



TIMSS *Advanced* 2015

Trends in International
Mathematics and
Science Study



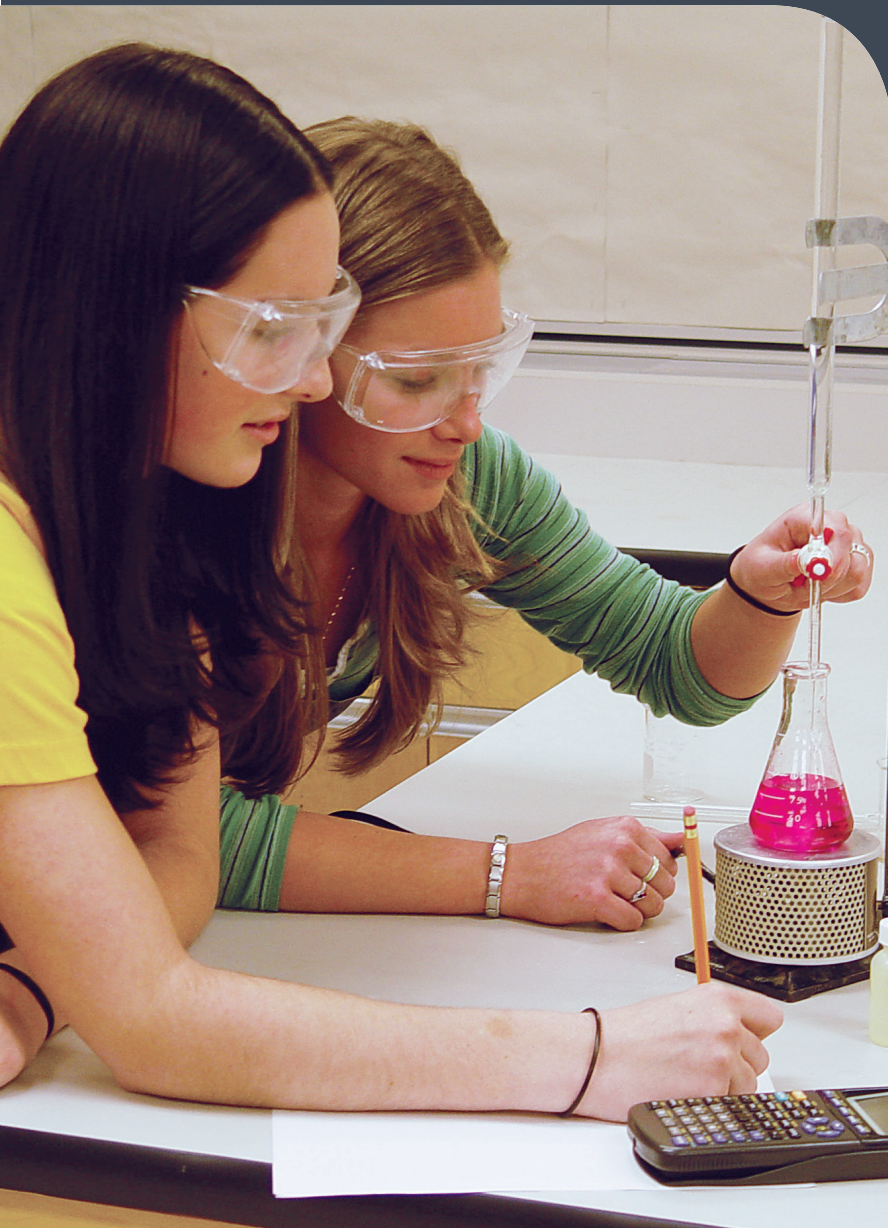
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INTERNATIONAL ASSESSMENT of ADVANCED MATHEMATICS and PHYSICS

*Innovation in
science, technology,
and engineering is
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economic growth.*

TIMSS Advanced 2015



Innovation in science, technology, and engineering is critical to a country's economic growth and improving the quality of life for its citizens. But innovation requires investment—countries need to ensure that sufficient numbers of prospective new scientists and engineers engage in advanced education and training to become the next generation of innovators and inventors. It is therefore critical that countries understand how successful they are at preparing future scientists and engineers, and what policies can be implemented to support and expand the pipeline of advanced students who enter science, technology, engineering, and mathematics (STEM) careers.

