TIMSS 2015

Introduction

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TIMSS 2015: 20 Years of Monitoring Trends

Because the information learned in mathematics and science is essential to becoming a knowledgeable and functioning individual as well as a contributing member of society, it is nearly universal across the world's countries that all school children study these subjects. An understanding of mathematics and basic scientific concepts can facilitate leading a productive personal life that includes maintaining good health habits, making informed financial decisions, and using effective problem-solving skills. At the national level, a citizenry well educated in mathematics and science is fundamental to improving medical, housing, and transportation conditions as well as to managing environmental issues and maintaining the economic health of the country. Specialized mathematics and science knowledge will be crucial in protecting our planet Earth for future generations.

Now entering into its 20th year of data collection, TIMSS is an international assessment of mathematics and science at the fourth and eighth grades. TIMSS 2015 is the most recent in the TIMSS series, which began with the first assessments in 1995 and has continued every four years—1999, 2003, 2007, and 2011. For countries with data back to 1995, TIMSS 2015 will provide the sixth in a series of trend measures collected over 20 years. Approximately 60 countries have TIMSS trend data, and new countries join TIMSS in each cycle. About 70 countries are expected to participate in TIMSS 2015.

TIMSS 2015 continues the long history of international assessments in mathematics and science conducted by the International Association for the Evaluation of Educational Achievement (IEA). 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 assessments of educational achievement in the 1960s to gain a deeper understanding of the effects of policies across countries' different systems of education. As a program of the IEA,

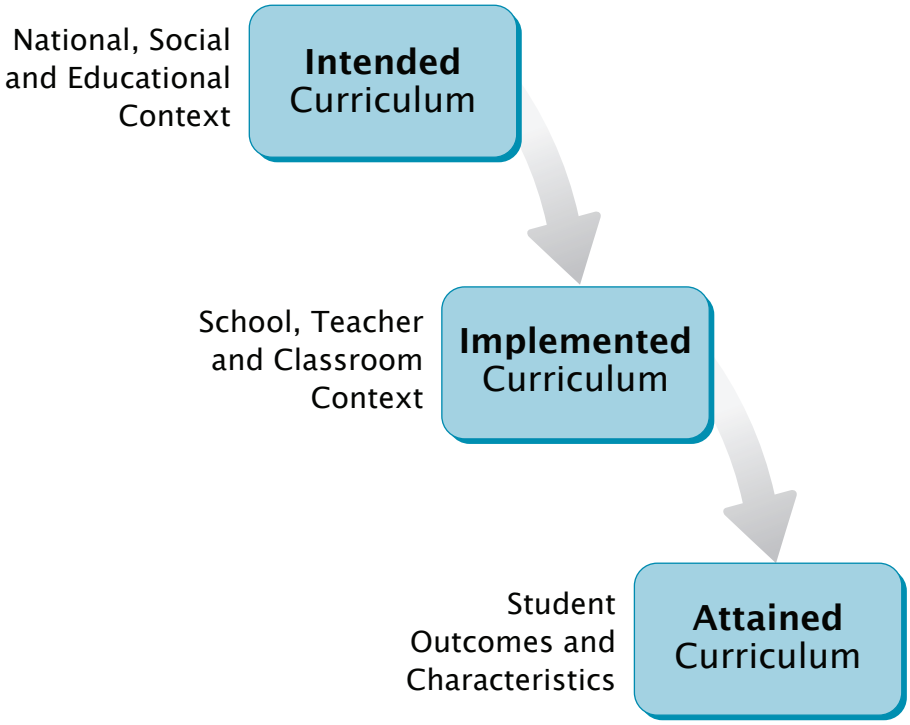
TIMSS has the benefit of drawing on the cooperative expertise provided by representatives from countries all around the world. TIMSS is directed by the TIMSS & PIRLS International Study Center at Boston College.

