About TIMSS Advanced 2015

In 2015, IEA and its TIMSS & PIRLS International Study Center at Boston College conducted TIMSS 2015 at fourth and eighth grades and TIMSS Advanced 2015 for students in the final year of secondary school enrolled in advanced mathematics and physics programs or tracks. Both TIMSS 2015 and TIMSS Advanced 2015 provide 20-year trend measures for countries that participated in the first TIMSS assessments in 1995.

TIMSS 2015 and TIMSS Advanced 2015 continue the long history of international assessments in mathematics and science conducted by IEA – the International Association for the Evaluation of Educational Achievement. 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.

IEA's TIMSS & PIRLS International Study Center is located in the Lynch School of Education at Boston College and has been responsible for directing TIMSS and TIMSS Advanced since 1995.

TIMSS Advanced 2015

With the current emphasis on college and career readiness and increasing global competitiveness in STEM (science, technology, engineering, and mathematics) fields, in 2015 TIMSS Advanced once again was joined with TIMSS. First conducted in 1995 as part of TIMSS and then separately again in 2008, TIMSS Advanced is the only international assessment that provides essential information about students’ achievement in advanced mathematics and physics. It assesses students in their final year of secondary school (often 12th grade) who are engaged in advanced mathematics and physics studies that prepare them to enter STEM programs in higher education.

TIMSS Advanced 2015 was offered together with TIMSS 2015 to provide 20 years of achievement trends at three important points in students’ schooling (4th grade, 8th grade, and final grade), and to examine how the foundations established in primary school can influence students’ educational career through lower secondary and impact achievement in students’ final year of secondary school. To develop the TIMSS Advanced 2015 Assessment Frameworks, the participating countries worked collaboratively to build upon the work of TIMSS Advanced 2008. In 2015, the advanced mathematics assessment covered algebra, calculus, and geometry (including trigonometry); the physics assessment covered mechanics and thermodynamics, electricity and
magnetism, and wave phenomena and atomic/nuclear physics. The assessments consisted of approximately 100 items each for advanced mathematics and for physics. Questionnaires were completed by the students, their teachers, and school principals.

Exhibit 1 lists the nine countries that participated in TIMSS Advanced 2015, including France, Italy, Lebanon, Norway, Portugal, the Russian Federation, Slovenia, Sweden, and the United States. In Advanced Mathematics, the Russian Federation participated with two populations of students—Profile students and a subset of those students who were in an even more intensive program. The students in the intensive program took 6 hours or more of mathematics lessons per week.

*For advanced mathematics, the Russian Federation participated in 2015 with an expanded population that included the more specialized students assessed in 1995 and 2008.

In total, TIMSS Advanced 2015 was administered to more than 56,000 students (32,000 in advanced mathematics and 24,000 in physics). Nearly 5,000 teachers and 3,000 schools completed questionnaires.

In shaping educational policy, countries need to consider the issue of at what level and how many specialists they should be preparing in mathematics, science, and engineering. Globally, students need to be educated to teach and pursue careers in a host of crucial medical, social, industrial, and agricultural fields. However, across countries, programs in advanced mathematics and physics vary widely in terms of the proportion of the age cohort of students enrolled in them.
and in the depth and sophistication of subject matter content included. By the end of the secondary level, a significant proportion of the age cohort may no longer be in school; and for students still in school, the percentages electing to specialize in advanced mathematics and physics vary greatly. Thus, it is important to realize that TIMSS Advanced 2015 provides 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 students in programs and tracks taking advanced mathematics and physics
- A rich set of contextual data on curricula, instruction, teacher preparation, and students’ future plans that can be used to guide education reform and policy planning in STEM fields

**TIMSS 2015**

TIMSS is an ongoing international assessment of mathematics and science at the fourth and eighth grades that has been conducted every four years since 1995. TIMSS 2015 is the sixth in the TIMSS series, providing 20 years of trends in educational achievement in mathematics and science, together with comprehensive data on students’ contexts for learning in these curricular areas.

In 2015, 57 countries and 7 benchmarking entities (regional jurisdictions of countries such as states or provinces) participated in TIMSS. In total, more than 580,000 students around the world participated in TIMSS 2015.

**Quality Assurance**

TIMSS 2015 and TIMSS Advanced 2015 made every effort to attend to the quality and comparability of the data through careful planning and documentation, cooperation among participating countries, standardized procedures, and rigorous attention to quality control throughout. The assessments were given to carefully selected and well-documented probability samples of students. Staff from Statistics Canada and the IEA Data Processing and Research Center (DPC) worked with National Research Coordinators on all phases of sampling activities to ensure compliance with sampling and participation requirements, with the few exceptions from compliance annotated in the data exhibits. The IEA Secretariat worked with the TIMSS & PIRLS International Study Center to manage an extensive series of verification checks to ensure the comparability of translations of the assessment items and questionnaires, and to conduct an international quality assurance program of school visits to monitor and report on the administration of the assessment. IEA DPC staff worked closely with National Research Coordinators all through the project to organize data collection operations and to check all data for accuracy and consistency within and across countries.
TIMSS Advanced 2015 Results

The international results for TIMSS Advanced 2015 are reported on this website, and the TIMSS 2015 results for mathematics and science achievement at fourth and eighth grades also can be accessed.

The TIMSS Advanced 2015 results are presented separately for Advanced Mathematics and Physics, with 11 chapters for each subject that contain an overview and exhibits summarizing students’ achievement, on average and at the International Benchmarks, as well as exhibits describing the school and classroom contexts for students in special STEM programs or tracks in their final year of secondary school. The data exhibits can be downloaded and printed from the Download Center.

The TIMSS Advanced 2015 website includes links to:

- **TIMSS Advanced 2015 Assessment Frameworks** describes the advanced mathematics and physics frameworks, including the major content and cognitive domains to be assessed and the information to be collected in the student, teacher, and school questionnaires

- **Methods and Procedures in TIMSS Advanced 2015** documents the methods and procedures used to develop, implement, and analyze the results from the TIMSS Advanced 2015 assessments

Note: All TIMSS Advanced 2015 countries participated in TIMSS 2015 and are included in the TIMSS 2015 Encyclopedia. Also, considerable information about the TIMSS Advanced 2015 programs and tracks as well as the courses taken by the TIMSS Advanced students can be found in the TIMSS Advanced 2015 exhibits and the curriculum chapter.
CHAPTER M1: STUDENT ACHIEVEMENT

TIMSS ADVANCED 2015 INTERNATIONAL RESULTS IN ADVANCED MATHEMATICS AND PHYSICS
International Achievement in Advanced Mathematics

**Average Advanced Mathematics Achievement by Advanced Mathematics Coverage Index**

- **TIMSS Advanced students:**
  - In final year of secondary education
  - Have studied advanced mathematics
  - Special tracks/programs — 2 to 6 years

The TIMSS Advanced Mathematics Coverage Index quantifies the differences across countries in the percentage of students enrolled in advanced programs/tracks.

**Advanced Mathematics Coverage Index**

- 5
- 10
- 15
- 20
- 25
- 30
- 35

**Average Advanced Mathematics Scale Score**

- 550
- 500
- 450
- 400

**Advanced Mathematics Achievement**

- Russian Federation (6hr+)
- Lebanon
- United States
- Norway
- Sweden
- Slovenia
- Portugal
- Italy

**TIMSS Advanced 2015 Reveals Disappointing Trends in Mathematics Achievement**

- Of the 6 countries with 20-year trend data, France, Italy, and Sweden had lower average achievement in 2015 than in 1995.
- The Russian Federation 6hr+, Slovenia, and the United States had no significant difference.
- As a bright spot, Norway and Sweden had upturns between 2008 and 2015.

**Attracting Women to STEM Education Remains a Challenge**

- More Males than Females were enrolled in Advanced Mathematics programs in 6 countries.
- Males had higher achievement than Females in 6 countries.
- More Males enrolled in:
  - France, Sweden, Norway, Italy, Lebanon, the United States

- More Females enrolled in:
  - Slovenia, Portugal

- Females had higher achievement in:
  - Russian Federation, Norway, Sweden, France, Slovenia, the United States

**SOURCE:** IEA’s Trends in International Mathematics and Science Study – TIMSS Advanced 2015.

<table>
<thead>
<tr>
<th>Country</th>
<th>Description of How the Programs (Tracks) Fit into the Overall Curriculum</th>
<th>Number of Years Students are Taught in These Programs (Tracks)</th>
<th>Number of Hours of Advanced Mathematics Instruction per Year</th>
<th>Criteria for Admission to These Programs (Tracks)</th>
<th>Prerequisites for Admission to These Programs (Tracks)</th>
</tr>
</thead>
<tbody>
<tr>
<td>France</td>
<td>Secondary schooling spans Grades 6–12. At the end of Grade 9 students choose either a vocational program or the general program. Students attending the general program choose among four tracks at the end of Grade 10: technological, literary, economic and social, or scientific. Students choosing the scientific track choose either the engineering sciences or the life and Earth sciences emphasis at Grade 11. At Grade 12, these students additionally choose a specialization among four—life and Earth sciences, mathematics, physics and chemistry, or computational sciences.</td>
<td>2 years</td>
<td>173</td>
<td>Students’ skills and attitudes towards science, their grades in mathematics and science, and teachers’ and principals’ opinions and reports all contribute.</td>
<td>Completion of Grade 10</td>
</tr>
<tr>
<td>Italy</td>
<td>Secondary education can last 5 years and is given in three types of schools—lyceums, technical schools, and vocational schools. The students assessed by TIMSS Advanced 2015 were in Grade 13 and completed an advanced mathematics course or an advanced mathematics and physics course. Most of these students were in general schools with scientific focus on mathematics and physics (Liceo Scientifico), in general schools with a focus on science, mathematics and physics (Liceo Scientifico opzione Scienze Applicate), or in technical institutes and receiving full-time vocational training.</td>
<td>5 years</td>
<td>132</td>
<td>Completion of lower secondary education (Scuola secondaria di I grado), Grades 6–8, and success on the national examination at the end of Grade 8.</td>
<td>No prerequisites</td>
</tr>
<tr>
<td>Lebanon</td>
<td>The curriculum in Lebanon is spiral in nature so mathematical concepts are introduced in Grade 1 and accumulate until Grade 12. Participation is a prerequisite for the university specialized studies in mathematics or related studies.</td>
<td>6 years</td>
<td>250</td>
<td>Students must obtain a grade of 12 out of 20 or higher in mathematics in Grade 11.</td>
<td>Since the system is spiral, students are prepared from Grade 1 on to take the courses in advanced mathematics.</td>
</tr>
<tr>
<td>Norway</td>
<td>The Norwegian students assessed by TIMSS Advanced 2015 completed 10 years of compulsory education followed by 3 years of upper-secondary education. Upper-secondary education is not compulsory. However, all students have the right to an upper-secondary education. Almost the entire cohort enters this level, approximately half of them in an academic track, the other half in vocational programs. All students in the academic track must take some mathematics in Grades 11 and 12. Those who want to specialize in mathematics choose the most theoretical courses offered. The last two of these are called ‘Mathematics R1’ and ‘Mathematics R2,’ normally taken in Grades 12 and 13, respectively. The Norwegian students assessed in advanced mathematics by TIMSS Advanced 2015 took the R2 course in their final year of secondary education.</td>
<td>2 years</td>
<td>140</td>
<td>Students must successfully complete a theoretical mathematics course in Grade 11.</td>
<td>In Grade 11 students can choose between two courses. The most theoretical one of these is a prerequisite for the R1 course. The R1 course is a prerequisite for the R2 course.</td>
</tr>
<tr>
<td>Portugal</td>
<td>Upper-secondary schooling is a 3-year program (Grades 10–12) and is compulsory for all students. Depending on the program in the upper-secondary academic track, students may take either 3 years of advanced mathematics (Matemática A for Sciences and Technology or Socio-Economic programs) or 2 years of Matemática B (Arts programs) with 2 years of Mathematics for the Social Sciences (Languages and Humanities programs). Only students enrolled in advanced mathematics (Matemática A) were assessed in TIMSS Advanced 2015.</td>
<td>3 years</td>
<td>146</td>
<td>Completion of lower secondary education. In upper-secondary education, students can choose a secondary education study program according to their academic and/or professional interests.</td>
<td>No prerequisites</td>
</tr>
<tr>
<td>Country</td>
<td>Description of How the Programs (Tracks) Fit into the Overall Curriculum</td>
<td>Number of Years Students are Taught in These Programs (Tracks)</td>
<td>Number of Hours of Advanced Mathematics Instruction per Year</td>
<td>Criteria for Admission to These Programs (Tracks)</td>
<td>Prerequisites for Admission to These Programs (Tracks)</td>
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<td>---------------------------------------------------------------</td>
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<td>---------------------------------------------------------------------------------------------------------------</td>
<td>--------------------------------------------------------</td>
</tr>
<tr>
<td>Russian Federation</td>
<td>Since 2012, for their final two years of secondary school students in Grade 10 are divided into three streams that include different amounts of mathematics courses: Basic—3 hours per week; Profile—4.5 hours per week; and Intensive—6 or more hours per week. The courses also vary in depth of content and attainment requirements. Grade 11 students in both the Profile and Intensive streams participated in TIMSS Advanced 2015. The students in the Profile and Intensive streams study in lyceums, gymnasiums, special schools for mathematics and physics tracks, and general secondary schools with different streams at the upper-secondary level. In Grade 11 they have mastered the general mathematics courses in Grades 1–9 before moving on to more advanced courses in Grades 10 and 11. In some cases, advanced coursework in mathematics is available for these students in Grades 7–9, so Profile and Intensive stream classes may consist of students who have done advanced work in mathematics in previous courses. Students who successfully complete Profile and Intensive programs of mathematics study meet the requirements for admission to universities that require a sufficiently deep knowledge of mathematics.</td>
<td>2 years</td>
<td>158 (Profile) 210 (Intensive)</td>
<td>Successful completion of basic education (Grades 1–9), successfully passing the state mathematics examination at Grade 9, and possibly an interview, oral or written mathematics test or examination, organized by the student’s school.</td>
<td>No prerequisites</td>
</tr>
<tr>
<td>Slovenia</td>
<td>Secondary education consists of two types of programs: general gymnasias; and vocational or technically oriented programs. Only the general gymnasia program offers students the possibility of admission to university studies. All general gymnasia students study the same mathematics course during their 4-year program.</td>
<td>4 years</td>
<td>105</td>
<td>Completion of elementary schooling.</td>
<td>No prerequisites</td>
</tr>
<tr>
<td>Country</td>
<td>Description of How the Programs (Tracks) Fit into the Overall Curriculum</td>
<td>Number of Years Students are Taught in These Programs (Tracks)</td>
<td>Number of Hours of Advanced Mathematics Instruction per Year</td>
<td>Criteria for Admission to These Programs (Tracks)</td>
<td>Prerequisites for Admission to These Programs (Tracks)</td>
</tr>
<tr>
<td>---------</td>
<td>---------------------------------------------------------------------------</td>
<td>---------------------------------------------------------------</td>
<td>-------------------------------------------------------------</td>
<td>-------------------------------------------------</td>
<td>-------------------------------------------------</td>
</tr>
<tr>
<td>Sweden</td>
<td>Upper-secondary education starts at Grade 10 and is divided into 18 national 3-year programs. There are 12 vocational programs and 6 programs preparing for studies at the university level. In Swedish upper-secondary schools, mathematics is taught in consecutive courses at 5 levels—Mathematics 1, 2, 3, 4, and 5—and in one specialized course. In addition, courses at the first 2 levels are taught in 3 tracks with one track for vocational programs, one for social science and economics programs, and one for science and technology programs. The third level has 2 tracks (no track for vocational programs) and there is only one track in levels 4 and 5. The vast majority of students studying mathematics at level 4 or above are found in the science and technology programs. For the science program, most students study Mathematics 4. It is compulsory for the vast majority of students. For students in the technology program, Mathematics 4 is compulsory in one track of the program and optional for students within the other tracks, but it is chosen by many students. Students who participated in TIMSS Advanced 2015 in advanced mathematics completed either Mathematics 1–4 (400 credits) or Mathematics 1–3, and were about to complete Mathematics 4. Some of the students who completed Mathematics 4 completed or were taking Mathematics 5 (100 credits) and/or a mathematics specialized course. These students studied in either the natural science program or technology program at Grade 12.</td>
<td>3 years</td>
<td>Varying, but approximately 150 on average</td>
<td>Completion of 9-year compulsory school with passing grades in Swedish, English, mathematics, biology, physics, chemistry, and at least six other subjects.</td>
<td>No prerequisites</td>
</tr>
<tr>
<td>United States</td>
<td>The mathematics programs/tracks vary by state and district. All students begin studying mathematics in elementary school with a focus on basic arithmetic and learning about objects they encounter in the environment. In middle school, students study basic algebra and concepts of variables, integers and polynomials. Some students take more advanced algebra in middle school. In high school, most students start taking focused courses such as higher level algebra, geometry, and pre-calculus. After completing those secondary mathematics requirements students can begin studying advanced mathematics (calculus/statistics) courses. The year during which students begin studying advanced courses varies, but generally it is in grade 11 and 12. In advanced mathematics, there are two main programs that are used across many states: College Board’s Advanced Placement (AP) Program and the International Baccalaureate’s (IB) Diploma Programme. The AP Calculus program includes two calculus courses, AP Calculus AB and AP Calculus BC, for students to choose between. Each course is independent and designed to be taught for one full academic year. AP Calculus BC is an accelerated version of the AB course that also covers additional topics. IB Mathematics is a two-year comprehensive program that also offers two courses, Standard Level (SL) and High Level (HL), for students to choose between. Each course is independent and has a two year duration. The TIMSS Advanced mathematics sample includes Grade 12 students who have taken an advanced mathematics course (AP, IB, or another advanced mathematics course specific to their state/district) in Grade 12 or in a prior grade.</td>
<td>Varies by district and school</td>
<td>Varies by school and by course</td>
<td>Varies by school and by course</td>
<td></td>
</tr>
</tbody>
</table>
Exhibit M1.2: Distribution of Advanced Mathematics Achievement