Preparing the Next Generation of Scientists and Engineers

TIMSS Advanced 2015 assesses students engaged in advanced mathematics and physics study that prepares them to enter STEM programs in universities and other systems of higher education. Students may be assessed either in their final year of secondary school or at the start of STEM coursework in universities.

For each participating country, TIMSS Advanced will provide valuable information on:

- The numbers of students and proportion of the overall student population who are participating in advanced mathematics and physics study at the end of secondary school; and
- The achievement of these students based on international benchmarks (advanced, high, and intermediate).

Accompanying questionnaires provide additional information about a host of factors that influence both educational opportunity and achievement in advanced mathematics and science.

Together, this information comprises a unique and critically needed tool that can help guide countries establish policies that support and strengthen the preparation of the next generation of scientists and engineers.

Ensuring Preparation for Careers in STEM Fields

Countries must ensure that a significant proportion of students in mathematics and science are well-equipped at the end of secondary school to enter challenging university preparation for careers in STEM fields. These students will be influential in maintaining and, indeed, driving the increasingly sophisticated technological infrastructure in nearly all sectors of the economy.

TIMSS Advanced provides vital information about the pipeline of advanced students entering STEM careers.

It is critical that countries understand how successful they are at preparing future scientists and engineers.

Globally, countries are increasing their funding of STEM education programs.

Globally, countries are raising educational goals and standards in STEM subjects.

Only TIMSS Advanced provides data on the preparation of future scientists and engineers.

Increased Investment in STEM Education

Countries have deepened their policy commitment to STEM education through increased funding, even during the Great Recession. In the U.S., funding for programs that encourage more students to enter study into STEM fields and strengthen the rigor and quality of preparation for STEM careers has increased from \$3.0 billion in FY2004 to \$3.7 billion in FY2010.

The policy focus on STEM education is particularly timely. Without a highly trained cadre of professional scientists and engineers, countries recognize that they will not be able to continually advance in technology, engineering, energy, manufacturing, agriculture, and medicine.

Global Focus on Mathematics and Science Standards

States in the U.S. have recently created new Common Core State Standards in Mathematics to guide the development of state curricula and assessments at the secondary school level. These curricula are intended to prepare increased numbers of students for college and careers. The states also are working collaboratively to develop Next Generation Science Education Standards. These standards are based on the recently released *Framework for K-12 Science Education* from the National Academy of Sciences, and are being benchmarked by Achieve to curricula in ten countries that have participated in TIMSS and PISA.

Recently revised mathematics and science standards and curricula emphasizing the importance of preparation for STEM careers also have been implemented in other countries, such as Singapore and the Netherlands. In Singapore, the education ministry works with the Agency for Science, Technology and Research (A*STAR) so students can learn under the guidance of scientists and researchers. In the Netherlands, the government's *Platform Bèta Techniek* initiative specifically encourages students to pursue a mathematics- or science-related career, and involves schools, universities, businesses, ministries, municipalities, and regions.

