

Introduction

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Overview of TIMSS Advanced 2015

The study of mathematics and science in primary school and secondary school prepares students to become knowledgeable, productive individuals and contributing members of society. TIMSS is an international assessment of the mathematics and science achievement of students at the fourth and eighth grades in more than sixty countries. Now entering its twentieth year of data collection, TIMSS provides countries with a measure of how well they are preparing their students with the mathematics and science knowledge they need to become effective citizens.

However, it also is critical for countries to ensure that capable secondary school students receive further preparation in advanced mathematics and science, so that they are ready to enter challenging university-level studies that prepare them for careers in science, technology, engineering, and mathematics (STEM) fields. This group of students will become the next generation of scientists and engineers who will drive innovation and technological development in all sectors of the economy; thus, it is important for countries to understand the mathematics and science achievement of these students as they begin their university-level education. First conducted in 1995, and then again in 2008, TIMSS Advanced is the only international assessment that targets this specific group of students and provides essential information about their advanced mathematics and physics achievement. 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.

Each country that participates in TIMSS Advanced 2015 gains 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.

Thus, countries that participate in TIMSS Advanced 2015 can obtain data to help them understand how successful they are at preparing the future generation of scientists and engineers, and what policies can be implemented to support and expand the pipeline of students who enter STEM careers.

TIMSS Advanced 2015 continues the series of international assessments in mathematics and science conducted by the International Association for the Evaluation of Educational Achievement (IEA). The 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 effects of policies and practices across countries' different systems of education. As a program of the IEA, TIMSS Advanced has the benefit of drawing on the cooperative expertise provided by representatives from countries all around the world. TIMSS Advanced is directed by the TIMSS & PIRLS International Study Center at Boston College.

Monitoring Trends and Progress across Grades

TIMSS Advanced 2015 provides countries that participated in the prior assessments in 1995 and 2008 the opportunity to continue the trend line that shows achievement in advanced mathematics and physics over time. Also, for the first time since 1995, both TIMSS and TIMSS Advanced will be conducted together in the same year. TIMSS has regularly assessed mathematics and science at the fourth and eighth grades since 1995, but reuniting TIMSS and TIMSS Advanced and assessing them together in 2015 provides countries an opportunity to obtain a complete view of mathematics and science education from primary and middle school through upper secondary school.

Policy Relevant Contexts for Learning Advanced Mathematics and Physics

In conjunction with the collection of advanced mathematics and physics achievement data, TIMSS Advanced 2015 also will collect an array of contextual data from curriculum specialists, school principals, mathematics and physics teachers, and the students themselves in each participating country. These data include the following:

- Organization of the advanced mathematics and physics curriculum;
- Topics actually taught;
- Teacher qualifications and experience;
- Classroom instructional strategies, including technology use;
- School resources;
- Amount of instructional time;
- School environment and climate for learning;
- Students' homework and out-of-school activities;
- Home educational supports, including information and communications technology (ICT); and
- Students' attitudes and aspirations toward STEM-related careers.

This extensive set of TIMSS Advanced 2015 contextual data can be used to evaluate current educational policies and instructional strategies, and shape them to improve enrollment and achievement in the advanced secondary school courses required to prepare students for university study in STEM fields.

The student achievement data and the contextual data for TIMSS Advanced 2008 was reported in a comprehensive publication, the *TIMSS Advanced 2008 International Report* (Mullis, Martin, Robitaille, & Foy, 2009). This report summarized students' overall achievement in advanced mathematics and physics and at the TIMSS Advanced International Benchmarks. The report also presented the rich array of contextual data (listed above) in relation to student achievement.

The TIMSS Advanced 2015 Assessment Frameworks

Chapter 1 of this publication contains the framework for the advanced mathematics assessment and Chapter 2 contains the framework for the physics assessment. Each chapter describes the major content domains (e.g., algebra, calculus, etc. in mathematics; and mechanics, thermodynamics, etc. in physics), the topic areas within each content domain, and the topics to be assessed. Across the assessment, each topic receives approximately equal weight in terms of time allocated to assessing the topic.

The items in each TIMSS Advanced assessment also cover a range of thinking processes as described within three cognitive domains: knowing, applying, and reasoning. These cognitive domains also are described in Chapters 1 and 2. In general terms, 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.

Also, new for TIMSS Advanced 2015, Chapter 2 contains a section describing science practices to be addressed in the physics assessment. These practices include skills that students use in a systematic way to conduct scientific inquiry.

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

Updating the TIMSS Advanced Frameworks for the 2015 Assessment

The TIMSS Advanced assessment frameworks for 2015 were updated from those used in the *TIMSS Advanced 2008 Assessment Frameworks* (Garden et al., 2006). Updating the frameworks provides participating countries opportunities

to provide fresh ideas and information about how curricula and instruction in mathematics and physics have evolved since the development of the frameworks for TIMSS Advanced 2008. These updates keep the frameworks educationally relevant, create coherence from assessment to assessment, and permit the frameworks, the instruments, and the procedures to evolve gradually into the future.

For TIMSS Advanced 2015, the advanced mathematics and physics frameworks were updated to better reflect the curricula, standards, and frameworks of the participating countries. Consideration also was given to current international research and initiatives in mathematics and science education. These updates were discussed by the TIMSS Advanced 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 TIMSS Advanced 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 Advanced 2015.

Next, the TIMSS 2015 expert group, the Science and Mathematics Item Review Committee (SMIRC), conducted its 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 Advanced 2015 Assessment Frameworks*. Using an iterative process, the frameworks as revised by the SMIRC were once again reviewed by the NRCs and updated for a final time prior to publication.