<table>
<thead>
<tr>
<th>Country</th>
<th>Advanced Mathematics Average Scale Score</th>
<th>Advanced Mathematics Coverage Index</th>
<th>Years of Formal Schooling**</th>
<th>Average Age at Time of Testing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Russian Federation 6hr+</td>
<td>540 (7.8)</td>
<td>1.9%</td>
<td>11</td>
<td>17.7</td>
</tr>
<tr>
<td>Lebanon</td>
<td>532 (3.1)</td>
<td>3.9%</td>
<td>12</td>
<td>17.8</td>
</tr>
<tr>
<td>TIMSS Scale Centerpoint</td>
<td>500</td>
<td>4%</td>
<td>12</td>
<td>18.1</td>
</tr>
<tr>
<td>United States</td>
<td>485 (5.2)</td>
<td>11.4%</td>
<td>11</td>
<td>17.7</td>
</tr>
<tr>
<td>Russian Federation</td>
<td>485 (5.7)</td>
<td>10.1%</td>
<td>12</td>
<td>18.1</td>
</tr>
<tr>
<td>Portugal</td>
<td>482 (2.5)</td>
<td>28.5%</td>
<td>12</td>
<td>18.0</td>
</tr>
<tr>
<td>France</td>
<td>463 (3.1)</td>
<td>21.5%</td>
<td>12</td>
<td>18.1</td>
</tr>
<tr>
<td>Slovenia</td>
<td>460 (3.4)</td>
<td>34.4%</td>
<td>13</td>
<td>18.8</td>
</tr>
<tr>
<td>Norway</td>
<td>459 (4.6)</td>
<td>10.6%</td>
<td>13</td>
<td>18.7</td>
</tr>
<tr>
<td>Sweden</td>
<td>431 (4.0)</td>
<td>14.1%</td>
<td>13</td>
<td>18.8</td>
</tr>
<tr>
<td>Italy</td>
<td>422 (5.3)</td>
<td>24.5%</td>
<td>13</td>
<td>18.9</td>
</tr>
</tbody>
</table>

There are two groups of students at the Russian Federation 6hr+ results are for a subset of the Russian Federation students. This subset of students are in an Intensive stream that have at least 6 hours of mathematics lessons per week.

The TIMSS Advanced achievement scale was established in 1995 based on the combined achievement distribution of all countries that participated in TIMSS Advanced 1995. To provide a point of reference for country comparisons, the scale centerpoint of 500 was located at the mean of the combined achievement distribution. The units of the scale were chosen so that 100 scale score points corresponded to the standard deviation of the distribution. The TIMSS Advanced achievement scale was established in 1995 based on the combined achievement distribution of all countries that participated in TIMSS Advanced 1995. To provide a point of reference for country comparisons, the scale centerpoint of 500 was located at the mean of the combined achievement distribution. The units of the scale were chosen so that 100 scale score points corresponded to the standard deviation of the distribution.

See Appendix MC.5 for sampling guidelines and sampling participation notes †, ‡, and ¶.

(1) Standard errors appear in parentheses. Because of rounding some results may appear inconsistent.

Average Advanced Mathematics Achievement by Advanced Mathematics Coverage Index*
### Exhibit M1.3: Multiple Comparisons of Average Advanced Mathematics Achievement

Instructions: Read across the row for a country to compare performance with the countries listed along the top of the chart. The symbols indicate whether the average achievement of the country in the row is significantly lower than that of the comparison country, significantly higher than that of the comparison country, or if there is no statistically significant difference between the average achievement of the two countries.

<table>
<thead>
<tr>
<th>Country</th>
<th>Average Scale Score</th>
<th>Lebanon</th>
<th>United States</th>
<th>Russian Federation</th>
<th>Portugal</th>
<th>France</th>
<th>Slovenia</th>
<th>Norway</th>
<th>Sweden</th>
<th>Italy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Russian Federation 6hr+</td>
<td>540 (7.8)</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Lebanon</td>
<td>532 (3.1)</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>United States</td>
<td>485 (5.2)</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Russian Federation</td>
<td>485 (5.7)</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Portugal</td>
<td>482 (2.5)</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>France</td>
<td>463 (3.1)</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Slovenia</td>
<td>460 (3.4)</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Norway</td>
<td>459 (4.6)</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Sweden</td>
<td>431 (4.0)</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Italy</td>
<td>422 (5.3)</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

- Average achievement significantly higher than comparison country
- Average achievement significantly lower than comparison country

The Russian Federation 6hr+ results are for a subset of the Russian Federation students. This subset of students are in an intensive stream that have at least 6 hours of mathematics lessons per week.

Significance tests were not adjusted for multiple comparisons. Five percent of the comparisons would be statistically significant by chance alone.

(1) Standard errors appear in parentheses. Because of rounding some results may appear inconsistent.
### Exhibit M1.4: Differences in Advanced Mathematics Achievement Across Assessment Years

Instructions: Read across the row to determine if the performance in the row year is significantly higher (○) or significantly lower (●) than the performance in the column year.

<table>
<thead>
<tr>
<th>Country</th>
<th>2008 Average Scale Score</th>
<th>1995 Average Scale Score</th>
<th>Differences Between Years</th>
<th>Advanced Mathematics Achievement Distribution</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>France</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2015</td>
<td>21.5% 463 (3.1)</td>
<td>-107</td>
<td></td>
<td><img src="null" alt="Graph" /></td>
</tr>
<tr>
<td>1995</td>
<td>19.9% 569 (3.9)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Italy</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2015</td>
<td>24.3% 422 (5.3)</td>
<td>-27</td>
<td>-61</td>
<td><img src="null" alt="Graph" /></td>
</tr>
<tr>
<td>2008</td>
<td>19.7% 449 (7.2)</td>
<td>-34</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1995</td>
<td>14.1% 483 (9.8)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lebanon</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2015</td>
<td>3.9% 532 (3.1)</td>
<td>-13</td>
<td></td>
<td><img src="null" alt="Graph" /></td>
</tr>
<tr>
<td>2008</td>
<td>5.9% 545 (2.2)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Norway</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2015</td>
<td>10.6% 459 (4.6)</td>
<td>20</td>
<td>○</td>
<td><img src="null" alt="Graph" /></td>
</tr>
<tr>
<td>2008</td>
<td>10.9% 459 (4.9)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Russian Federation 6hr+</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2015</td>
<td>1.9% 540 (7.8)</td>
<td>-21</td>
<td>-9</td>
<td><img src="null" alt="Graph" /></td>
</tr>
<tr>
<td>2008</td>
<td>1.4% 561 (7.0)</td>
<td>12</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1995</td>
<td>2.0% 549 (8.2)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Slovenia</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2015</td>
<td>34.4% 468 (3.4)</td>
<td>2</td>
<td>-18</td>
<td><img src="null" alt="Graph" /></td>
</tr>
<tr>
<td>2008</td>
<td>40.3% 457 (4.3)</td>
<td>-20</td>
<td>●</td>
<td><img src="null" alt="Graph" /></td>
</tr>
<tr>
<td>1995</td>
<td>75.4% 478 (9.3)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sweden</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2015</td>
<td>14.1% 431 (4.0)</td>
<td>19</td>
<td>-71</td>
<td><img src="null" alt="Graph" /></td>
</tr>
<tr>
<td>2008</td>
<td>12.8% 412 (5.6)</td>
<td>-89</td>
<td>●</td>
<td><img src="null" alt="Graph" /></td>
</tr>
<tr>
<td>1995</td>
<td>16.2% 502 (5.2)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>United States</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2015</td>
<td>11.4% 485 (5.2)</td>
<td>-12</td>
<td></td>
<td><img src="null" alt="Graph" /></td>
</tr>
<tr>
<td>1995</td>
<td>6.4% 497 (7.4)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

---

* See Appendix MC.2 for a description of the Advanced Mathematics Coverage Index. Russian Federation trend results are available only for the Intensive stream students (6hr+). The United States adjusted the 1995 sample to correspond with the course-taking definitions used in 2015, and the 1995 results were recomputed.

See Appendix MC.1 for target population coverage notes 1, 2, and 3.

See Appendix MC.5 for sampling guidelines and sampling participation notes †, ‡, and ¶.

( ) Standard errors appear in parentheses. Because of rounding some results may appear inconsistent.
Russian Federation trend results are available only for the Intensive stream students (6hr+). The United States adjusted the 1995 sample to correspond with the course-taking definitions used in 2015, and the 1995 results were recomputed.
Exhibit M1.5: Relative Achievement of 2015 Advanced Mathematics Cohort at the Eighth and Fourth Grades*

Instructions: To compare relative achievement across grades as the cohort of students assessed at the fourth grade in 2007 moved to eighth grade four years later in 2011 and then to TIMSS Advanced in 2015, start in the upper-left hand panel and follow the darker green arrows pointing diagonally downwards.