In 2011, nationally representative samples of students in 63 countries and 14 benchmarking entities (regional jurisdictions of countries, such as states or provinces) participated in TIMSS. In total, more than 600,000 students participated in TIMSS 2011. The results for the TIMSS 2011 mathematics and science assessments were reported in two companion volumes: *TIMSS 2011 International Results in Mathematics* (Mullis, Martin, Foy, & Arora, 2012) and *TIMSS 2011 International Results in Science* (Martin, Mullis, Foy, & Stanco, 2012). These reports summarized trends in fourth and eighth grade students' achievement overall and at the TIMSS International Benchmarks. The reports also presented a rich array of information about the students' backgrounds and their attitudes toward mathematics and science, teachers' education and training, classroom characteristics and activities, and school contexts for learning and instruction in mathematics and science.

Policy Relevant Data about the 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 in 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 compiles the TIMSS Encyclopedia with each assessment cycle to document education policies and the curriculum in mathematics and science in each of the participating countries. The two volumes of the *TIMSS 2011 Encyclopedia* (Mullis et al., 2012) provide 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 participant summarizes the structure of its education system, the mathematics and science curricula and instruction in 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 teachers, and their school principals to complete questionnaires about their school and classroom instructional contexts for learning mathematics and science. Data from these questionnaires provide a dynamic picture of the implementation of educational policies and practices that

can raise issues and provide avenues relevant to educational improvement efforts. TIMSS 2011 included nearly 20 context questionnaire scales about teaching and learning mathematics and science. Each context questionnaire scale was created using IRT methods; and to facilitate interpretation, the results were presented for three scale regions (most to least desirable, using scale score equivalents of response combinations to determine the cutpoints between the regions).

Including the *TIMSS 2015 Encyclopedia* and questionnaire data, TIMSS 2015 will collect data on the following range of student contexts for learning mathematics and science:

- National and community contexts;
- Home contexts;
- School contexts; and
- Classroom contexts.

One of the important findings from TIMSS 2011 was that an early start in school appears to be crucial in developing students' mathematics and science achievement. To examine students' early home experiences and preschool experiences in learning mathematics and science, TIMSS 2015 at the fourth grade will include a home questionnaire to be completed by students' parents and caregivers. The questionnaire will be similar to the *Learning to Read Questionnaire* that has been an important part of each cycle of PIRLS (Progress in International Reading Literacy Study) since its inception in 2001.

TIMSS and TIMSS Advanced in 2015

First conducted in 1995 and then again in 2008, TIMSS Advanced is the only international assessment that provides essential information about student achievement in advanced mathematics and physics. 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, or as an option offered in 2015 for the first time, at the start of their STEM coursework in universities.

With the current emphasis on college and career readiness and increasing global competitiveness in STEM fields, in 2015 TIMSS Advanced once again will be joined with TIMSS. This is the first time since 1995 that TIMSS together with TIMSS Advanced will provide countries with a complete profile of mathematics

and science learning from elementary through the end of secondary school. For example, Norway (Grønmo & Onstad, 2013) examined its TIMSS Advanced 2008 data together with TIMSS 2007 data to learn how the domino effect that begins in elementary school can work up the educational ladder and impact achievement in students' final year of secondary school. Also, both TIMSS and TIMSS Advanced 2015 will provide trend data for the countries that participated in previous cycles of the assessments.

More specifically, each country that participates in TIMSS Advanced 2015 gains critically valuable information on the following:

- The numbers of students and the proportion of the overall student population who are participating in advanced mathematics and physics study at the end of secondary school;
- The achievement of these students based on international benchmarks (advanced, high, and intermediate); and
- A rich set of contextual data on curricula, teaching and learning strategies, teacher preparation, school resources, and student preparation and attitudes that can be used to guide education reform and policy planning in STEM fields.

Detailed information about the TIMSS Advanced 2015 frameworks for the advanced mathematics and physics assessments is found in *TIMSS Advanced 2015 Assessment Frameworks* (Mullis & Martin, 2013).

TIMSS Numeracy

TIMSS 2015 at the fourth grade has a new, less difficult mathematics assessment called TIMSS Numeracy. TIMSS Numeracy is being introduced in 2015 to assess fundamental mathematical knowledge, procedures, and problem-solving strategies that are prerequisites for success on TIMSS Mathematics—Fourth Grade. TIMSS Numeracy asks students to answer questions and work problems similar to TIMSS Mathematics—Fourth Grade, except with easier numbers and more straightforward procedures. TIMSS Numeracy is designed to assess mathematics at the end of the primary school cycle (4^{th}, 5^{th}, or 6^{th} grades) for countries where most children are still developing fundamental mathematics skills.