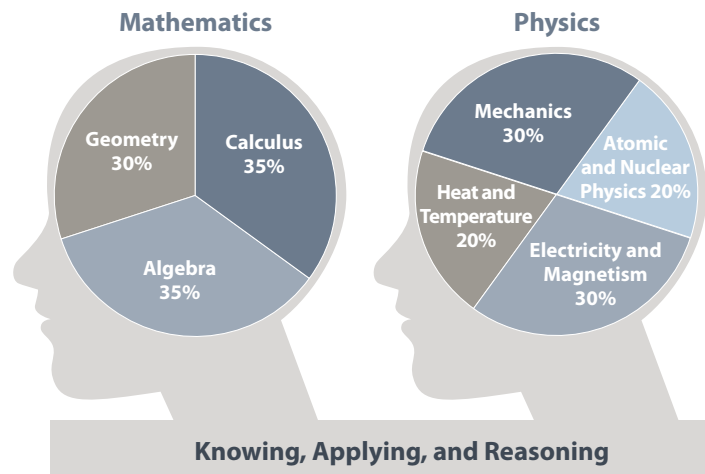
Monitoring Preparation for STEM Careers

TIMSS assessments at grades 4 and 8 and OECD's PISA assessment provide data on the general math and science achievement of the full student population. But only TIMSS Advanced provides information specifically on the successful preparation of students who will become the next generation of scientists and engineers.

Assessing Advanced Content and Thinking Processes

TIMSS Advanced assesses students in two domains—a cognitive domain specifying thinking processes, and a content domain specifying subject matter knowledge. The cognitive domains of knowing, applying, and reasoning each occupy approximately one-third of the TIMSS Advanced assessment. As shown in Exhibit 1, the advanced mathematics assessment includes geometry, calculus, and algebra, while the physics assessment is comprised of mechanics, electricity and magnetism, heat and temperature, and atomic and nuclear physics. The content domains incorporate advanced mathematics and physics concepts that must be applied to solve real-world problems.

Exhibit 1
TIMSS Advanced Mathematics and Physics Content



Measuring Global Trends and Baseline Achievement

TIMSS Advanced is the only assessment that provides essential information about advanced mathematics and physics students in an international context. TIMSS Advanced was conducted in 1995 and 2008. TIMSS Advanced 2015 continues this trend line for those countries that participated in these prior assessments.

As new standards become embedded in school curricula, it is important to establish a baseline measure of student achievement in advanced mathematics and science at the end of secondary school. This baseline can be then used to measure the impact of newly implemented curricula on student achievement into the future. TIMSS Advanced 2015 provides just such an opportunity to establish this baseline measure.

Participants also will be able to assess the comparative international standing of their students' achievement. Countries can evaluate their mathematics and science programs in an international context as well as learn about effective educational approaches from each other.

Effective System Monitoring Across the Grades

Participating in both TIMSS and TIMSS Advanced enables a complete view of STEM education and achievement from primary and middle school to finishing upper secondary school. TIMSS and TIMSS Advanced were first assessed in 1995, and TIMSS has regularly assessed mathematics and science at the fourth and eighth grades every four years since then. As an example, Norway analyzed their TIMSS and TIMSS Advanced data from primary, middle, and upper secondary school to develop a comprehensive picture of mathematics and science education across the Norwegian educational system. For the first time since 1995, TIMSS and TIMSS Advanced will be reunited and assessed together in 2015.

Evaluate comparative international standing and track future student achievement.

TIMSS and TIMSS Advanced together provide a comprehensive view of STEM education from primary to the end of upper secondary school.

TIMSS Advanced provides a rich data resource about country contexts for learning advanced mathematics and physics.

Examine important policy areas, such as equity of educational opportunity and achievement among advanced students.

Assembling Rich Evidence for Evaluation

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

- Organization of the advanced mathematics and physics curriculum;
- Topics actually taught;
- Teacher qualifications and experiences;
- 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);
- Students' attitudes and aspirations toward STEM related careers.

Insights from TIMSS Advanced Physics Data

TIMSS Advanced data are available for examining a number of policy areas, including equity in educational opportunity and achievement of advanced students. For example, many countries have instituted programs to increase access to and success in mathematics and science among female students and other traditionally underserved groups.

Exhibit 2 presents achievement and some of the related contextual data that provide insight into student performance in physics in five countries that participated in TIMSS Advanced 2008. Average achievement is positively correlated with the Human Development Index (HDI). However, Iran, with the lowest HDI among the five countries portrayed here, has nearly as large a proportion of students in the age cohort enrolling in physics as does the Netherlands and Norway, which have the highest HDIs.

