IEA TIMSS 2019

TIMSS 2019 Assessment Frameworks

Introduction

IEA
TIMSS & PIRLS International Study Center
Lynch School of Education
BOSTON COLLEGE

Introduction

Ina V.S. Mullis

TIMSS 2019: Monitoring Trends in Mathematics and Science Achievement

Entering into its third decade and seventh cycle of data collection, TIMSS (Trends in International Mathematics and Science Study) is a well established international assessment of mathematics and science at the fourth and eighth grades. TIMSS 2019 is the most recent in the TIMSS trend series, which began with the first assessments in 1995 and continued every four years—1999, 2003, 2007, 2011, 2015, and 2019. About 60 countries use TIMSS trend data for monitoring the effectiveness of their educational systems in a global context, and new countries join TIMSS in each cycle. About 70 countries are expected to participate in TIMSS 2019.

As a mathematics and science assessment, TIMSS is a valuable resource for monitoring educational effectiveness because science, technology, engineering, and mathematics, often known as STEM, are key curriculum areas. It is clear that even today many jobs require a basic understanding of mathematics and science, and this will become increasingly so in the future. Workers in STEM occupations are responsible for finding solutions to world problems such as hunger and disappearing habitats as well as sustaining growth and stability in the global economy. Mathematics and science also are basic to daily life. Science is the natural world, including our weather, land and water, and sources of food and fuel. Mathematics helps us manage a host of daily tasks and is essential in developing the technology we depend on, such as computers, smartphones, and television.

Because mathematics and science pervade every aspect of our lives, the International Association for the Evaluation of Educational Achievement, more widely known as IEA, has been conducting international assessments of mathematics and science for nearly 60 years.

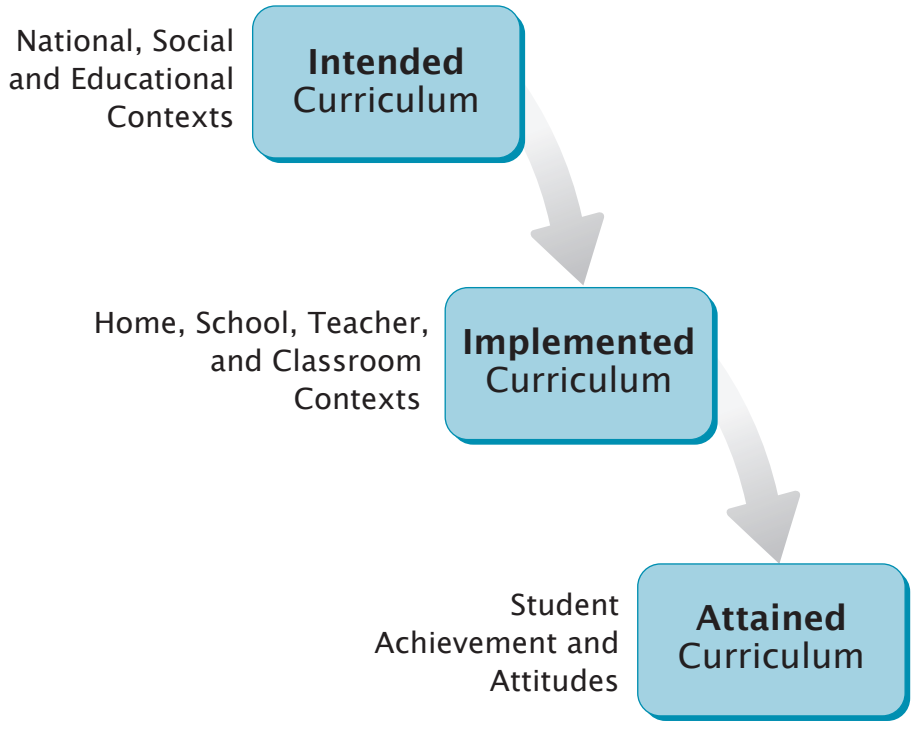
IEA is an independent international cooperative of national research institutions and government agencies that has been conducting studies of cross-national achievement since 1959. IEA pioneered international comparative assessment of educational achievement in the 1960s to gain a deeper understanding of policy effects across countries' different systems of education. Today, IEA's Amsterdam office manages country participation in a number of international studies, and IEA's Hamburg division is a large data processing and research center. As a major program of IEA, TIMSS has the benefit of drawing on the cooperative expertise provided by representatives from countries all around the world.

TIMSS is directed by the TIMSS & PIRLS International Study Center in the Lynch School of Education at Boston College. TIMSS and PIRLS (Progress in International Reading Literacy Study), an international assessment of reading, together comprise IEA's core cycle of studies measuring achievement in three fundamental subjects—mathematics, science, and reading.