**2007 - TIMSS Fourth Grade Mathematics**

<table>
<thead>
<tr>
<th>Country</th>
<th>Achievement Difference from TIMSS Scale Centerpoint (500)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Russian Federation</td>
<td>44 (4.9)</td>
</tr>
<tr>
<td>United States</td>
<td>29 (2.5)</td>
</tr>
<tr>
<td>Italy</td>
<td>7 (3.1)</td>
</tr>
<tr>
<td>Sweden</td>
<td>3 (2.6)</td>
</tr>
<tr>
<td>Slovenia</td>
<td>2 (1.8)</td>
</tr>
<tr>
<td>Norway (4)</td>
<td>-27 (2.6)</td>
</tr>
<tr>
<td>France</td>
<td>0</td>
</tr>
<tr>
<td>Lebanon</td>
<td>0</td>
</tr>
</tbody>
</table>

**2011 - TIMSS Fourth Grade Mathematics**

<table>
<thead>
<tr>
<th>Country</th>
<th>Achievement Difference from TIMSS Scale Centerpoint (500)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Russian Federation</td>
<td>42 (3.7)</td>
</tr>
<tr>
<td>United States</td>
<td>41 (1.9)</td>
</tr>
<tr>
<td>Slovenia</td>
<td>13 (2.1)</td>
</tr>
<tr>
<td>Italy</td>
<td>8 (2.6)</td>
</tr>
<tr>
<td>Sweden</td>
<td>4 (2.1)</td>
</tr>
<tr>
<td>Norway (4)</td>
<td>-5 (2.8)</td>
</tr>
<tr>
<td>France</td>
<td>0</td>
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<tr>
<td>Lebanon</td>
<td>0</td>
</tr>
</tbody>
</table>

**2015 - TIMSS Fourth Grade Mathematics**

<table>
<thead>
<tr>
<th>Country</th>
<th>Achievement Difference from TIMSS Scale Centerpoint (500)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Russian Federation</td>
<td>64 (3.4)</td>
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<tr>
<td>United States</td>
<td>39 (2.3)</td>
</tr>
<tr>
<td>Slovenia</td>
<td>20 (1.9)</td>
</tr>
<tr>
<td>Sweden</td>
<td>19 (2.8)</td>
</tr>
<tr>
<td>Italy</td>
<td>7 (2.6)</td>
</tr>
<tr>
<td>Norway (4)</td>
<td>-7 (2.3)</td>
</tr>
<tr>
<td>France</td>
<td>-12 (2.9)</td>
</tr>
<tr>
<td>Lebanon</td>
<td>0</td>
</tr>
</tbody>
</table>

**2007 - TIMSS Eighth Grade Mathematics**

<table>
<thead>
<tr>
<th>Country</th>
<th>Achievement Difference from TIMSS Scale Centerpoint (500)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Russian Federation</td>
<td>12 (4.0)</td>
</tr>
<tr>
<td>United States</td>
<td>8 (2.9)</td>
</tr>
<tr>
<td>Slovenia</td>
<td>1 (2.2)</td>
</tr>
<tr>
<td>Sweden</td>
<td>-9 (2.3)</td>
</tr>
<tr>
<td>Italy</td>
<td>-20 (3.1)</td>
</tr>
<tr>
<td>Norway (8)</td>
<td>-31 (2.0)</td>
</tr>
<tr>
<td>Lebanon</td>
<td>-51 (4.1)</td>
</tr>
<tr>
<td>France</td>
<td>0</td>
</tr>
</tbody>
</table>

**2011 - TIMSS Eighth Grade Mathematics**

<table>
<thead>
<tr>
<th>Country</th>
<th>Achievement Difference from TIMSS Scale Centerpoint (500)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Russian Federation</td>
<td>39 (3.6)</td>
</tr>
<tr>
<td>United States</td>
<td>9 (2.7)</td>
</tr>
<tr>
<td>Slovenia</td>
<td>5 (2.2)</td>
</tr>
<tr>
<td>Italy</td>
<td>-2 (2.3)</td>
</tr>
<tr>
<td>Sweden</td>
<td>-16 (1.9)</td>
</tr>
<tr>
<td>Norway (8)</td>
<td>-25 (2.5)</td>
</tr>
<tr>
<td>Lebanon</td>
<td>-51 (3.9)</td>
</tr>
<tr>
<td>France</td>
<td>0</td>
</tr>
</tbody>
</table>

**2015 - TIMSS Eighth Grade Mathematics**

<table>
<thead>
<tr>
<th>Country</th>
<th>Achievement Difference from TIMSS Scale Centerpoint (500)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Russian Federation</td>
<td>38 (4.7)</td>
</tr>
<tr>
<td>United States</td>
<td>18 (3.1)</td>
</tr>
<tr>
<td>Slovenia</td>
<td>16 (2.1)</td>
</tr>
<tr>
<td>Sweden</td>
<td>1 (2.8)</td>
</tr>
<tr>
<td>Italy</td>
<td>-6 (2.5)</td>
</tr>
<tr>
<td>Norway (8)</td>
<td>-13 (2.0)</td>
</tr>
<tr>
<td>Lebanon</td>
<td>-58 (3.6)</td>
</tr>
<tr>
<td>France</td>
<td>0</td>
</tr>
</tbody>
</table>

**2008 - TIMSS Advanced Advanced Mathematics**

<table>
<thead>
<tr>
<th>Country</th>
<th>Achievement Difference from TIMSS Scale Centerpoint (500)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Russian Federation 6hr+</td>
<td>61 (7.0)</td>
</tr>
<tr>
<td>Lebanon</td>
<td>45 (2.2)</td>
</tr>
<tr>
<td>Slovenia</td>
<td>-43 (4.3)</td>
</tr>
<tr>
<td>Italy</td>
<td>-51 (7.2)</td>
</tr>
<tr>
<td>Norway (8)</td>
<td>-61 (4.9)</td>
</tr>
<tr>
<td>Sweden</td>
<td>-80 (5.6)</td>
</tr>
<tr>
<td>France</td>
<td>0</td>
</tr>
<tr>
<td>Russian Federation</td>
<td>0</td>
</tr>
<tr>
<td>United States</td>
<td>0</td>
</tr>
</tbody>
</table>

**2015 - TIMSS Advanced Advanced Mathematics**

<table>
<thead>
<tr>
<th>Country</th>
<th>Achievement Difference from TIMSS Scale Centerpoint (500)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Russian Federation 6hr+</td>
<td>40 (7.8)</td>
</tr>
<tr>
<td>Lebanon</td>
<td>32 (3.1)</td>
</tr>
<tr>
<td>United States</td>
<td>-15 (3.2)</td>
</tr>
<tr>
<td>Russian Federation</td>
<td>-15 (3.7)</td>
</tr>
<tr>
<td>France</td>
<td>-31 (3.1)</td>
</tr>
<tr>
<td>Slovenia</td>
<td>-40 (3.4)</td>
</tr>
<tr>
<td>Norway (8)</td>
<td>-41 (4.6)</td>
</tr>
<tr>
<td>Sweden</td>
<td>-69 (4.0)</td>
</tr>
<tr>
<td>Italy</td>
<td>-78 (3.3)</td>
</tr>
</tbody>
</table>

- Country average significantly higher than the centerpoint of the TIMSS scale
- Country average significantly lower than the centerpoint of the TIMSS scale

The Russian Federation 6hr+ results are for a subset of the Russian Federation students. This subset of students are in an Intensive stream that have at least 6 hours of mathematics lessons per week.

Russian Federation trend results are available only for the Intensive stream students (6hr+). The United States adjusted the 1995 sample to correspond with the course-taking definitions used in 2015, and the 1995 results were recomputed.

A diamond (◊) indicates the country did not participate in this year’s assessment.

( ) Standard errors appear in parentheses. Because of rounding some results may appear inconsistent.

TIMSS 2011 data from: TIMSS 2011 International Results in Mathematics
TIMSS 2015 data from: TIMSS 2015 International Results in Mathematics
TIMSS Advanced 2008 data from: TIMSS Advanced 2008 International Report
### Exhibit M1.6: Advanced Mathematics Participation and Average Achievement by Gender

#### Participation in Advanced Mathematics by Gender

<table>
<thead>
<tr>
<th>Country</th>
<th>Females</th>
<th>Males</th>
<th>Absolute Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Slovenia</td>
<td>60 (1.1)</td>
<td>40 (1.1)</td>
<td></td>
</tr>
<tr>
<td>† Portugal</td>
<td>51 (1.2)</td>
<td>49 (1.2)</td>
<td></td>
</tr>
<tr>
<td>Russian Federation</td>
<td>50 (1.3)</td>
<td>50 (1.3)</td>
<td></td>
</tr>
<tr>
<td>‡ United States</td>
<td>49 (0.9)</td>
<td>51 (0.9)</td>
<td></td>
</tr>
<tr>
<td>France</td>
<td>47 (1.1)</td>
<td>53 (1.1)</td>
<td></td>
</tr>
<tr>
<td>Russian Federation 6hr+</td>
<td>46 (1.1)</td>
<td>54 (1.1)</td>
<td></td>
</tr>
<tr>
<td>Sweden</td>
<td>40 (1.2)</td>
<td>60 (1.2)</td>
<td></td>
</tr>
<tr>
<td>Norway</td>
<td>38 (1.4)</td>
<td>62 (1.4)</td>
<td></td>
</tr>
<tr>
<td>Italy</td>
<td>37 (1.3)</td>
<td>63 (1.3)</td>
<td></td>
</tr>
<tr>
<td>‡ Lebanon</td>
<td>36 (2.0)</td>
<td>64 (2.0)</td>
<td></td>
</tr>
</tbody>
</table>

#### Average Advanced Mathematics Achievement by Gender

<table>
<thead>
<tr>
<th>Country</th>
<th>Females</th>
<th>Males</th>
<th>Absolute Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Italy</td>
<td>427 (6.1)</td>
<td>419 (6.6)</td>
<td>8 (7.5)</td>
</tr>
<tr>
<td>‡ Lebanon</td>
<td>533 (4.8)</td>
<td>531 (3.9)</td>
<td>2 (6.1)</td>
</tr>
<tr>
<td>† Portugal</td>
<td>481 (3.0)</td>
<td>483 (3.1)</td>
<td>2 (3.6)</td>
</tr>
<tr>
<td>Russian Federation</td>
<td>480 (6.0)</td>
<td>489 (6.2)</td>
<td>9 (4.3)</td>
</tr>
<tr>
<td>Norway</td>
<td>453 (5.1)</td>
<td>463 (5.2)</td>
<td>10 (4.8)</td>
</tr>
<tr>
<td>Sweden</td>
<td>424 (5.1)</td>
<td>436 (4.6)</td>
<td>13 (5.3)</td>
</tr>
<tr>
<td>Russian Federation 6hr+</td>
<td>530 (9.0)</td>
<td>549 (7.5)</td>
<td>20 (5.2)</td>
</tr>
<tr>
<td>France</td>
<td>449 (3.1)</td>
<td>475 (3.4)</td>
<td>26 (2.8)</td>
</tr>
<tr>
<td>Slovenia</td>
<td>449 (3.5)</td>
<td>476 (4.9)</td>
<td>27 (4.7)</td>
</tr>
<tr>
<td>‡ United States</td>
<td>470 (5.3)</td>
<td>500 (6.4)</td>
<td>30 (5.8)</td>
</tr>
</tbody>
</table>

The Russian Federation 6hr+ results are for a subset of the Russian Federation students. This subset of students are in an Intensive stream that have at least 6 hours of mathematics lessons per week.

See Appendix MC.5 for sampling guidelines and sampling participation notes †, ‡, and ‡.

( ) Standard errors appear in parentheses. Because of rounding some results may appear inconsistent.
Exhibit M1.7: Differences in Advanced Mathematics Achievement by Gender Across Assessment Years

Instructions: Read across the row to determine if the performance in the row year is significantly higher (○) or significantly lower (▼) than the performance in the column year.

<table>
<thead>
<tr>
<th>Country</th>
<th>Females</th>
<th></th>
<th>Males</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Percent of Students</td>
<td>Average Scale Score</td>
<td>Differences Between Years</td>
<td>Percent of Students</td>
</tr>
<tr>
<td>France</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>2015</td>
<td>47 (1.1)</td>
<td>449 (3.1)</td>
<td>-112 ▼</td>
</tr>
<tr>
<td></td>
<td>1995</td>
<td>37 (2.0)</td>
<td>561 (4.8)</td>
<td>63 (2.0)</td>
</tr>
<tr>
<td>Italy</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>2015</td>
<td>37 (1.3)</td>
<td>427 (6.1)</td>
<td>-27 ▼</td>
</tr>
<tr>
<td></td>
<td>2008</td>
<td>34 (2.5)</td>
<td>454 (9.5)</td>
<td>-23</td>
</tr>
<tr>
<td></td>
<td>1995</td>
<td>39 (3.8)</td>
<td>477 (12.5)</td>
<td>61 (3.8)</td>
</tr>
<tr>
<td>Lebanon</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>2015</td>
<td>36 (2.0)</td>
<td>533 (4.8)</td>
<td>-21 ▼</td>
</tr>
<tr>
<td></td>
<td>2008</td>
<td>29 (1.6)</td>
<td>554 (3.1)</td>
<td>71 (1.6)</td>
</tr>
<tr>
<td></td>
<td>1995</td>
<td>38 (1.7)</td>
<td>434 (5.3)</td>
<td>62 (1.4)</td>
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<tr>
<td>Norway</td>
<td></td>
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<td></td>
</tr>
<tr>
<td></td>
<td>2015</td>
<td>38 (1.4)</td>
<td>453 (5.1)</td>
<td>19 ○</td>
</tr>
<tr>
<td></td>
<td>2008</td>
<td>38 (1.7)</td>
<td>434 (5.3)</td>
<td>62 (1.7)</td>
</tr>
<tr>
<td>Russian Federation 6hr+</td>
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<tr>
<td></td>
<td>2015</td>
<td>46 (1.1)</td>
<td>530 (9.0)</td>
<td>-21</td>
</tr>
<tr>
<td></td>
<td>2008</td>
<td>45 (1.8)</td>
<td>551 (7.5)</td>
<td>25 ○</td>
</tr>
<tr>
<td></td>
<td>1995</td>
<td>48 (2.4)</td>
<td>526 (9.1)</td>
<td>52 (2.4)</td>
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<tr>
<td>Slovenia</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>2015</td>
<td>60 (1.1)</td>
<td>449 (3.5)</td>
<td>1</td>
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<tr>
<td></td>
<td>2008</td>
<td>60 (1.8)</td>
<td>448 (5.3)</td>
<td>-21</td>
</tr>
<tr>
<td></td>
<td>1995</td>
<td>50 (4.2)</td>
<td>469 (11.4)</td>
<td>50 (4.2)</td>
</tr>
<tr>
<td>Sweden</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>2015</td>
<td>40 (1.2)</td>
<td>424 (5.1)</td>
<td>20 ○</td>
</tr>
<tr>
<td></td>
<td>2008</td>
<td>40 (2.1)</td>
<td>404 (6.6)</td>
<td>-88 ▼</td>
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<tr>
<td></td>
<td>1995</td>
<td>31 (3.5)</td>
<td>492 (4.8)</td>
<td>69 (3.5)</td>
</tr>
<tr>
<td>United States</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>2015</td>
<td>49 (0.9)</td>
<td>470 (5.3)</td>
<td>-16</td>
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<tr>
<td></td>
<td>1995</td>
<td>47 (3.2)</td>
<td>486 (10.1)</td>
<td>53 (3.2)</td>
</tr>
</tbody>
</table>

○ More recent year significantly higher
▼ More recent year significantly lower

Russian Federation trend results are available only for the Intensive stream students (6hr+). The United States adjusted the 1995 sample to correspond with the course-taking definitions used in 2015, and the 1995 results were recomputed.

See Appendix MC.5 for sampling guidelines and sampling participation notes †, ‡, and ¶.

( ) Standard errors appear in parentheses. Because of rounding some results may appear inconsistent.
Russian Federation trend results are available only for the Intensive stream students (6hr+). The United States adjusted the 1995 sample to correspond with the course-taking definitions used in 2015, and the 1995 results were recomputed.