Exhibit 2

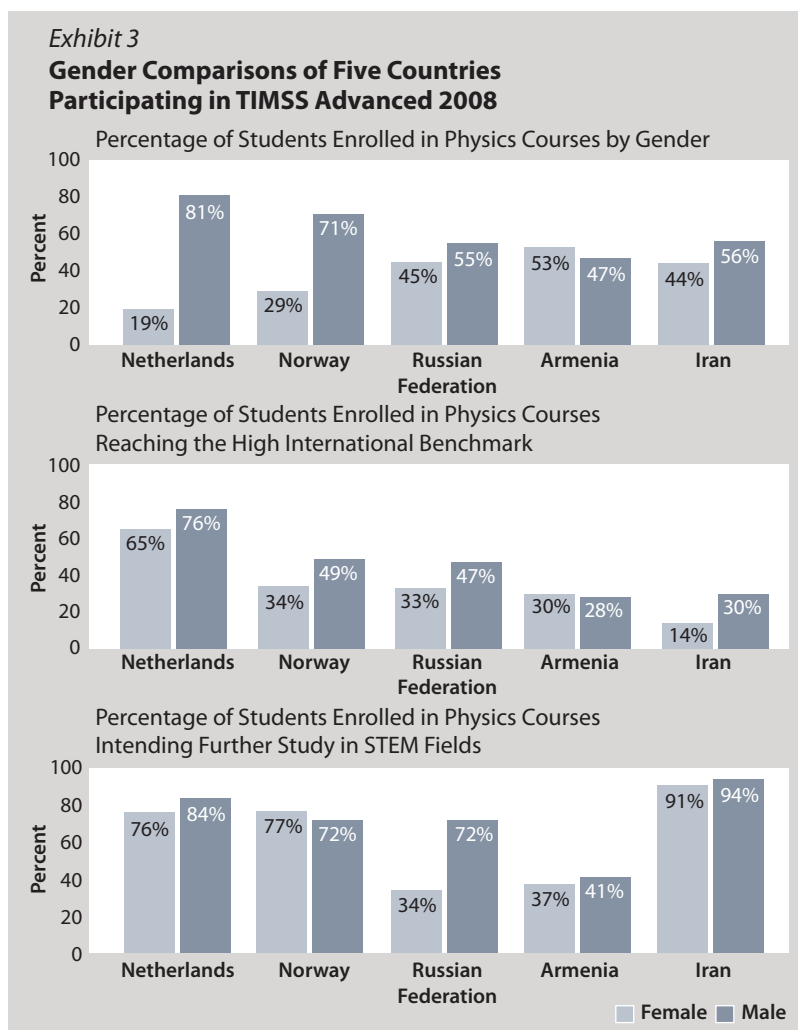
Comparative Achievement in Physics and Related Contextual Data for Five Countries Participating in TIMSS Advanced 2008

	Netherlands	Norway	Russian Federation	Armenia	Iran
Average Achievement (Scale score; mean = 500)	582	534	521	495	460
Percentage of Age Cohort Enrolled in Physics	3.4%	6.8%	2.6%	4.3%	6.6%
Human Development Index (HDI)	0.953	0.968	0.813	0.775	0.759

HDI is an index developed by the United Nations Development Programme. Countries with high values on the index have long life expectancies, high levels of school enrollment and adult literacy, and a good standard of living as measured by per capita Gross Domestic Product.