Policy Relevant Data About the Content and Contexts for Learning Mathematics and Science

TIMSS uses the curriculum, broadly defined, as the major organizing concept in considering how educational opportunities are provided to students and the factors that influence how students use these opportunities. The TIMSS Curriculum Model has three aspects: the intended curriculum, the implemented curriculum, and the attained curriculum (see Exhibit 1). These represent, respectively, the mathematics and science that students are expected to learn as defined by countries' curriculum policies and publications and how the educational system should be organized to facilitate this learning; what is actually taught in classrooms, the characteristics of those teaching it, and how it is taught; and, finally, what it is that students have learned and what they think about learning these subjects.

Exhibit 1: TIMSS Curriculum Model



Working from this model, TIMSS routinely publishes the TIMSS Encyclopedia with each assessment to document education policies and the curriculum in mathematics and science in each of the participating countries. The *TIMSS 2015 Encyclopedia: Education Policy and Curriculum in Mathematics and Science* (Mullis, Martin, Goh, & Cotter, 2016) provides an important resource for helping to understand the teaching and learning of mathematics and science around the world, with particular emphasis on schooling through the eighth grade. A chapter prepared by each country and benchmarking participant summarizes the structure of its education system, the mathematics and science curricula instruction in the primary and secondary grades, the teacher education requirements, and the types of examinations and assessments employed. To provide standard information across countries that supplements the chapters, countries complete a curriculum questionnaire about their mathematics and science curricula, school organizational approaches, and instructional practices.

TIMSS also asks students, their parents or caregivers, their teachers, and their school principals to complete questionnaires about their home and school experiences and instructional contexts for learning mathematics and science. The questionnaires are developed according to a carefully developed framework that is updated with each assessment through iterative reviews by the TIMSS National Research Coordinators and the TIMSS Questionnaire Item Review Committee of international experts. Data from these questionnaires provide a dynamic picture of the implementation of educational policies and practices that can raise important issues and suggest avenues for educational improvement.

Chapter 3 of this volume contains the TIMSS 2019 Context Questionnaire Framework. TIMSS 2019 will concentrate on measuring trends for the existing context questionnaire scales and developing several new context questionnaire scales that address emerging areas of research in educational effectiveness.

The TIMSS International Assessments in Mathematics and Science

The TIMSS international assessments of mathematics and science were inaugurated in 1995 as a follow-up to IEA's earlier studies conducted separately in these curriculum areas (two in mathematics and two in science) during the 1960s through the 1980s. After the early assessment cycles in the 1990s, TIMSS has been stable over the next two decades with regular assessments every four years at the fourth and eighth grades. Since 1995, the achievement results of each TIMSS assessment (mathematics and science, fourth and eighth grades) have been reported on achievement scales that span the assessment cycles, making it possible to detect changes in achievement from one cycle to the next, and to measure trends in achievement over time. In addition, assessing fourth and eighth grades provides a quasi-cohort design with the fourth grade student cohort assessed in one cycle becoming the eighth grade student cohort assessed in the next cycle. This enables TIMSS to provide valuable information about trends in educational achievement across time and across grades within a particular assessment.

There also are periodic assessments of TIMSS Advanced. First conducted in 1995 and then again in 2008, TIMSS Advanced was recently assessed again as part of TIMSS 2015. It targets students who are engaged in advanced mathematics and physics studies that prepare them to enter STEM (science, technology, engineering, and mathematics) programs in higher education. TIMSS Advanced assesses these students in their final year of secondary school, and is the only international assessment that provides essential information about students specifically prepared for STEM careers.

All of the countries, institutions, and agencies involved in the TIMSS assessments have worked collaboratively in building the most comprehensive, innovative, and stable trend measures of mathematics and science achievement possible. The TIMSS & PIRLS International Study Center, IEA Amsterdam, IEA Hamburg, and the participating countries have worked together to make continual enhancements to TIMSS over its long history of development. For example, in 2011 TIMSS and PIRLS were assessed together to study the relative impact of mathematics, science, and reading achievement at the fourth grade. In 2015, to celebrate 20 years of trends TIMSS and TIMSS Advanced were assessed together for the first time since 1995, providing a profile of education through secondary school. Now, for 2019, TIMSS is starting the transition to a digital format (see the section eTIMSS: The Future of TIMSS).

Taken together, TIMSS' focus on regular assessments measuring trends in achievement, attention to emerging issues in content and the contexts for learning, and robust methods and procedures make it important to educational decision making in the participating countries.