Scale interval is 10 points for each country, but the part of the scale shown differs according to each country's average achievement.
CHAPTER M2: PERFORMANCE AT INTERNATIONAL BENCHMARKS

TIMSS ADVANCED 2015 INTERNATIONAL RESULTS IN ADVANCED MATHEMATICS AND PHYSICS
Students Struggle to Reach the TIMSS Advanced International Benchmarks

TIMSS Advanced describes achievement at three International Benchmarks along the scale: Advanced, High, and Intermediate. There was a range of results across countries, but on average the majority of students found the TIMSS Advanced mathematics assessment very difficult.

Percentage of Students Reaching Benchmarks (averaged across countries)

- **Advanced Benchmark (625)**
  - In the Russian Federation, Lebanon, and the United States 7-10% reached the Advanced Benchmark, but only 1-3% did in the other countries.
  - 2%

- **High Benchmark (550)**
  - Students can apply a broad range of mathematical concepts and procedures in algebra, calculus, geometry, and trigonometry to analyze and solve multi-step problems set in routine and non-routine contexts.
  - 14%

- **Intermediate Benchmark (475)**
  - Students demonstrate basic knowledge of concepts and procedures in algebra, calculus, and geometry to solve routine problems.
  - 43%

The surprisingly low percentages of students reaching the Intermediate Benchmark reflected substantial declines in 4 countries compared to 1995.

## Exhibit M2.1: Descriptions of the TIMSS Advanced 2015 International Benchmarks of Advanced Mathematics Achievement

### 625 Advanced International Benchmark

Students demonstrate thorough understanding of concepts, mastery of procedures, and mathematical reasoning skills. They can solve problems in complex contexts in algebra, calculus, geometry, and trigonometry.

In algebra, students can reason with functions to solve pure mathematical problems. They demonstrate facility with complex numbers and permutations and can find sums of algebraic and infinite geometric series.

In calculus, students demonstrate thorough understanding of continuity and differentiability. They can solve problems about optimization in different contexts and justify their solutions. They can use definite integrals to calculate the area between two curves.

Students use geometric reasoning to solve complex problems. They use properties of vectors to express relationships among vectors. They can use trigonometric properties including the sine and cosine rules to solve non-routine problems about geometric figures.

### 550 High International Benchmark

Students can apply a broad range of mathematical concepts and procedures in algebra, calculus, geometry, and trigonometry to analyze and solve multi-step problems set in routine and non-routine contexts.

Students can analyze and solve algebra problems, including problems set in a practical context. They can solve problems requiring interpretation of information related to functions and graphs of functions. They can determine a sum of an arithmetic sequence and solve quadratic and other inequalities. They can simplify logarithmic expressions and multiply complex numbers.

In calculus, students have a basic understanding of continuity and differentiability. They can analyze equations of functions and graphs of functions. They can relate the graphs of functions to graphs and signs of their first and second derivatives. Students show some conceptual understanding of definite integrals.

Students can use trigonometric properties to solve a variety of problems involving trigonometric functions and geometric figures. They can use the Cartesian plane to solve problems, identify a vector perpendicular to a given vector, and prove that a quadrilateral given in the coordinate system is a parallelogram.

### 475 Intermediate International Benchmark

Students demonstrate basic knowledge of concepts and procedures in algebra, calculus, and geometry to solve routine problems.

Students can apply and transform a formula to solve a word problem. They can determine a term in a geometric sequence and analyze a proposed solution of a simple logarithmic equation. They can recognize a graph of the absolute value of a function and identify and evaluate composite functions.

Students can find the derivative of exponential, trigonometric, and simple rational functions. They can find limits of rational and exponential functions. They can make connections between the sign of the derivative and the graph of a function.

Students can use knowledge of basic properties of geometric figures and the Pythagorean theorem to solve problems. They can add and subtract vectors in coordinate form.
**Exhibit M2.2: Performance at the International Benchmarks of Advanced Mathematics Achievement**

<table>
<thead>
<tr>
<th>Country</th>
<th>Percentages of Students Reaching International Benchmarks</th>
<th>Advanced Benchmark (625)</th>
<th>High Benchmark (550)</th>
<th>Intermediate Benchmark (475)</th>
<th>Advanced Mathematics Coverage Index*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Russian Federation 6hr+</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Russian Federation</td>
<td></td>
<td>20 (2.4)</td>
<td>48 (3.2)</td>
<td>75 (3.0)</td>
<td>1.9%</td>
</tr>
<tr>
<td>Lebanon</td>
<td></td>
<td>10 (1.1)</td>
<td>29 (1.9)</td>
<td>55 (2.3)</td>
<td>10.1%</td>
</tr>
<tr>
<td>United States</td>
<td></td>
<td>8 (1.0)</td>
<td>40 (2.7)</td>
<td>79 (1.8)</td>
<td>3.9%</td>
</tr>
<tr>
<td>Slovenia</td>
<td></td>
<td>7 (1.2)</td>
<td>26 (1.6)</td>
<td>56 (2.5)</td>
<td>11.4%</td>
</tr>
<tr>
<td>Italy</td>
<td></td>
<td>3 (0.5)</td>
<td>14 (1.2)</td>
<td>42 (1.7)</td>
<td>34.4%</td>
</tr>
<tr>
<td>Portugal</td>
<td></td>
<td>2 (0.5)</td>
<td>12 (1.0)</td>
<td>34 (1.7)</td>
<td>24.5%</td>
</tr>
<tr>
<td>Sweden</td>
<td></td>
<td>2 (0.5)</td>
<td>18 (1.1)</td>
<td>54 (1.7)</td>
<td>28.5%</td>
</tr>
<tr>
<td>France</td>
<td></td>
<td>2 (0.3)</td>
<td>11 (0.8)</td>
<td>34 (1.6)</td>
<td>14.1%</td>
</tr>
<tr>
<td>Norway</td>
<td></td>
<td>1 (0.3)</td>
<td>11 (1.0)</td>
<td>43 (1.7)</td>
<td>21.5%</td>
</tr>
<tr>
<td>International Median</td>
<td></td>
<td>1 (0.3)</td>
<td>10 (1.4)</td>
<td>41 (2.9)</td>
<td>10.6%</td>
</tr>
</tbody>
</table>

* See Appendix MC.2 for a description of the Advanced Mathematics Coverage Index.

† The Russian Federation 6hr+ results are for a subset of the Russian Federation students. This subset of students are in an Intensive stream that have at least 6 hours of mathematics lessons per week.

‡ See Appendix MC.5 for sampling guidelines and sampling participation notes †, †, and ‡.

( ) Standard errors appear in parentheses. Because of rounding some results may appear inconsistent.
### Exhibit M2.3: Percentages of Students Reaching the International Benchmarks of Advanced Mathematics Achievement Across Assessment Years

<table>
<thead>
<tr>
<th>Country</th>
<th>Advanced International Benchmark (625)</th>
<th>High International Benchmark (550)</th>
<th>Intermediate International Benchmark (475)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Percent of Students</td>
<td>Percent of Students</td>
<td>Percent of Students</td>
</tr>
<tr>
<td>Russian Federation 6hr+</td>
<td>20</td>
<td>24</td>
<td>22</td>
</tr>
<tr>
<td>Lebanon</td>
<td>8</td>
<td>9</td>
<td></td>
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<tr>
<td>United States</td>
<td>7</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>Slovenia</td>
<td>3</td>
<td>3</td>
<td>5</td>
</tr>
<tr>
<td>Italy</td>
<td>2</td>
<td>3</td>
<td>5</td>
</tr>
<tr>
<td>Sweden</td>
<td>2</td>
<td>1</td>
<td>6</td>
</tr>
<tr>
<td>France</td>
<td>1</td>
<td>15</td>
<td></td>
</tr>
<tr>
<td>Norway</td>
<td>1</td>
<td>1</td>
<td></td>
</tr>
</tbody>
</table>

*Source: IEA's Trends in International Mathematics and Science Study – TIMSS Advanced 2015*

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Russian Federation trend results are available only for the Intensive stream students (6hr+). The United States adjusted the 1995 sample to correspond with the course-taking definitions used in 2015, and the 1995 results were recomputed.
An empty cell indicates a country did not participate in that year’s assessment.
Summary

*Students demonstrate basic knowledge of concepts and procedures in algebra, calculus, and geometry to solve routine problems.*

Students can apply and transform a formula to solve a word problem. They can determine a term in a geometric sequence and analyze a proposed solution of a simple logarithmic equation. They can recognize a graph of the absolute value of a function and identify and evaluate composite functions.

Students can find the derivative of exponential, trigonometric, and simple rational functions. They can find limits of rational and exponential functions. They can make connections between the sign of the derivative and the graph of a function.

Students can use knowledge of basic properties of geometric figures and the Pythagorean theorem to solve problems. They can add and subtract vectors in coordinate form.
### Exhibit M2.4.1: Intermediate International Benchmark – Example Item 1

<table>
<thead>
<tr>
<th>Country</th>
<th>Percent Correct</th>
<th>Note</th>
</tr>
</thead>
<tbody>
<tr>
<td>Slovenia</td>
<td>88 (1.6)</td>
<td></td>
</tr>
<tr>
<td>† Portugal</td>
<td>86 (1.4)</td>
<td></td>
</tr>
<tr>
<td>Russian Federation 6hr+</td>
<td>84 (2.2)</td>
<td></td>
</tr>
<tr>
<td>Russian Federation</td>
<td>71 (2.2)</td>
<td></td>
</tr>
<tr>
<td>‡ Lebanon</td>
<td>70 (2.9)</td>
<td></td>
</tr>
<tr>
<td>International Avg.</td>
<td>65 (0.7)</td>
<td></td>
</tr>
<tr>
<td>France</td>
<td>62 (1.5)</td>
<td>▼</td>
</tr>
<tr>
<td>Italy</td>
<td>60 (2.5)</td>
<td>▼</td>
</tr>
<tr>
<td>Norway</td>
<td>54 (2.1)</td>
<td>▼</td>
</tr>
<tr>
<td>† United States</td>
<td>54 (2.5)</td>
<td>▼</td>
</tr>
<tr>
<td>Sweden</td>
<td>43 (2.8)</td>
<td>▼</td>
</tr>
</tbody>
</table>

**Content Domain: Algebra**

**Cognitive Domain: Knowing**

**Description:** Recognizes the graph of the absolute value of a function given the graph of the function.

The graph of \( y = f(x) \) is shown here.

Which one of the following graphs shows \( y = |f(x)| \)?

- ![Graph A](image1)
- ![Graph B](image2)
- ![Graph C](image3)
- ![Graph D](image4)

- ▼ Percent significantly lower than international average
- ○ Percent significantly higher than international average

The Russian Federation 6hr+ results are for a subset of the Russian Federation students. This subset of students are in an Intensive stream that have at least 6 hours of mathematics lessons per week.

See Appendix MC.5 for sampling guidelines and sampling participation notes †, ‡, and ‡.

( ) Standard errors appear in parentheses. Because of rounding some results may appear inconsistent.
### Exhibit M2.4.1: Intermediate International Benchmark – Example Item 1 (Continued)

<table>
<thead>
<tr>
<th>Country</th>
<th>Percent of Students Responding to Each Answer Option</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>A</td>
</tr>
<tr>
<td>Slovenia</td>
<td>88 (1.6)</td>
</tr>
<tr>
<td>† Portugal</td>
<td>86 (1.4)</td>
</tr>
<tr>
<td>Russian Federation 6hr+</td>
<td>84 (2.2)</td>
</tr>
<tr>
<td>Russian Federation</td>
<td>71 (2.2)</td>
</tr>
<tr>
<td>† Lebanon</td>
<td>70 (2.9)</td>
</tr>
<tr>
<td>France</td>
<td>62 (1.5)</td>
</tr>
<tr>
<td>Italy</td>
<td>60 (2.3)</td>
</tr>
<tr>
<td>Norway</td>
<td>54 (2.1)</td>
</tr>
<tr>
<td>† United States</td>
<td>54 (2.3)</td>
</tr>
<tr>
<td>Sweden</td>
<td>43 (2.8)</td>
</tr>
</tbody>
</table>

* No Response.

The Russian Federation 6hr+ results are for a subset of the Russian Federation students. This subset of students are in an Intensive stream that have at least 6 hours of mathematics lessons per week.

See Appendix MC.5 for sampling guidelines and sampling participation notes †, ‡, and ¶.

( ) Standard errors appear in parentheses. Because of rounding some results may appear inconsistent.
### Exhibit M2.4.2: Intermediate International Benchmark – Example Item 2

<table>
<thead>
<tr>
<th>Country</th>
<th>Percent Correct</th>
<th>Content Domain: Algebra</th>
</tr>
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<tbody>
<tr>
<td><strong>Cognitive Domain: Knowing</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Russian Federation 6hr+</td>
<td>79 (1.9)</td>
<td></td>
</tr>
<tr>
<td>Russian Federation</td>
<td>71 (1.8)</td>
<td></td>
</tr>
<tr>
<td>United States</td>
<td>61 (2.0)</td>
<td></td>
</tr>
<tr>
<td>Norway</td>
<td>59 (2.2)</td>
<td></td>
</tr>
<tr>
<td>Slovenia</td>
<td>57 (2.4)</td>
<td></td>
</tr>
<tr>
<td><strong>International Avg.</strong></td>
<td>50 (0.7)</td>
<td></td>
</tr>
<tr>
<td>Lebanon</td>
<td>47 (3.7)</td>
<td></td>
</tr>
<tr>
<td>† Portugal</td>
<td>45 (1.7)</td>
<td></td>
</tr>
<tr>
<td>Sweden</td>
<td>45 (1.3)</td>
<td></td>
</tr>
<tr>
<td>Italy</td>
<td>36 (1.8)</td>
<td></td>
</tr>
<tr>
<td>France</td>
<td>34 (1.4)</td>
<td></td>
</tr>
</tbody>
</table>

The Russian Federation 6hr+ results are for a subset of the Russian Federation students. This subset of students are in an Intensive stream that have at least 6 hours of mathematics lessons per week.

In the geometric sequence \(\frac{1}{3}, 1, 3, \ldots, t_n, \ldots\), where \(t_n\) is the \(n^{th}\) term, which term has a value of 243?