Exhibit 3 displays data providing insight into physics achievement by gender in the five countries:

- Notably, the largest gender gaps in participation are in the Netherlands and Norway (the countries with the highest HDIs).
- Gender gaps in achievement exist in the Netherlands, Norway, the Russian Federation, and Iran, with males scoring higher than females and larger proportions of males enrolling in physics than females.
- Armenia exhibits gender equity in enrollment and achievement. However, the percentages of both male and female physics students who intend to pursue further study in STEM fields is relatively low.
- The percentage of physics students intending to pursue further study in STEM fields is highly variable across countries. The highest rates occur in Iran, with over 90% of physics students intending to pursue further study (primarily in engineering).



TIMSS Advanced data can provide important portrayals of the status of advanced mathematics and science education at the end of secondary school. More importantly, these data can instigate thought-provoking questions, prompting countries to examine and evaluate their own and other countries' educational policies. For example:

- What factors lead to relatively low participation in physics by female students?
- What policies or educational strategies lead to relatively high participation in physics coursework?
- What factors lead to high percentages of students pursuing further STEM study?

TIMSS Advanced results can prompt a thoughtful examination of educational policies.

Insights from TIMSS Advanced Mathematics Data

As shown in Exhibit 4, student mathematics achievement is relatively high in both the Russian Federation and the Netherlands, compared to Iran. Yet, Iran has a greater proportion of students taking advanced mathematics.

Exhibit 4

Comparative Advanced Mathematics Achievement and Related Contextual Data for Three Countries Participating in TIMSS Advanced 2008

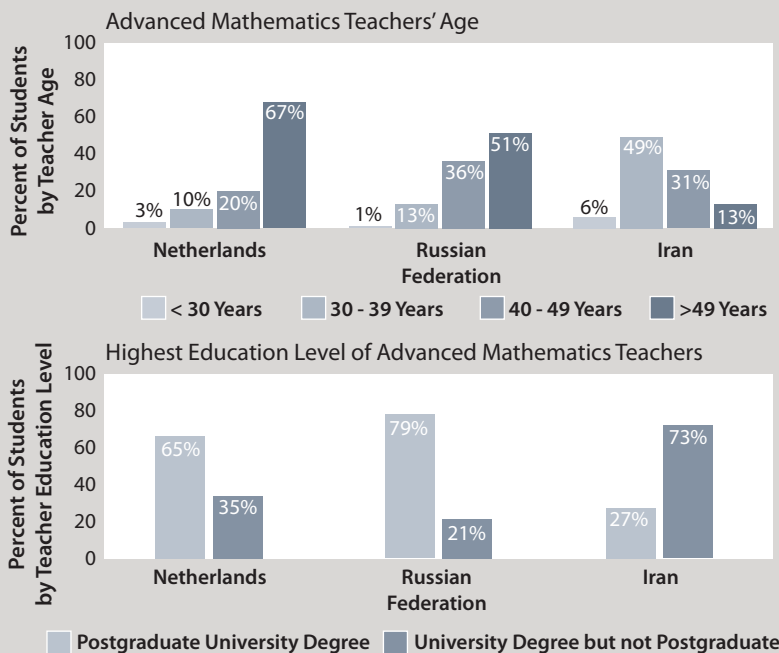
	Netherlands	Russian Federation	Iran
Average Achievement (Scale score; mean = 500)	552	561	497
Percentage of Age Cohort Enrolled in Advanced Mathematics	3.5%	1.4%	6.5%
Human Development Index (HDI)	0.953	0.813	0.759

Examine teacher quality in international context.

An example analysis of TIMSS Advanced data asks—do teachers of advanced courses themselves have advanced training, and are new teachers being prepared to teach the next generation of advanced mathematics and science students? Data from the Netherlands, the Russian Federation, and Iran reveal very different pictures of the state of the teaching force across these three countries.

Exhibit 5

Teacher Experience and Education in Three Countries Participating in TIMSS Advanced 2008



As shown in Exhibit 5, in the Netherlands and the Russian Federation, the teaching force is very senior, with more than half of the students being taught by teachers aged 50 or higher. The data also reveal that Iran has a relatively young teaching force, and a relatively small proportion of these teachers have advanced postgraduate training in mathematics.