The TIMSS achievement data in combination with the context questionnaire scales can be used to:

- Monitor system-level achievement trends in a global context
- Use TIMSS results to inform educational policy, and monitor the impact of new or revised policies
- Pinpoint any underperforming areas, and stimulate curriculum reform
- See how the fourth grade cohort from a previous cycle performs at the eighth grade in the next cycle
- Obtain important information about the home and school contexts for teaching and learning in relation to students' achievement in mathematics and science

The TIMSS 2019 Assessment Frameworks

Chapters 1 and 2 of this volume contain the TIMSS 2019 Assessment Frameworks for mathematics and science, respectively.

The TIMSS assessments are conducted according to mathematics and science assessment frameworks that have been updated with each assessment throughout TIMSS' 24 year history. The frameworks are organized around two dimensions: a content dimension specifying the subject matter to be assessed and a cognitive dimension specifying the thinking processes to be assessed as students engage with the content.

TIMSS 2019 will follow the usual practice of conducting assessments at the fourth and eighth grades. The *TIMSS 2019 Assessment Frameworks* for these assessments are summarized briefly below.

Mathematics Content Domains

- Fourth Grade—Number, Measurement and Geometry, and Data
- Eighth Grade—Number, Algebra, Geometry, Data and Probability

Science Content Domains

- Fourth Grade—Life Science, Physical Science, Earth Science
- Eighth Grade—Biology, Chemistry, Physics, Earth Science

Cognitive Domains in Mathematics and Science

- Fourth and Eighth Grades—Knowing, Applying, and Reasoning

It is important to emphasize that the items in each TIMSS assessment cover a range of thinking skills, including students' abilities to apply what they have learned, solve problems, and use analysis and logical thinking to reason through situations. As noted above, the three cognitive domains are the same for mathematics and science and for both grades, encompassing a range of cognitive processes involved in learning mathematics and science concepts, and then applying these concepts and reasoning with them. TIMSS Science also integrates science practices across domains, including skills from daily life and school studies that students use in systematic ways to conduct the scientific inquiry that is fundamental to all science disciplines.

The TIMSS assessment frameworks for 2019 were updated from those used in 2015 to provide participating countries opportunities to introduce fresh ideas and current information about curricula, standards, frameworks, and instruction in mathematics and science. The updating process keeps the frameworks educationally relevant, creates coherence from assessment to assessment, and permits the TIMSS frameworks, instruments, and procedures to evolve gradually into the future.

For TIMSS 2019, the TIMSS & PIRLS International Study Center prepared the initial draft based on information from the *TIMSS 2015 Encyclopedia* (Mullis, Martin, Goh, & Cotter, 2016) and reviews provided by the TIMSS 2019 expert group, the Science and Mathematics Item Review Committee (SMIRC), whose members are listed in Appendix A. The updates were discussed by the TIMSS 2019 National Research Coordinators (NRCs) at their first meeting. Each participating country identified an NRC to work with the international project staff to ensure that the assessments are responsive to the country's concerns. Following the discussion at the first NRC meeting, the NRCs consulted with national experts and responded to a topic by topic survey about how best to update the content and cognitive domains for TIMSS 2019. The results of the survey were used to create another draft that was further reviewed and refined by SMIRC. Using an iterative process, the penultimate drafts were once again reviewed by the NRCs as part of their second meeting for TIMSS 2019 and updated a final time prior to publication.

eTIMSS: The Future of TIMSS

TIMSS 2019 will begin the transition to conducting the assessments in the eTIMSS digital format. eTIMSS will provide enhanced measurement of the TIMSS mathematics and science frameworks and take advantage of efficiencies provided by the IEA eAssessment systems. It is anticipated that about half the countries participating in TIMSS 2019 will transition to administering the assessment via computer. The rest of the countries will administer TIMSS in a paper and pencil format as in previous assessments.

To provide extended coverage of the mathematics and science frameworks, eTIMSS 2019 will include additional innovative problem solving and inquiry tasks, known as PSIs. The PSIs simulate real world and laboratory situations where students can integrate and apply process skills and content knowledge to solve mathematics problems and conduct scientific experiments or investigations. The PSI tasks—such as design a building or study plants' growing conditions—involve visually attractive, interactive scenarios that present students with adaptive and responsive ways to follow a series of steps toward a solution. According to early pilot efforts, students find the PSIs engaging and motivating. Also, there will be an opportunity digitally to track students' problem solving or inquiry paths through the PSIs. Studying the process data about what student approaches are successful or unsuccessful in solving problems may provide information to help improve instruction.