- A) \(t_6\)
- B) \(t_7\)
- C) \(t_8\)
- D) \(t_{61}\)

**Note:** Standard errors appear in parentheses. Because of rounding some results may appear inconsistent.
### Exhibit M2.4.2: Intermediate International Benchmark – Example Item 2 (Continued)

<table>
<thead>
<tr>
<th>Country</th>
<th>Percent of Students Responding to Each Answer Option</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>A</td>
</tr>
<tr>
<td>Russian Federation 6hr+</td>
<td>9 (1.1)</td>
</tr>
<tr>
<td>Russian Federation</td>
<td>11 (1.0)</td>
</tr>
<tr>
<td>United States</td>
<td>14 (1.4)</td>
</tr>
<tr>
<td>Norway</td>
<td>15 (1.3)</td>
</tr>
<tr>
<td>Slovenia</td>
<td>11 (1.0)</td>
</tr>
<tr>
<td>Lebanon</td>
<td>24 (2.7)</td>
</tr>
<tr>
<td>Portugal</td>
<td>10 (1.2)</td>
</tr>
<tr>
<td>Sweden</td>
<td>14 (1.0)</td>
</tr>
<tr>
<td>Italy</td>
<td>13 (1.4)</td>
</tr>
<tr>
<td>France</td>
<td>31 (1.5)</td>
</tr>
</tbody>
</table>

* No Response.

The Russian Federation 6hr+ results are for a subset of the Russian Federation students. This subset of students are in an Intensive stream that have at least 6 hours of mathematics lessons per week.

See Appendix MC.5 for sampling guidelines and sampling participation notes †, ‡, and ¶.

( ) Standard errors appear in parentheses. Because of rounding some results may appear inconsistent.
Exhibit M2.4.3: Intermediate International Benchmark – Example Item 3

<table>
<thead>
<tr>
<th>Country</th>
<th>Percent Correct</th>
</tr>
</thead>
<tbody>
<tr>
<td>France</td>
<td>80 (1.1)</td>
</tr>
<tr>
<td>Norway</td>
<td>79 (1.7)</td>
</tr>
<tr>
<td>Russian Federation 6hr+</td>
<td>77 (1.9)</td>
</tr>
<tr>
<td>Russian Federation</td>
<td>74 (1.7)</td>
</tr>
<tr>
<td>Lebanon</td>
<td>72 (2.6)</td>
</tr>
<tr>
<td>Portugal</td>
<td>71 (1.5)</td>
</tr>
<tr>
<td>International Avg.</td>
<td>62 (0.6)</td>
</tr>
<tr>
<td>United States</td>
<td>59 (2.6)</td>
</tr>
<tr>
<td>Slovenia</td>
<td>47 (1.7)</td>
</tr>
<tr>
<td>Sweden</td>
<td>37 (1.4)</td>
</tr>
<tr>
<td>Italy</td>
<td>37 (1.7)</td>
</tr>
</tbody>
</table>

Content Domain: Geometry
Cognitive Domain: Knowing
Description: Calculates the difference between vectors in coordinate form

Find the difference \( \vec{b} - \vec{a} \) of the vectors \( \vec{a} = \begin{pmatrix} 4 \\ 2 \end{pmatrix} \) and \( \vec{b} = \begin{pmatrix} 0 \\ 3 \end{pmatrix} \).

Options:
A. \( \begin{pmatrix} -4 \\ -2 \end{pmatrix} \)
B. \( \begin{pmatrix} -4 \\ 1 \end{pmatrix} \)
C. \( \begin{pmatrix} 4 \\ -1 \end{pmatrix} \)
D. \( \begin{pmatrix} 4 \\ 2 \end{pmatrix} \)
E. \( \begin{pmatrix} 4 \\ 5 \end{pmatrix} \)

The Russian Federation 6hr+ results are for a subset of the Russian Federation students. This subset of students are in an intensive stream that have at least 6 hours of mathematics lessons per week.

See Appendix M.C.5 for sampling guidelines and sampling participation notes †, ‡, and ¶.

( ) Standard errors appear in parentheses. Because of rounding some results may appear inconsistent.
### Exhibit M2.4.3: Intermediate International Benchmark – Example Item 3 (Continued)

<table>
<thead>
<tr>
<th>Country</th>
<th>Percent of Students Responding to Each Answer Option</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>A</td>
</tr>
<tr>
<td>France</td>
<td>1 (0.2)</td>
</tr>
<tr>
<td>Norway</td>
<td>1 (0.2)</td>
</tr>
<tr>
<td>Russian Federation 6hr+</td>
<td>1 (0.2)</td>
</tr>
<tr>
<td>Russian Federation</td>
<td>1 (0.3)</td>
</tr>
<tr>
<td>Lebanon</td>
<td>2 (1.1)</td>
</tr>
<tr>
<td>Portugal</td>
<td>1 (0.2)</td>
</tr>
<tr>
<td>United States</td>
<td>2 (0.7)</td>
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<tr>
<td>Slovenia</td>
<td>4 (0.7)</td>
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<tr>
<td>Sweden</td>
<td>4 (0.6)</td>
</tr>
<tr>
<td>Italy</td>
<td>3 (0.7)</td>
</tr>
</tbody>
</table>

* No Response.

The Russian Federation 6hr+ results are for a subset of the Russian Federation students. This subset of students are in an Intensive stream that have at least 6 hours of mathematics lessons per week.

See Appendix M.C.5 for sampling guidelines and sampling participation notes †, ‡, and ¶.

( ) Standard errors appear in parentheses. Because of rounding some results may appear inconsistent.
### Exhibit M2.4.4: Intermediate International Benchmark – Example Item 4

<table>
<thead>
<tr>
<th>Country</th>
<th>Percent Correct</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sweden</td>
<td>65 (1.3)</td>
</tr>
<tr>
<td>† Portugal</td>
<td>65 (1.7)</td>
</tr>
<tr>
<td>Norway</td>
<td>63 (1.7)</td>
</tr>
<tr>
<td><strong>Russian Federation 6hr+</strong></td>
<td>62 (2.9)</td>
</tr>
<tr>
<td>‡ Lebanon</td>
<td>61 (2.3)</td>
</tr>
<tr>
<td>Slovenia</td>
<td>59 (2.0)</td>
</tr>
<tr>
<td><strong>International Avg.</strong></td>
<td>58 (0.6)</td>
</tr>
<tr>
<td>† United States</td>
<td>58 (2.5)</td>
</tr>
<tr>
<td><strong>Russian Federation</strong></td>
<td>53 (2.1)</td>
</tr>
<tr>
<td>France</td>
<td>52 (1.5)</td>
</tr>
<tr>
<td>Italy</td>
<td>50 (1.8)</td>
</tr>
</tbody>
</table>

**Content Domain: Geometry**

**Cognitive Domain: Applying**

**Description:** Solves a word problem about height given the distance and angle of elevation

A lighthouse is located on the top of an islet. The base is 4 meters above sea level. A ship is located 170 m from the lighthouse. The angle between sea level and a straight line from the boat to the top of the lighthouse is equal to 10°. What is the height of the lighthouse to the nearest meter?

- (A) 22 m
- (B) 26 m
- (C) 30 m
- (D) 34 m

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See Appendix MC.5 for sampling guidelines and sampling participation notes †, ‡, and ¶.

(1) Standard errors appear in parentheses. Because of rounding some results may appear inconsistent.
<table>
<thead>
<tr>
<th>Country</th>
<th>Percent of Students Responding to Each Answer Option</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>A</td>
</tr>
<tr>
<td>Sweden</td>
<td>5 (0.7)</td>
</tr>
<tr>
<td>† Portugal</td>
<td>5 (0.6)</td>
</tr>
<tr>
<td>Norway</td>
<td>4 (0.8)</td>
</tr>
<tr>
<td>Russian Federation 6hr+</td>
<td>9 (1.3)</td>
</tr>
<tr>
<td>† Lebanon</td>
<td>2 (0.9)</td>
</tr>
<tr>
<td>Slovenia</td>
<td>4 (0.6)</td>
</tr>
<tr>
<td>† United States</td>
<td>5 (0.9)</td>
</tr>
<tr>
<td>Russian Federation</td>
<td>11 (1.0)</td>
</tr>
<tr>
<td>France</td>
<td>6 (0.7)</td>
</tr>
<tr>
<td>Italy</td>
<td>10 (1.0)</td>
</tr>
</tbody>
</table>

* No Response.

† The Russian Federation 6hr+ results are for a subset of the Russian Federation students. This subset of students are in an intensive stream that have at least 6 hours of mathematics lessons per week.

‡ See Appendix MC.5 for sampling guidelines and sampling participation notes †, ‡, and ¶.

§ Standard errors appear in parentheses. Because of rounding some results may appear inconsistent.
**Exhibit M2.5: Description of the TIMSS Advanced 2015 High International Benchmark (550) of Advanced Mathematics Achievement**

<table>
<thead>
<tr>
<th>550</th>
<th>High International Benchmark</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Summary</strong></td>
<td>Students can apply a broad range of mathematical concepts and procedures in algebra, calculus, geometry, and trigonometry to analyze and solve multi-step problems set in routine and non-routine contexts.</td>
</tr>
<tr>
<td></td>
<td>Students can analyze and solve algebra problems, including problems set in a practical context. They can solve problems requiring interpretation of information related to functions and graphs of functions. They can determine a sum of an arithmetic sequence and solve quadratic and other inequalities. They can simplify logarithmic expressions and multiply complex numbers.</td>
</tr>
<tr>
<td></td>
<td>In calculus, students have a basic understanding of continuity and differentiability. They can analyze equations of functions and graphs of functions. They can relate the graphs of functions to graphs and signs of their first and second derivatives. Students show some conceptual understanding of definite integrals.</td>
</tr>
<tr>
<td></td>
<td>Students can use trigonometric properties to solve a variety of problems involving trigonometric functions and geometric figures. They can use the Cartesian plane to solve problems, identify a vector perpendicular to a given vector, and prove that a quadrilateral given in the coordinate system is a parallelogram.</td>
</tr>
</tbody>
</table>
Exhibit M2.5.1: High International Benchmark – Example Item 1

<table>
<thead>
<tr>
<th>Country</th>
<th>Percent</th>
<th>Full Credit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lebanon</td>
<td>65 (3.3)</td>
<td>✶</td>
</tr>
<tr>
<td>Russian Federation 6hr+</td>
<td>58 (3.1)</td>
<td>✶</td>
</tr>
<tr>
<td>Russian Federation</td>
<td>41 (2.1)</td>
<td></td>
</tr>
<tr>
<td>Italy</td>
<td>36 (2.0)</td>
<td></td>
</tr>
<tr>
<td>Slovenia</td>
<td>34 (2.0)</td>
<td></td>
</tr>
<tr>
<td>International Avg.</td>
<td>33 (0.7)</td>
<td></td>
</tr>
<tr>
<td>Portugal</td>
<td>31 (1.6)</td>
<td></td>
</tr>
<tr>
<td>United States</td>
<td>26 (2.3)</td>
<td>✶</td>
</tr>
<tr>
<td>France</td>
<td>26 (1.4)</td>
<td>✶</td>
</tr>
<tr>
<td>Norway</td>
<td>22 (1.7)</td>
<td>✶</td>
</tr>
<tr>
<td>Sweden</td>
<td>18 (1.1)</td>
<td>✶</td>
</tr>
</tbody>
</table>

**Content Domain: Algebra**

**Cognitive Domain: Applying**

**Description:** Determines the values of two constants in a rational expression given its graph with two specified points.

The graph of the function \( f(x) = \frac{ax + 5}{x + b} \) is shown above. Find the values of \( a \) and \( b \).

\[
\begin{align*}
  a &= 5 \\
  b &= -3
\end{align*}
\]

The answer shown illustrates the type of response that would receive full credit (1 point). To receive 1 point, students indicated \( a = 5 \) and \( b = -3 \).

✶ Percent significantly higher than international average
✶ Percent significantly lower than international average

The Russian Federation 6hr+ results are for a subset of the Russian Federation students. This subset of students are in an intensive stream that have at least 6 hours of mathematics lessons per week.

See Appendix MC.5 for sampling guidelines and sampling participation notes †, ‡, and ¶.

( ) Standard errors appear in parentheses. Because of rounding some results may appear inconsistent.
### Exhibit M2.5.1: High International Benchmark – Example Item 1 (Continued)

**Scoring Guide**

<table>
<thead>
<tr>
<th>Code</th>
<th>Response</th>
<th>Item: MA33179</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>$a = 5$</td>
<td></td>
</tr>
<tr>
<td></td>
<td>$b = -3$</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Correct Response</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Incorrect Response</th>
<th>70</th>
<th>71</th>
<th>79</th>
<th>NR*</th>
</tr>
</thead>
<tbody>
<tr>
<td>$a = 5$ correct only</td>
<td>12 (2.7)</td>
<td>7 (1.7)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$b = -3$ correct only</td>
<td>14 (1.4)</td>
<td>16 (2.9)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other incorrect (including crossed out, erased, stray marks, illegible, or off task)</td>
<td>23 (1.7)</td>
<td>22 (1.6)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Country**

<table>
<thead>
<tr>
<th>Country</th>
<th>Correct Student Response</th>
<th>Incorrect Student Responses</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>10</td>
<td>70</td>
</tr>
<tr>
<td>Lebanon</td>
<td>65 (3.3)</td>
<td>16 (2.0)</td>
</tr>
<tr>
<td>Russian Federation 6hr+</td>
<td>58 (3.1)</td>
<td>12 (1.2)</td>
</tr>
<tr>
<td>Russian Federation</td>
<td>41 (2.1)</td>
<td>14 (1.4)</td>
</tr>
<tr>
<td>Italy</td>
<td>36 (2.0)</td>
<td>13 (1.2)</td>
</tr>
<tr>
<td>Slovenia</td>
<td>34 (2.0)</td>
<td>28 (2.5)</td>
</tr>
<tr>
<td>Portugal</td>
<td>31 (1.6)</td>
<td>20 (1.4)</td>
</tr>
<tr>
<td>United States</td>
<td>26 (2.3)</td>
<td>16 (1.4)</td>
</tr>
<tr>
<td>France</td>
<td>26 (1.4)</td>
<td>13 (0.9)</td>
</tr>
<tr>
<td>Norway</td>
<td>22 (1.7)</td>
<td>15 (1.0)</td>
</tr>
<tr>
<td>Sweden</td>
<td>18 (1.1)</td>
<td>12 (0.8)</td>
</tr>
</tbody>
</table>

* No Response.

