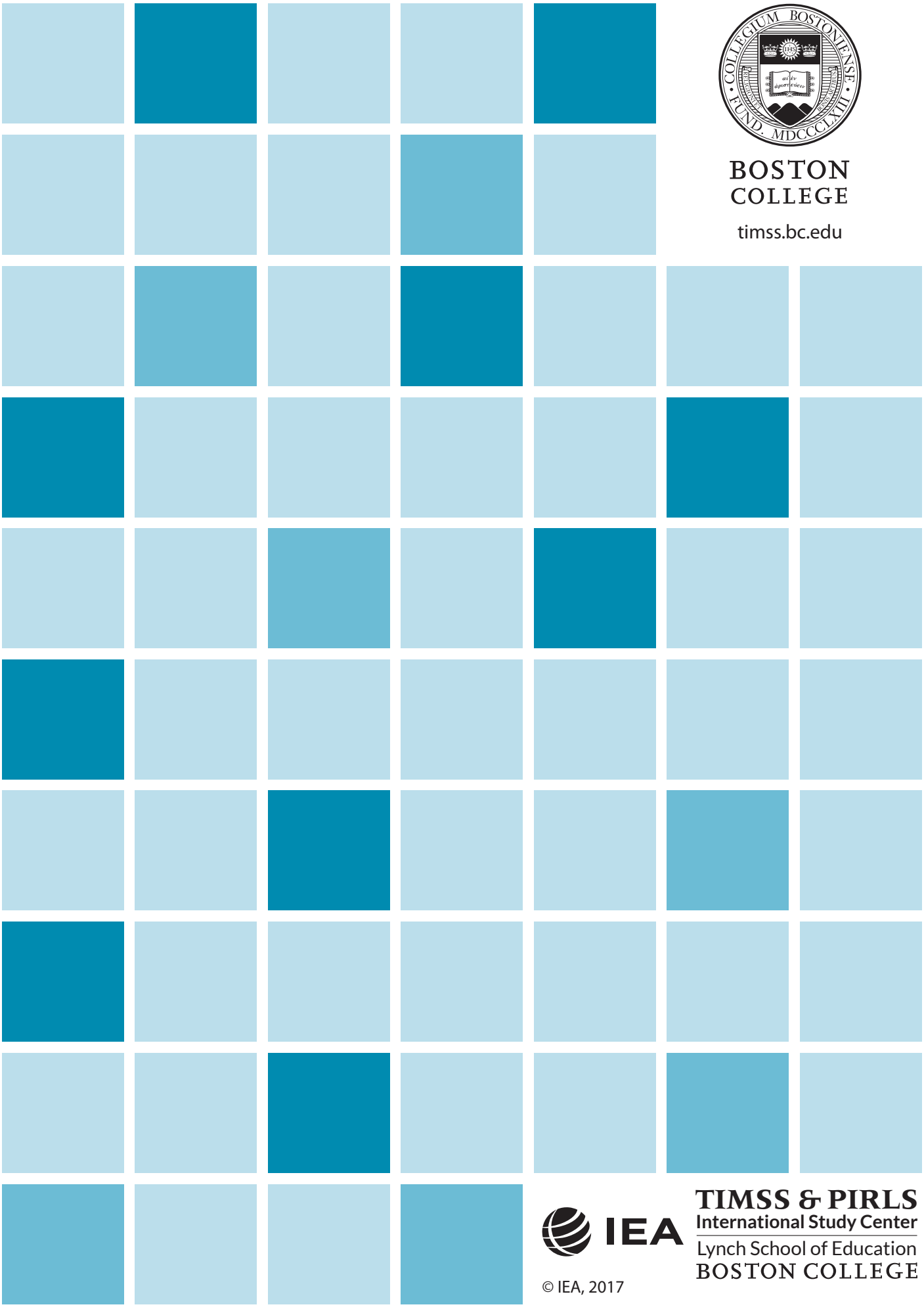

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