Together with IEA's prePIRLS reading assessment, TIMSS Numeracy is intended to be responsive to the needs of the global education community and efforts to work towards universal learning for all children. As the debates

shift from *access for all* to *learning for all*, ways to measure progress toward learning goals are needed. Because literacy and numeracy are fundamental to every child's education, prePIRLS and TIMSS Numeracy can contribute to helping countries and international organizations measure and improve learning outcomes for children and youth worldwide.

The TIMSS 2015 Assessment Frameworks

Taken together, Chapters 1 and 2 of this publication contain frameworks for five different mathematics and science assessments. Chapter 1 contains the three frameworks for TIMSS Mathematics:

- TIMSS Mathematics—Fourth Grade;
- TIMSS Numeracy, a less difficult version of TIMSS Mathematics—Fourth Grade that is newly developed for TIMSS 2015; and
- TIMSS Mathematics—Eighth Grade.

Chapter 2 contains the two TIMSS Science Frameworks:

- TIMSS Science—Fourth Grade; and
- TIMSS Science—Eighth Grade.

Chapters 1 and 2, respectively, describe in some detail the major content and cognitive domains in mathematics and science to be assessed at the fourth and eighth grades. For each subject at each grade, there is a description of the three to four major content domains (e.g, algebra, geometry, etc. in mathematics; and biology, chemistry, etc. in science), the topic areas within each content domain, and the specific topics within that topic area to be assessed. In the science fourth and eighth grade frameworks, each topic is elaborated further with specific objectives. Also, new for TIMSS 2015, there is a section describing the science practices to be addressed in the science assessments at fourth and eighth grades. These practices include skills from daily life and school studies that students use in a systematic way to conduct scientific inquiry, and are fundamental to all science disciplines.

It is important to emphasize that the items in each TIMSS assessment cover a range of thinking skills as described within three cognitive domains: knowing, applying, and reasoning. For the most part, the items assess students' abilities to demonstrate their knowledge, apply what they have learned, solve problems, and reason through analysis and logical thinking. The knowing, applying, and

reasoning cognitive domains describe the thinking students should be doing as they engage with the mathematics and science content, and are parallel for mathematics and science and across grades, but with different levels of emphasis depending on the subject and grade.

Chapter 3 contains the TIMSS 2015 Contextual Framework describing the types of learning situations and factors associated with students' achievement in mathematics and science that will be investigated via the questionnaire data. Finally, Chapter 4 provides an overview of the TIMSS 2015 Assessment Design, including general guidelines for item development.

Updating the TIMSS Frameworks for the TIMSS 2015 Assessment

The TIMSS assessment frameworks for 2015 were updated from those used in the TIMSS 2011 Assessment Frameworks (Mullis, Martin, Ruddock, O'Sullivan, & Preuschoff, 2009). Updating the frameworks regularly provides participating countries opportunities to introduce fresh ideas and current information about curricula, standards, frameworks, and instruction in mathematics and science, which results in keeping the frameworks educationally relevant, creates coherence from assessment to assessment, and permits the frameworks, the instruments, and the procedures to evolve gradually into the future.

For TIMSS 2015, the mathematics and science frameworks were updated using information from the *TIMSS 2011 Encyclopedia* (Mullis et al., 2012). These updates were discussed by the TIMSS National Research Coordinators (NRCs) from the participating countries at their first meeting. Each participating country identifies 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 their national experts and responded to a topic-by-topic survey about how best to update the content and cognitive domains for TIMSS 2015.

Next, the TIMSS 2015 expert group, the Science and Mathematics Item Review Committee (SMIRC), conducted their own in-depth review of the frameworks, and worked with the international project staff to use the countries' survey results to further refine and update the TIMSS 2015 Assessment Frameworks. Using an iterative process, the frameworks as revised by the SMIRC were once again reviewed by the NRCs and updated a final time prior to publication.