The Russian Federation 6hr+ results are for a subset of the Russian Federation students. This subset of students are in an intensive stream that have at least 6 hours of mathematics lessons per week.

See Appendix MC.5 for sampling guidelines and sampling participation notes †, ‡, and ¶.

( ) Standard errors appear in parentheses. Because of rounding some results may appear inconsistent.
Exhibit M2.5.2: High International Benchmark – Example Item 2

<table>
<thead>
<tr>
<th>Country</th>
<th>Percent Full Credit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sweden</td>
<td>57 (1.4)</td>
</tr>
<tr>
<td>Russian Federation 6hr+</td>
<td>55 (3.0)</td>
</tr>
<tr>
<td>Norway</td>
<td>51 (2.0)</td>
</tr>
<tr>
<td>† Portugal</td>
<td>43 (1.7)</td>
</tr>
<tr>
<td>‡ United States</td>
<td>41 (2.4)</td>
</tr>
<tr>
<td>International Avg.</td>
<td>41 (0.7)</td>
</tr>
<tr>
<td>Russian Federation</td>
<td>39 (1.9)</td>
</tr>
<tr>
<td>‡ Lebanon</td>
<td>36 (2.7)</td>
</tr>
<tr>
<td>France</td>
<td>32 (1.6)</td>
</tr>
<tr>
<td>Slovenia</td>
<td>32 (1.8)</td>
</tr>
<tr>
<td>Italy</td>
<td>32 (1.9)</td>
</tr>
</tbody>
</table>

**Content Domain: Algebra**

**Cognitive Domain: Applying**

**Description:** Solves a word problem involving dimensions of two cylindrical containers given their volumes.

A manufacturer produces cylindrical cans with a diameter of 6 cm to hold 600 cm³ of soup. He wants to change the diameter of the cans, leaving the height unchanged so that they will hold 750 cm³ of soup. What will the new diameter be?

Show your work.

\[
V_1 = \pi r_1^2 h \quad V_2 = \pi r_2^2 h
\]

\[
\frac{V_1}{V_2} = \frac{\pi r_1^2 h}{\pi r_2^2 h}
\]

\[
r_2^2 = \frac{V_2}{V_1} \cdot r_1^2 = \frac{750}{600} \quad (3^2)
\]

\[
= \frac{5}{4} \quad (3^2)
\]

\[
= \frac{3\sqrt{5}}{2}
\]

New diameter = \(3\sqrt{5}\) cm

The answer shown illustrates the type of response that would receive full credit (2 points). To receive 2 points, student work included a mathematical expression equating the ratio of the volumes of the cylinders and the ratio of the product of their squared radii and heights, substitution of the relevant values, and the final answer.

- Percent significantly higher than international average
- Percent significantly lower than international average

The Russian Federation 6hr+ results are for a subset of the Russian Federation students. This subset of students are in an Intensive stream that have at least 6 hours of mathematics lessons per week.

See Appendix MC.5 for sampling guidelines and sampling participation notes †, ‡, and ¶.

( ) Standard errors appear in parentheses. Because of rounding some results may appear inconsistent.
**Exhibit M2.5.2: High International Benchmark – Example Item 2 (Continued)**

### Scoring Guide

<table>
<thead>
<tr>
<th>Code</th>
<th>Correct Response</th>
<th>Incorrect Student Responses</th>
</tr>
</thead>
<tbody>
<tr>
<td>20</td>
<td>Any of $3\sqrt[3]{5}$ cm, 6.72 cm, 6.7 cm, or other equivalent with correct work</td>
<td></td>
</tr>
<tr>
<td>21</td>
<td>An equation for finding the new diameter is correctly presented, followed by a statement about using the calculator to solve the equation, giving a correct answer</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Partially Correct Response</th>
<th>Incorrect Response</th>
<th>Nonresponse</th>
</tr>
</thead>
<tbody>
<tr>
<td>10 Correct method but numerical error</td>
<td>70 Calculator used—answer incorrect or explanation inadequate</td>
<td>NR No Response</td>
</tr>
<tr>
<td>11 A correct equation for finding the new diameter is given but there is a subsequent error</td>
<td>79 Other incorrect (including crossed out, erased, stray marks, illegible, or off task)</td>
<td></td>
</tr>
<tr>
<td>12 Code 10 or code 11, but using calculator</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Percent of Students in Each Scoring Guide Category

<table>
<thead>
<tr>
<th>Country</th>
<th>Correct Student Responses</th>
<th>Incorrect Student Responses</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Percent of Students</td>
<td></td>
</tr>
<tr>
<td></td>
<td>20</td>
<td>21</td>
</tr>
<tr>
<td>Sweden</td>
<td>57 (1.4)</td>
<td>0 (0.1)</td>
</tr>
<tr>
<td>Russian Federation 6hr+</td>
<td>54 (3.0)</td>
<td>1 (0.4)</td>
</tr>
<tr>
<td>Norway</td>
<td>51 (2.0)</td>
<td>0 (0.2)</td>
</tr>
<tr>
<td>Portugal</td>
<td>43 (1.7)</td>
<td>0 (0.1)</td>
</tr>
<tr>
<td>United States</td>
<td>40 (2.5)</td>
<td>1 (0.4)</td>
</tr>
<tr>
<td>Russian Federation</td>
<td>39 (1.9)</td>
<td>1 (0.4)</td>
</tr>
<tr>
<td>Lebanon</td>
<td>36 (2.7)</td>
<td>0 (0.0)</td>
</tr>
<tr>
<td>France</td>
<td>32 (1.6)</td>
<td>0 (0.0)</td>
</tr>
<tr>
<td>Slovenia</td>
<td>32 (1.8)</td>
<td>0 (0.0)</td>
</tr>
<tr>
<td>Italy</td>
<td>32 (1.9)</td>
<td>0 (0.0)</td>
</tr>
</tbody>
</table>

* No Response.

The Russian Federation 6hr+ results are for a subset of the Russian Federation students. This subset of students are in an intensive stream that have at least 6 hours of mathematics lessons per week.

See Appendix MC.5 for sampling guidelines and sampling participation notes †, ‡, and ¶.

( ) Standard errors appear in parentheses. Because of rounding some results may appear inconsistent.
Exhibit M2.5.3: High International Benchmark – Example Item 3

### Content Domain: Calculus

#### Cognitive Domain: Reasoning

Description: Identifies the graph of a function given the graph of its first derivative

The graph of the first derivative of the function $f$ is shown below.

Which graph best represents the function $f$?

![Graphs A, B, and C showing the function $f(x)$ and its derivative $f'(x)$]

- **A**
- **B**
- **C**

### Data

<table>
<thead>
<tr>
<th>Country</th>
<th>Percent Correct</th>
<th>Content Domain: Calculus</th>
</tr>
</thead>
<tbody>
<tr>
<td>Russian Federation 6hr+</td>
<td>69 (2.8)</td>
<td></td>
</tr>
<tr>
<td>Lebanon</td>
<td>60 (2.8)</td>
<td></td>
</tr>
<tr>
<td>United States</td>
<td>58 (2.8)</td>
<td></td>
</tr>
<tr>
<td>Russian Federation</td>
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<tr>
<td>Portugal</td>
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<td>Norway</td>
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<tr>
<td>France</td>
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</tr>
<tr>
<td>International Avg.</td>
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</tr>
<tr>
<td>Sweden</td>
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</tr>
<tr>
<td>Slovenia</td>
<td>34 (2.1)</td>
<td></td>
</tr>
<tr>
<td>Italy</td>
<td>32 (1.7)</td>
<td></td>
</tr>
</tbody>
</table>

- Percent significantly higher than international average
- Percent significantly lower than international average

The Russian Federation 6hr+ results are for a subset of the Russian Federation students. This subset of students are in an Intensive stream that have at least 6 hours of mathematics lessons per week.

See Appendix MC.5 for sampling guidelines and sampling participation notes †, ‡, and ¶.

Standard errors appear in parentheses. Because of rounding some results may appear inconsistent.
Exhibit M2.5.3: High International Benchmark – Example Item 3
(Continued)

<table>
<thead>
<tr>
<th>Country</th>
<th>Percent of Students Responding to Each Answer Option</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>A</td>
</tr>
<tr>
<td>Russian Federation 6hr+</td>
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</tr>
<tr>
<td>Lebanon</td>
<td>7 (1.5)</td>
</tr>
<tr>
<td>United States</td>
<td>9 (1.0)</td>
</tr>
<tr>
<td>Russian Federation</td>
<td>8 (1.0)</td>
</tr>
<tr>
<td>Portugal</td>
<td>7 (1.0)</td>
</tr>
<tr>
<td>Norway</td>
<td>11 (1.2)</td>
</tr>
<tr>
<td>France</td>
<td>9 (0.9)</td>
</tr>
<tr>
<td>Sweden</td>
<td>11 (1.1)</td>
</tr>
<tr>
<td>Slovenia</td>
<td>13 (1.2)</td>
</tr>
<tr>
<td>Italy</td>
<td>10 (1.1)</td>
</tr>
</tbody>
</table>

* No Response.
The Russian Federation 6hr+ results are for a subset of the Russian Federation students. This subset of students are in an Intensive stream that have at least 6 hours of mathematics lessons per week.
See Appendix MC.5 for sampling guidelines and sampling participation notes †, ‡, and ¶.
( ) Standard errors appear in parentheses. Because of rounding some results may appear inconsistent.
Exhibit M2.5.4: High International Benchmark – Example Item 4

<table>
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<tr>
<th>Country</th>
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</tr>
<tr>
<td>Lebanon</td>
<td>62 (3.4)</td>
</tr>
<tr>
<td>Russian Federation</td>
<td>59 (1.5)</td>
</tr>
<tr>
<td>United States</td>
<td>43 (2.7)</td>
</tr>
<tr>
<td>Italy</td>
<td>42 (2.0)</td>
</tr>
<tr>
<td>International Avg.</td>
<td>42 (0.7)</td>
</tr>
<tr>
<td>Slovenia</td>
<td>38 (1.5)</td>
</tr>
<tr>
<td>Norway</td>
<td>35 (1.6)</td>
</tr>
<tr>
<td>Sweden</td>
<td>34 (1.4)</td>
</tr>
<tr>
<td>Portugal</td>
<td>33 (1.4)</td>
</tr>
<tr>
<td>France</td>
<td>29 (1.4)</td>
</tr>
</tbody>
</table>

Content Domain: Geometry
Cognitive Domain: Applying
Description: Determines the ratio of the squares of two sides of a scalene triangle given two of its angles

What is the value of $\frac{a^2}{b^2}$?

- (A) $\frac{2}{3}$
- (B) $\frac{3}{2}$
- (C) $\frac{2}{\sqrt{3}}$
- (D) $\frac{\sqrt{2}}{\sqrt{3}}$

The Russian Federation 6hr+ results are for a subset of the Russian Federation students. This subset of students are in an intensive stream that have at least 6 hours of mathematics lessons per week.
See Appendix MC.5 for sampling guidelines and sampling participation notes †, ‡, and ¶.
( ) Standard errors appear in parentheses. Because of rounding some results may appear inconsistent.
### Exhibit M2.5.4: High International Benchmark – Example Item 4
(Continued)

<table>
<thead>
<tr>
<th>Country</th>
<th>Percent of Students Responding to Each Answer Option</th>
</tr>
</thead>
<tbody>
<tr>
<td>Russian Federation 6hr+</td>
<td>69 (2.5) 12 (1.4) 9 (1.3) 6 (0.9) 4 (0.9)</td>
</tr>
<tr>
<td>Lebanon</td>
<td>62 (3.4) 12 (1.9) 8 (1.9) 4 (1.2) 14 (2.2)</td>
</tr>
<tr>
<td>Russian Federation</td>
<td>59 (1.5) 16 (1.0) 11 (0.9) 10 (1.0) 4 (0.7)</td>
</tr>
<tr>
<td>United States</td>
<td>43 (2.7) 14 (1.3) 20 (1.9) 12 (1.6) 11 (2.5)</td>
</tr>
<tr>
<td>Italy</td>
<td>42 (2.0) 18 (1.3) 14 (1.5) 12 (1.2) 14 (1.2)</td>
</tr>
<tr>
<td>Slovenia</td>
<td>38 (1.5) 21 (1.5) 18 (1.4) 13 (1.2) 11 (1.0)</td>
</tr>
<tr>
<td>Norway</td>
<td>35 (1.6) 13 (1.3) 21 (1.7) 17 (1.2) 14 (1.0)</td>
</tr>
<tr>
<td>Sweden</td>
<td>34 (1.4) 14 (1.0) 21 (1.3) 19 (1.3) 12 (1.0)</td>
</tr>
<tr>
<td>Portugal</td>
<td>33 (1.4) 24 (1.2) 17 (1.4) 10 (1.2) 16 (1.1)</td>
</tr>
<tr>
<td>France</td>
<td>29 (1.4) 19 (1.2) 20 (1.3) 12 (0.9) 20 (1.3)</td>
</tr>
</tbody>
</table>

* No Response.

The Russian Federation 6hr+ results are for a subset of the Russian Federation students. This subset of students are in an intensive stream that have at least 6 hours of mathematics lessons per week.

See Appendix MC.5 for sampling guidelines and sampling participation notes †, ‡, and ¶.

( ) Standard errors appear in parentheses. Because of rounding some results may appear inconsistent.
**Exhibit M2.5.5: High International Benchmark – Example Item 5**

<table>
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<th>Percent</th>
<th>Full Credit</th>
</tr>
</thead>
<tbody>
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<td>Russian Federation 6hr+</td>
<td>52 (3.3)</td>
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</tr>
<tr>
<td>Lebanon</td>
<td>45 (3.2)</td>
<td>🟦</td>
</tr>
<tr>
<td>United States</td>
<td>36 (2.6)</td>
<td>🟦</td>
</tr>
<tr>
<td>Russian Federation</td>
<td>32 (1.9)</td>
<td>🟦</td>
</tr>
<tr>
<td>Portugal</td>
<td>30 (1.8)</td>
<td>🟦</td>
</tr>
<tr>
<td>Norway</td>
<td>28 (2.4)</td>
<td>🟦</td>
</tr>
<tr>
<td>International Avg.</td>
<td>27 (0.7)</td>
<td>🟦</td>
</tr>
<tr>
<td>Slovenia</td>
<td>20 (1.7)</td>
<td>🟦</td>
</tr>
<tr>
<td>Sweden</td>
<td>18 (1.0)</td>
<td>🟦</td>
</tr>
<tr>
<td>Italy</td>
<td>17 (1.6)</td>
<td>🟦</td>
</tr>
<tr>
<td>France</td>
<td>13 (1.0)</td>
<td>🟦</td>
</tr>
</tbody>
</table>

**Content Domain: Geometry**

**Cognitive Domain: Reasoning**

**Description:** Finds the maximum value of a trigonometric function and a value of the independent variable at which it occurs.