It should be emphasized that the demanding criteria for the PSIs make them very difficult and resource intensive to develop. Special teams of consultants as well as the TIMSS 2019 SMIRC members have collaborated virtually and in meetings to develop tasks that: 1) assess mathematics and science (not reading or perseverance), 2) take advantage of the "e" environment, and 3) are engaging and motivating for students.

To support the transition to eTIMSS, IEA Hamburg is developing eAssessment systems to increase operational efficiency in item development, translation and translation verification, assessment

delivery, data entry, and scoring. The eTIMSS infrastructure will include: the eTIMSS Item Builder to enter the achievement items, an online translation system to support translation and verification, the eTIMSS Player to deliver the assessment and record students' responses, an online Data Monitor to track data collection, and an online scoring system to facilitate national centers' work in managing and implementing scoring of students' constructed responses.

eTIMSS also includes new digitally based ways for students to respond to constructed response items, which will enable students' responses to many items to be scored by computer rather than "human" scored. In particular, a number keypad enables students to enter the answers to many constructed response mathematics items, such that the answers can be computer scored. Other types of constructed response items that can be computer scored use the drag and drop or sorting functions to answer questions about classifications or measurements.

Design considerations for TIMSS 2019 and eTIMSS 2019 are described in Chapter 4: TIMSS 2019 Assessment Design.

Less Difficult TIMSS Mathematics at Fourth Grade

By their fourth year of schooling, many children have graduated from basic arithmetic and are studying the broader domains and concepts of mathematics. For a variety of reasons, however, there are countries where most children in the fourth grade are still developing fundamental numeracy skills. Thus, beginning in 2015 and continuing in 2019, IEA has extended TIMSS by offering a less difficult mathematics assessment at the fourth grade.

The purpose of including less difficult items was to extend the TIMSS mathematics achievement scale at fourth grade to provide better measurement at the lower end of the scale. In 2015, the less difficult mathematics items, known as TIMSS Numeracy, were given as a separate mathematics assessment, although most countries that participated in TIMSS Numeracy also participated in TIMSS, as usual, to have science results. This led to several important developments. First, TIMSS 2015 was able to report all fourth grade mathematics results on the same achievement scale whether the students participated in TIMSS, TIMSS Numeracy, or both. In turn, this enables TIMSS 2019 to have two versions of TIMSS—one with less difficult mathematics—so that countries do not have to administer two different assessments in order to assess both numeracy and science. Depending on a country's educational development and the students' mathematics proficiency, countries can participate in either version of TIMSS to conduct the most effective assessment.

It is important to understand that for TIMSS 2019 at the fourth grade:

- Both versions of the mathematics assessment, regular and less difficult, were developed according to the fourth grade mathematics framework contained in this volume (see Chapter 1)

- The availability of two versions of TIMSS mathematics at fourth grade enables TIMSS to target the assessment to each country's situation in order to provide the best possible measurement
- The mathematics results for all countries participating in TIMSS 2019 will be reported on the same achievement scale, including the results for countries administering the less difficult version of TIMSS mathematics

Both regular and less difficult versions of TIMSS mathematics at fourth grade are equivalent in scope, and about one-third of the items are the same. The other two-thirds of the items are based on the same areas of the framework, but with those in the less difficult version being generally less difficult. A substantial portion of the items in the less difficult version are from TIMSS Numeracy 2015 to enable measuring trends. The items in common between the two versions of mathematics at fourth grade will enable the two assessments to be linked, so that the results can be reported together and directly compared.