Some countries may need to establish policies that support:

- Providing professional development so existing mathematics teachers who are not teaching advanced courses will be able to replace senior teachers; and/or
- Recruiting and preparing many new teachers to teach advanced mathematics.

Presenting Opportunities to Shape Policy and Strategy

Analyses based on gender or teacher preparation are only examples of the full range of data provided through TIMSS Advanced. But these examples typify how such data can provide a foundation for understanding, setting, and revising important education policies in an international context.

TIMSS Advanced 2015 provides an excellent, unique opportunity for countries to:

- Assess student achievement in advanced mathematics and physics in an international context;
- Connect that achievement to contextual factors that impact achievement; and
- Shape policies and instructional strategies to improve enrollment and achievement in the courses of study required to build the pipeline of new scientists and engineers.

Crucial Value of Contextual Data

The extensive set of TIMSS Advanced contextual data is essential for evaluating current educational policies and instructional strategies, and for guiding future policies and strategies.

Analysis and research based on TIMSS Advanced achievement and contextual data can be used to:

- Monitor the end-of-secondary-school achievement of the future generation of scientists and engineers in a comparative international context;
- Establish a baseline for tracking whether recent STEM policy and funding initiatives result in the desired increase in the quantity and quality of students who are prepared to enter university study in STEM fields at the end of secondary school;
- Improve advanced mathematics and physics teaching and learning by examining instructional practices and resource allocations that are related to high achievement;
- Guide strategies to improve the fidelity with which the intended curriculum is implemented in the classroom, and the degree to which the curriculum is achieved by students; and
- Evaluate equity of educational opportunity and achievement in advanced mathematics and physics across important subgroups.

Connect achievement to factors that impact the quality of preparation for the next generation of scientists and engineers.

Improve curriculum fidelity, teaching, and learning in advanced mathematics and physics.

There is a strong global emphasis on strengthening the preparation of students for STEM careers in order to ensure future economic growth.

Why Participate in TIMSS Advanced 2015?

Innovation in science, technology, and engineering is critical to a country's economic growth and improving the quality of life for its citizens.

Effectively positioning a country's educational sector and stimulating future growth means obtaining reliable comparative data on:

- The numbers of students participating in advanced mathematics and physics coursework (and the proportion of the total cohort enrolling in such courses); and
- The advanced mathematics and physics achievement of these students.

In order to evaluate and guide educational policies with evidence-based decisions, it is critical to have reliable, comparative data about:

- The advanced mathematics and science curriculum and the extent to which it is implemented in schools; and
- The impact of teachers, instructional approaches, school contexts, and student backgrounds and attitudes on advanced student achievement.

This full rich set of data is only available in an international context through TIMSS Advanced.

Participation Options

Traditionally, countries have participated in TIMSS Advanced at the end of the twelfth grade. However, as an option, TIMSS Advanced also may be given to students in their first year of tertiary education, whether at a college or university, immediately following their graduation from secondary education.

Participating in TIMSS at both the fourth and eighth grades as well as TIMSS Advanced provides a comprehensive set of data at three important points across a country's educational system. However, it is possible to participate in TIMSS Advanced only.

For Country Enrollment, Contact:
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A commitment to sustainable growth and improved quality of life requires long-term strategic support. For over twenty years, TIMSS data has equipped countries with the critical tools needed to evaluate progress and shape policy. With increasing investment in STEM education and new and revised educational standards in many countries, it is now essential and responsible for countries to evaluate the impact of these investments—namely, their ability to prepare this next generation of innovators and inventors. Compared to countries' overall investments in STEM initiatives, the cost for countries to participate in TIMSS Advanced 2015 is relatively modest. For countries seeking opportunity to expand the pipeline of advanced students entering STEM careers, the value of participating in TIMSS Advanced is beyond measure.



TIMSS Advanced 2015

*Preparing the
Next Generation
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International Association
for the Evaluation of
Educational Achievement



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