The number of animals in a certain population $P(t)$ varies periodically with time $t$. This can be modeled by

$$P(t) = 900 + 600 \sin\left(t + \frac{\pi}{3}\right)$$

What is the maximum number of animals?

Indicate one of the times at which the maximum occurs.

**Maximum number of animals:**

$$P(t) = \underline{1500}$$

**One time at which maximum occurs:**

$$t = \underline{\frac{\pi}{6}}$$

The answer shown illustrates the type of response that would receive full credit (2 points). To receive 2 points, students indicated both that the maximum number of animals is 1500 and that the time at which the maximum occurs is $\pi/6$ (or equivalent).

○ Percent significantly higher than international average

▼ Percent significantly lower than international average

The Russian Federation 6hr+ results are for a subset of the Russian Federation students. This subset of students are in an Intensive stream that have at least 6 hours of mathematics lessons per week.

See Appendix MC.5 for sampling guidelines and sampling participation notes 1, 4, and 3.

( ) Standard errors appear in parentheses. Because of rounding some results may appear inconsistent.
Exhibit M2.5.5: High International Benchmark – Example Item 5 (Continued)

Scoring Guide

<table>
<thead>
<tr>
<th>Code</th>
<th>Response</th>
<th>Item: MA33232</th>
</tr>
</thead>
<tbody>
<tr>
<td>20</td>
<td>$P(t) = 1500$ $i = \frac{\pi}{6}$ (or any other value of the type $\frac{\pi}{6} + 2k\pi$)</td>
<td></td>
</tr>
</tbody>
</table>

Partially Correct Response

| 10   | $P(t)$ correct only                          |               |
| 11   | $i$ correct only                             |               |

Incorrect Response

| 79   | Incorrect (including crossed out, erased, stray marks, illegible, or off task) |               |

Nonresponse

| NR   | No Response                                  |               |

<table>
<thead>
<tr>
<th>Country</th>
<th>Percent of Students in Each Scoring Guide Category</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Correct Student Responses</td>
</tr>
<tr>
<td>--------------------------------</td>
<td>---------------------------</td>
</tr>
<tr>
<td>Russian Federation 6hr+</td>
<td>52 (3.3)</td>
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<tr>
<td></td>
<td>2 (0.5)</td>
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<tr>
<td></td>
<td>28 (3.1)</td>
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<tr>
<td>Lebanon</td>
<td>45 (3.2)</td>
</tr>
<tr>
<td></td>
<td>2 (0.8)</td>
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<td></td>
<td>26 (2.2)</td>
</tr>
<tr>
<td>United States</td>
<td>36 (2.6)</td>
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<tr>
<td></td>
<td>6 (1.2)</td>
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<td></td>
<td>16 (1.7)</td>
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<td></td>
<td>3 (1.1)</td>
</tr>
<tr>
<td></td>
<td>30 (1.8)</td>
</tr>
<tr>
<td>Norway</td>
<td>28 (2.4)</td>
</tr>
<tr>
<td></td>
<td>2 (0.8)</td>
</tr>
<tr>
<td></td>
<td>27 (1.8)</td>
</tr>
<tr>
<td>Slovenia</td>
<td>20 (1.7)</td>
</tr>
<tr>
<td></td>
<td>2 (0.5)</td>
</tr>
<tr>
<td></td>
<td>40 (2.0)</td>
</tr>
<tr>
<td>Sweden</td>
<td>18 (1.0)</td>
</tr>
<tr>
<td></td>
<td>1 (0.2)</td>
</tr>
<tr>
<td></td>
<td>23 (1.5)</td>
</tr>
<tr>
<td>Italy</td>
<td>17 (1.6)</td>
</tr>
<tr>
<td></td>
<td>2 (0.6)</td>
</tr>
<tr>
<td></td>
<td>60 (2.1)</td>
</tr>
<tr>
<td>France</td>
<td>13 (1.0)</td>
</tr>
<tr>
<td></td>
<td>0 (0.2)</td>
</tr>
<tr>
<td></td>
<td>39 (1.5)</td>
</tr>
</tbody>
</table>

* No Response.

The Russian Federation 6hr+ results are for a subset of the Russian Federation students. This subset of students are in an intensive stream that have at least 6 hours of mathematics lessons per week.

See Appendix MC.5 for sampling guidelines and sampling participation notes †, ‡, and ¶.

( ) Standard errors appear in parentheses. Because of rounding some results may appear inconsistent.
Exhibit M2.6: Description of the TIMSS Advanced 2015 Advanced International Benchmark (625) of Advanced Mathematics Achievement

Summary

Students demonstrate thorough understanding of concepts, mastery of procedures, and mathematical reasoning skills. They can solve problems in complex contexts in algebra, calculus, geometry, and trigonometry.

In algebra, students can reason with functions to solve pure mathematical problems. They demonstrate facility with complex numbers and permutations and can find sums of algebraic and infinite geometric series.

In calculus, students demonstrate thorough understanding of continuity and differentiability. They can solve problems about optimization in different contexts and justify their solutions. They can use definite integrals to calculate the area between two curves.

Students use geometric reasoning to solve complex problems. They use properties of vectors to express relationships among vectors. They can use trigonometric properties including the sine and cosine rules to solve non-routine problems about geometric figures.
### Exhibit M2.6.1: Advanced International Benchmark – Example Item 1

**Content Domain: Algebra**

**Cognitive Domain: Applying**

Description: Determines the intersection of two functions in terms of an unknown, non-zero coefficient

---

<table>
<thead>
<tr>
<th>Country</th>
<th>Percent</th>
<th>Full Credit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Russian Federation 6hr+</td>
<td>50 (2.8)</td>
<td></td>
</tr>
<tr>
<td>† Lebanon</td>
<td>39 (2.6)</td>
<td></td>
</tr>
<tr>
<td>Russian Federation</td>
<td>35 (1.9)</td>
<td></td>
</tr>
<tr>
<td>Italy</td>
<td>29 (1.6)</td>
<td></td>
</tr>
<tr>
<td>Slovenia</td>
<td>26 (1.7)</td>
<td></td>
</tr>
<tr>
<td>International Avg.</td>
<td>20 (0.5)</td>
<td></td>
</tr>
<tr>
<td>† Portugal</td>
<td>13 (1.1)</td>
<td>v</td>
</tr>
<tr>
<td>Norway</td>
<td>11 (1.2)</td>
<td>v</td>
</tr>
<tr>
<td>Sweden</td>
<td>9 (1.1)</td>
<td>v</td>
</tr>
<tr>
<td>France</td>
<td>8 (1.0)</td>
<td>v</td>
</tr>
<tr>
<td>† United States</td>
<td>7 (1.0)</td>
<td>v</td>
</tr>
</tbody>
</table>

---

Let \( a \) be a non-zero constant. Find the two \( x \)-values where the graphs of

\[
y = 10^a x \quad \text{and} \quad y = \frac{x^2}{10^a}
\]

intersect.

Answer: \( x = 0 \), \( x = 10 \sqrt{a} \)

---

The answer shown illustrates the type of response that would receive full credit (2 points). To receive 2 points, students indicated that \( x = 0 \) and \( x = 10^{\sqrt{a}} \).

---

- **\( \circ \)** Percent significantly higher than international average
- **\( \triangledown \)** Percent significantly lower than international average

---

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See Appendix MC.5 for sampling guidelines and sampling participation notes †, ‡, and ¶.

( ) Standard errors appear in parentheses. Because of rounding some results may appear inconsistent.
**Exhibit M2.6.1: Advanced International Benchmark – Example Item 1 (Continued)**

### Scoring Guide

<table>
<thead>
<tr>
<th>Code</th>
<th>Response</th>
<th>Item: MA33121</th>
</tr>
</thead>
<tbody>
<tr>
<td>20</td>
<td>( x = 0 ) and ( x = 10^{12} a )</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Partially Correct Response</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>( x = 0 ) correct only</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>( x = 10^{12} a ) correct only</td>
<td></td>
</tr>
<tr>
<td>79</td>
<td>Incorrect (including crossed out, erased, stray marks, illegible, or off task)</td>
<td></td>
</tr>
<tr>
<td>NR</td>
<td>No Response</td>
<td></td>
</tr>
</tbody>
</table>

### Percent of Students in Each Scoring Guide Category

<table>
<thead>
<tr>
<th>Country</th>
<th>Correct Student Responses</th>
<th>Incorrect Student Responses</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>20</td>
<td>10</td>
</tr>
<tr>
<td>Russian Federation 6hr+</td>
<td>50</td>
<td>11</td>
</tr>
<tr>
<td>Lebanon</td>
<td>39</td>
<td>9</td>
</tr>
<tr>
<td>Russian Federation</td>
<td>35</td>
<td>13</td>
</tr>
<tr>
<td>Italy</td>
<td>29</td>
<td>8</td>
</tr>
<tr>
<td>Slovenia</td>
<td>26</td>
<td>9</td>
</tr>
<tr>
<td>Portugal</td>
<td>13</td>
<td>12</td>
</tr>
<tr>
<td>Norway</td>
<td>11</td>
<td>15</td>
</tr>
<tr>
<td>Sweden</td>
<td>9</td>
<td>10</td>
</tr>
<tr>
<td>France</td>
<td>8</td>
<td>11</td>
</tr>
<tr>
<td>United States</td>
<td>7</td>
<td>22</td>
</tr>
</tbody>
</table>

* NR* No Response.

The Russian Federation 6hr+ results are for a subset of the Russian Federation students. This subset of students are in an Intensive stream that have at least 6 hours of mathematics lessons per week.

See Appendix MC.5 for sampling guidelines and sampling participation notes 1, 4, and 3.

( ) Standard errors appear in parentheses. Because of rounding some results may appear inconsistent.
### Exhibit M2.6.2: Advanced International Benchmark – Example Item 2

<table>
<thead>
<tr>
<th>Country</th>
<th>Percent Correct</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Russian Federation</td>
<td>52 (2.4)</td>
<td>Maximizes the volume of a cylinder given a relationship between its height and diameter</td>
</tr>
<tr>
<td>Slovenia</td>
<td>35 (1.8)</td>
<td></td>
</tr>
<tr>
<td>United States</td>
<td>31 (1.9)</td>
<td></td>
</tr>
<tr>
<td>Sweden</td>
<td>31 (1.2)</td>
<td></td>
</tr>
<tr>
<td>International Avg.</td>
<td>30 (0.6)</td>
<td></td>
</tr>
<tr>
<td>Italy</td>
<td>29 (1.8)</td>
<td></td>
</tr>
<tr>
<td>Portugal</td>
<td>28 (1.6)</td>
<td></td>
</tr>
<tr>
<td>Norway</td>
<td>28 (1.6)</td>
<td></td>
</tr>
<tr>
<td>France</td>
<td>25 (1.3)</td>
<td></td>
</tr>
<tr>
<td>Lebanon</td>
<td>19 (1.7)</td>
<td></td>
</tr>
</tbody>
</table>

The intersection of a cylinder with a plane through its axis is a rectangle of perimeter 6 m. The radius of the cylinder satisfying this condition and having maximum volume is

- **A** 2.5 m
- **B** 2 m
- **C** 1.5 m
- **D** 1 m
- **E** 0.5 m

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( ) Standard errors appear in parentheses. Because of rounding some results may appear inconsistent.
Exhibit M2.6.2: Advanced International Benchmark – Example Item 2
(Continued)

<table>
<thead>
<tr>
<th>Country</th>
<th>Percent of Students Responding to Each Answer Option</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>A</td>
</tr>
<tr>
<td>Russian Federation 6hr+</td>
<td>9 (1.0)</td>
</tr>
<tr>
<td>Russian Federation</td>
<td>8 (0.9)</td>
</tr>
<tr>
<td>Slovenia</td>
<td>9 (1.1)</td>
</tr>
<tr>
<td>United States</td>
<td>10 (1.5)</td>
</tr>
<tr>
<td>Sweden</td>
<td>10 (1.1)</td>
</tr>
<tr>
<td>Italy</td>
<td>7 (1.0)</td>
</tr>
<tr>
<td>Portugal</td>
<td>6 (1.0)</td>
</tr>
<tr>
<td>Norway</td>
<td>10 (1.0)</td>
</tr>
<tr>
<td>France</td>
<td>13 (1.0)</td>
</tr>
<tr>
<td>Lebanon</td>
<td>15 (1.9)</td>
</tr>
</tbody>
</table>

* No Response.

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See Appendix MC.5 for sampling guidelines and sampling participation notes 1, 4, and 3.

( ) Standard errors appear in parentheses. Because of rounding some results may appear inconsistent.
## Exhibit M2.6.3: Advanced International Benchmark – Example Item 3

<table>
<thead>
<tr>
<th>Country</th>
<th>Percent</th>
<th>Full Credit</th>
</tr>
</thead>
<tbody>
<tr>
<td>United States</td>
<td>37 (2.8)</td>
<td>☑</td>
</tr>
<tr>
<td>Sweden</td>
<td>23 (1.3)</td>
<td>☑</td>
</tr>
<tr>
<td>Russian Federation 6hr+</td>
<td>22 (2.2)</td>
<td>☑</td>
</tr>
<tr>
<td>Lebanon</td>
<td>20 (2.8)</td>
<td></td>
</tr>
<tr>
<td>Norway</td>
<td>20 (2.3)</td>
<td></td>
</tr>
<tr>
<td>International Avg.</td>
<td>16 (0.6)</td>
<td></td>
</tr>
<tr>
<td>Russian Federation</td>
<td>16 (1.5)</td>
<td></td>
</tr>
<tr>
<td>Slovenia</td>
<td>15 (1.2)</td>
<td></td>
</tr>
<tr>
<td>France</td>
<td>7 (0.8)</td>
<td>☑</td>
</tr>
<tr>
<td>Italy</td>
<td>6 (1.0)</td>
<td>☑</td>
</tr>
<tr>
<td>Portugal</td>
<td>1 (0.3)</td>
<td>☑</td>
</tr>
</tbody>
</table>

### Content Domain: Calculus

### Cognitive Domain: Applying

**Description:** Calculates the area between the graphs of a linear and a quadratic function

###What is the area enclosed by the graphs of functions $y = x^2$ and $y = 5x - 4$?