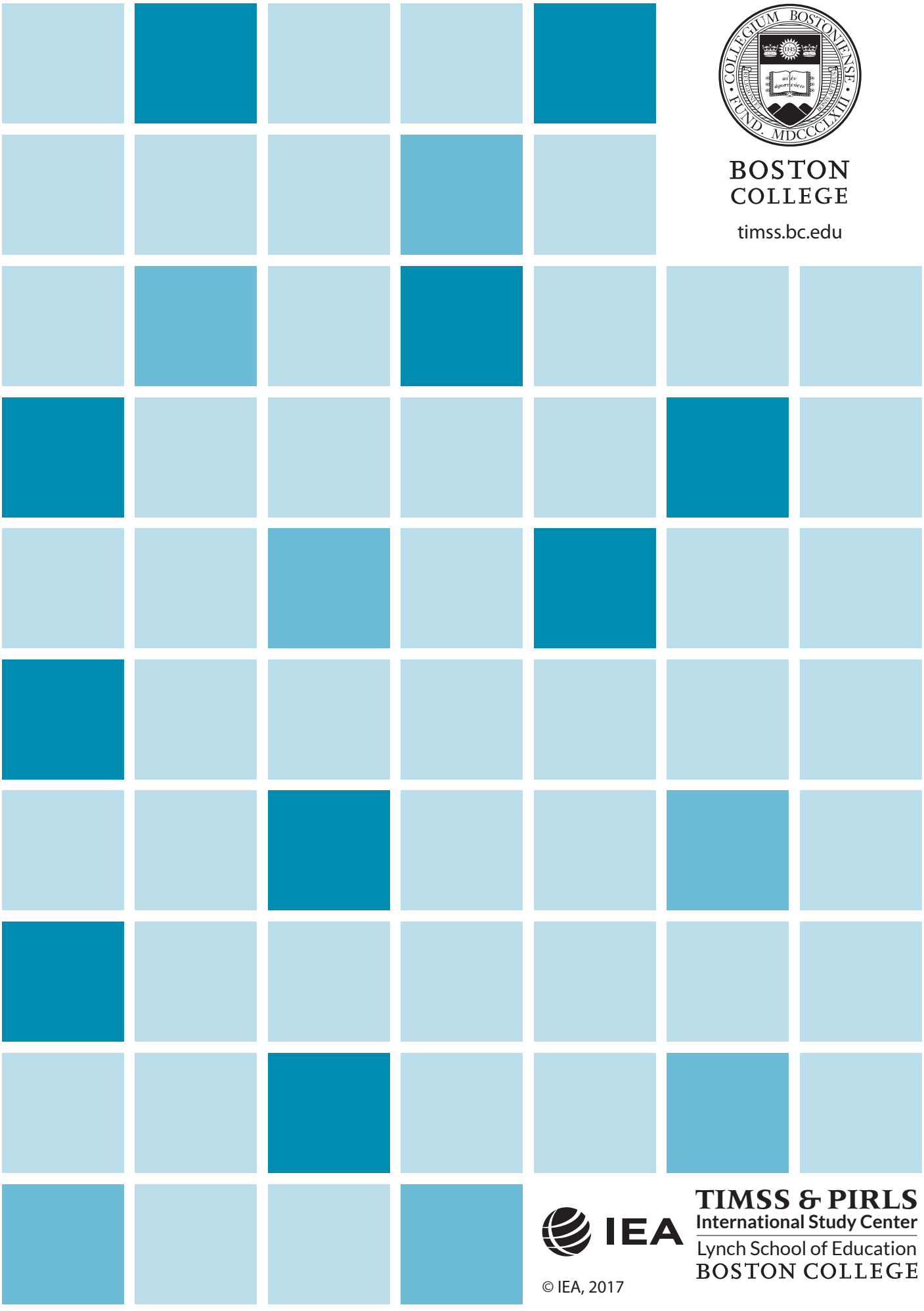
It is important to have a good match between TIMSS and the students' curriculum and achievement. Experience with TIMSS Numeracy and PIRLS Literacy (the less difficult version of IEA's PIRLS reading assessment) indicates that lower performing students are more strongly motivated by less difficult items, and better able to demonstrate what they know and can do, resulting in fewer omitted items, especially for constructed response questions, and higher completion rates.

Introducing LaNA—IEA's Literacy and Numeracy Assessment for Developing Countries

Considering increased efforts to raise literacy and numeracy levels in many countries around the world, IEA has developed an assessment specifically for countries where many students' reading and numeracy skills are emerging but not fully developed. LaNA's literacy and numeracy assessments reflect the same concept of reading and mathematics as PIRLS and TIMSS, respectively, except they are less difficult and designed to assess basic skills that are prerequisites for PIRLS and TIMSS. LaNA is a stepping stone to participating in PIRLS and TIMSS, intended to be responsive to the needs of the global education community and to support efforts that work toward universal learning for all. As debates shift from access to learning for all toward measuring progress toward learning goals for all, LaNA can be an effective avenue to help countries and international organizations assess students' educational achievement and thereby improve reading and mathematics learning outcomes for young students worldwide.

References

Mullis, I.V.S., Martin, M.O., Goh, S., & Cotter, K. (Eds.). (2016). *TIMSS 2015 encyclopedia: Education policy and curriculum in mathematics and science*. Retrieved from Boston College, TIMSS & PIRLS International Study Center website: http://timssandpirls.bc.edu/timss2015/encyclopedia/



BOSTON COLLEGE

timss.bc.edu

IEA

TIMSS & PIRLS
International Study Center
Lynch School of Education
BOSTON COLLEGE