**Show your work.**

\[
\begin{align*}
A &= \int_{x=1}^{x=4} (5x - 4 - x^2) \, dx \\
A &= \left[ 5x^2 - 4x - \frac{x^3}{3} \right]_1^4 \\
A &= \left( 80 - 16 - \frac{64}{3} \right) - \left( 5 - 4 - \frac{1}{3} \right) \\
A &= \frac{9}{2}
\end{align*}
\]

The answer shown illustrates the type of response that would receive full credit (2 points). To receive 2 points, student work showed the subtraction of the definite integrals from $x = 1$ to $x = 4$ of $5x - 4$ and $x^2$, respectively, and the final answer.

- ☑ Percent significantly higher than international average
- ☑ Percent significantly lower than international average

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### Exhibit M2.6.3: Advanced International Benchmark – Example Item 3 (Continued)

#### Scoring Guide

<table>
<thead>
<tr>
<th>Code</th>
<th>Correct Response</th>
<th>Item: MA23043</th>
</tr>
</thead>
<tbody>
<tr>
<td>20</td>
<td>Integrations and subtraction shown correctly to give area of $\frac{1}{2} + \frac{9}{2} = 4.5$, or equivalent</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Note: No need to explicitly show how points of intersection of the two functions was determined</td>
<td></td>
</tr>
<tr>
<td>21</td>
<td>Correct solution by use of calculator. Calculator use is described in examples</td>
<td></td>
</tr>
</tbody>
</table>

#### Partially Correct Response

<table>
<thead>
<tr>
<th>Code</th>
<th>Correct method with computation error</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>Correct method using calculator but correct answer not given</td>
</tr>
<tr>
<td>11</td>
<td>$-\frac{1}{2}$ or equivalent with correct method shown</td>
</tr>
</tbody>
</table>

#### Incorrect Response

<table>
<thead>
<tr>
<th>Code</th>
<th>Correct method with computation error</th>
</tr>
</thead>
<tbody>
<tr>
<td>70</td>
<td>Calculator used—answer incorrect or explanation inadequate</td>
</tr>
<tr>
<td>79</td>
<td>Other incorrect (including crossed out, erased, stray marks, illegible, or off task)</td>
</tr>
</tbody>
</table>

#### Nonresponse

<table>
<thead>
<tr>
<th>Code</th>
<th>Correct method with computation error</th>
</tr>
</thead>
<tbody>
<tr>
<td>NR</td>
<td>No Response</td>
</tr>
</tbody>
</table>

#### Percent of Students in Each Scoring Guide Category

<table>
<thead>
<tr>
<th>Country</th>
<th>Correct Student Responses</th>
<th>Incorrect Student Responses</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>20</td>
<td>21</td>
</tr>
<tr>
<td>United States</td>
<td>24</td>
<td>14</td>
</tr>
<tr>
<td>Sweden</td>
<td>16</td>
<td>6</td>
</tr>
<tr>
<td>Russian Federation 6hr+</td>
<td>22</td>
<td>0</td>
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<tr>
<td>Lebanon</td>
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<td>1</td>
</tr>
<tr>
<td>Norway</td>
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<td>4</td>
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<tr>
<td>Russian Federation</td>
<td>16</td>
<td>0</td>
</tr>
<tr>
<td>Slovenia</td>
<td>15</td>
<td>0</td>
</tr>
<tr>
<td>France</td>
<td>5</td>
<td>1</td>
</tr>
<tr>
<td>Italy</td>
<td>6</td>
<td>0</td>
</tr>
<tr>
<td>Portugal</td>
<td>0</td>
<td>1</td>
</tr>
</tbody>
</table>

* NR* No Response.

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**Exhibit M2.6.4: Advanced International Benchmark – Example Item 4**

<table>
<thead>
<tr>
<th>Country</th>
<th>Percent Correct</th>
</tr>
</thead>
<tbody>
<tr>
<td>Russian Federation 6hr+</td>
<td>56 (2.7)</td>
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<tr>
<td>Russian Federation</td>
<td>45 (1.9)</td>
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<tr>
<td>Slovenia</td>
<td>43 (2.2)</td>
</tr>
<tr>
<td>Sweden</td>
<td>41 (1.6)</td>
</tr>
<tr>
<td>Norway</td>
<td>40 (2.2)</td>
</tr>
<tr>
<td>Portugal</td>
<td>39 (2.0)</td>
</tr>
<tr>
<td>United States</td>
<td>39 (2.1)</td>
</tr>
<tr>
<td>International Avg.</td>
<td>39 (0.7)</td>
</tr>
<tr>
<td>France</td>
<td>34 (1.6)</td>
</tr>
<tr>
<td>Italy</td>
<td>34 (2.0)</td>
</tr>
<tr>
<td>Lebanon</td>
<td>32 (2.2)</td>
</tr>
</tbody>
</table>

**Content Domain: Geometry**

**Cognitive Domain: Knowing**

**Description:** Uses properties of vectors to analyze equivalence of conditions involving the sum and difference of two vectors.

- If $\vec{a} = \vec{0}$ and $\vec{b} \neq \vec{0}$, which of the following is equivalent to the equation $|\vec{a} + \vec{b}| = |\vec{a} - \vec{b}|$?

  - **A** $|\vec{a}| = |\vec{b}|$
  - **B** $\vec{a}$ and $\vec{b}$ are parallel vectors.
  - **C** $\vec{a}$ and $\vec{b}$ are perpendicular vectors.
  - **D** $\vec{a} + \vec{b} = \vec{0}$

---

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### Exhibit M2.6.4: Advanced International Benchmark – Example Item 4 (Continued)

<table>
<thead>
<tr>
<th>Country</th>
<th>Percent of Students Responding to Each Answer Option</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>A</td>
</tr>
<tr>
<td>Russian Federation 6hr+</td>
<td>9 (1.4)</td>
</tr>
<tr>
<td>Russian Federation</td>
<td>11 (1.0)</td>
</tr>
<tr>
<td>Slovenia</td>
<td>10 (1.0)</td>
</tr>
<tr>
<td>Sweden</td>
<td>11 (0.9)</td>
</tr>
<tr>
<td>Norway</td>
<td>10 (0.9)</td>
</tr>
<tr>
<td>† Portugal</td>
<td>11 (1.2)</td>
</tr>
<tr>
<td>† United States</td>
<td>9 (1.1)</td>
</tr>
<tr>
<td>France</td>
<td>14 (1.0)</td>
</tr>
<tr>
<td>Italy</td>
<td>14 (1.3)</td>
</tr>
<tr>
<td>† Lebanon</td>
<td>13 (2.1)</td>
</tr>
</tbody>
</table>

* No Response.

The Russian Federation 6hr+ results are for a subset of the Russian Federation students. This subset of students are in an Intensive stream that have at least 6 hours of mathematics lessons per week.

See Appendix MC.5 for sampling guidelines and sampling participation notes †, ‡, and ¶.

( ) Standard errors appear in parentheses. Because of rounding some results may appear inconsistent.
CHAPTER M3: ACHIEVEMENT IN CONTENT AND COGNITIVE DOMAINS

TIMSS ADVANCED 2015 INTERNATIONAL RESULTS IN ADVANCED MATHEMATICS AND PHYSICS
Achievement by Content Domains

Within mathematics, TIMSS Advanced provided results for three content domains—Algebra, Calculus, and Geometry. Each country demonstrated strengths in one or two content domains compared to mathematics achievement overall, and weaknesses in one or two content domains.

**Algebra**
- **Relative Strength**
  - 4 Countries: Russian Federation, Portugal, France, and Slovenia
  - 4 Countries: Norway, Sweden, and Italy

**Calculus**
- **Relative Strength**
  - 5 Countries: Lebanon, the United States, Norway, Sweden, and Italy
  - 3 Countries: Russian Federation, Portugal, and Slovenia

**Geometry**
- **Relative Strength**
  - 2 Countries: Russian Federation and Norway
  - 6 Countries: Lebanon, the United States, Portugal, France, Slovenia, and Italy

Achievement differences in content domains by gender reflect males’ higher achievement in 6 countries in mathematics overall.

**Achievement by Cognitive Domains**

TIMSS Advanced provided results for three cognitive domains—Knowing, Applying, and Reasoning. Although there was some balance in achievement across cognitive domains, most countries had at least one strength and one weakness compared to mathematics achievement overall.

**Knowing**
- **Relative Strength**
  - 3 Countries: Lebanon, France, and Slovenia
  - 3 Countries: Russian Federation, Norway, and Sweden

**Applying**
- **Relative Strength**
  - 2 Countries: Russian Federation and Slovenia
  - 3 Countries: The United States, Portugal, and France

**Reasoning**
- **Relative Strength**
  - 3 Countries: Portugal, Norway, and Sweden
  - 3 Countries: Lebanon, Slovenia, and Italy

Besides reflecting males’ higher achievement in 6 countries in mathematics overall, achievement differences in the cognitive domains by gender show a male advantage, especially in Reasoning.

**Differences reflected in Achievement by Gender**

Achievement differences in content domains by gender reflect males’ higher achievement in 6 countries in mathematics overall.

**Achievement by Gender**

Number of Countries where Males had higher achievement than Females: 5
Number of Countries where Females had higher achievement than Males: 0

Algebra: 5
Calculus: 0
Geometry: 6
<table>
<thead>
<tr>
<th>Country</th>
<th>Overall Advanced Mathematics Average Scale Score</th>
<th>Average Scale Score</th>
<th>Difference from Overall Advanced Mathematics Score</th>
<th>Average Scale Score</th>
<th>Difference from Overall Advanced Mathematics Score</th>
<th>Average Scale Score</th>
<th>Difference from Overall Advanced Mathematics Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Russian Federation 6hr+</td>
<td>540 (7.8)</td>
<td>556 (9.0)</td>
<td>16 (3.9)</td>
<td>513 (8.0)</td>
<td>-27 (2.3)</td>
<td>560 (8.4)</td>
<td>20 (3.2)</td>
</tr>
<tr>
<td>† Lebanon</td>
<td>532 (3.1)</td>
<td>525 (4.0)</td>
<td>-6 (3.6)</td>
<td>544 (3.9)</td>
<td>12 (2.8)</td>
<td>526 (3.7)</td>
<td>-6 (2.3)</td>
</tr>
<tr>
<td>† United States</td>
<td>485 (5.2)</td>
<td>478 (5.0)</td>
<td>-7 (1.7)</td>
<td>504 (6.0)</td>
<td>19 (2.9)</td>
<td>455 (5.7)</td>
<td>-30 (2.6)</td>
</tr>
<tr>
<td>Russian Federation</td>
<td>485 (5.7)</td>
<td>495 (6.3)</td>
<td>10 (1.9)</td>
<td>459 (5.9)</td>
<td>-26 (1.2)</td>
<td>500 (5.8)</td>
<td>15 (1.0)</td>
</tr>
<tr>
<td>† Portugal</td>
<td>482 (2.5)</td>
<td>495 (2.7)</td>
<td>12 (1.5)</td>
<td>476 (2.6)</td>
<td>-6 (1.4)</td>
<td>464 (3.2)</td>
<td>-18 (1.5)</td>
</tr>
<tr>
<td>France</td>
<td>463 (3.1)</td>
<td>469 (2.9)</td>
<td>7 (1.8)</td>
<td>466 (3.2)</td>
<td>3 (1.8)</td>
<td>441 (3.7)</td>
<td>-22 (1.3)</td>
</tr>
<tr>
<td>Slovenia</td>
<td>460 (3.4)</td>
<td>474 (3.5)</td>
<td>14 (1.1)</td>
<td>437 (4.4)</td>
<td>-23 (2.0)</td>
<td>456 (4.0)</td>
<td>-4 (1.4)</td>
</tr>
<tr>
<td>Norway</td>
<td>459 (4.6)</td>
<td>446 (4.1)</td>
<td>-13 (1.6)</td>
<td>463 (5.3)</td>
<td>4 (1.5)</td>
<td>473 (4.6)</td>
<td>14 (2.0)</td>
</tr>
<tr>
<td>Sweden</td>
<td>431 (4.0)</td>
<td>422 (4.1)</td>
<td>-9 (1.2)</td>
<td>438 (3.9)</td>
<td>7 (1.5)</td>
<td>430 (3.7)</td>
<td>-1 (1.4)</td>
</tr>
<tr>
<td>Italy</td>
<td>422 (5.3)</td>
<td>414 (5.1)</td>
<td>-8 (2.2)</td>
<td>433 (5.2)</td>
<td>11 (2.7)</td>
<td>413 (5.7)</td>
<td>-9 (3.2)</td>
</tr>
</tbody>
</table>

¢ Subscale score significantly higher than overall mathematics score
 cupid Subscale score significantly lower than overall mathematics score

The Russian Federation 6hr+ results are for a subset of the Russian Federation students. This subset of students are in an intensive stream that have at least 6 hours of mathematics lessons per week.

See Appendix MC.5 for sampling guidelines and sampling participation notes †, ‡, and ¶.

(1) Standard errors appear in parentheses. Because of rounding some results may appear inconsistent.
### Exhibit M3.2: Achievement in Advanced Mathematics Content Domains by Gender

<table>
<thead>
<tr>
<th>Country</th>
<th>Algebra Females</th>
<th>Algebra Males</th>
<th>Calculus Females</th>
<th>Calculus Males</th>
<th>Geometry Females</th>
<th>Geometry Males</th>
</tr>
</thead>
<tbody>
<tr>
<td>Russian Federation 6hr+</td>
<td>544 (10.3)</td>
<td>567 (8.5)</td>
<td>504 (9.3)</td>
<td>521 (7.6)</td>
<td>548 (9.2)</td>
<td>571 (8.2)</td>
</tr>
<tr>
<td>Lebanon</td>
<td>525 (6.1)</td>
<td>526 (4.1)</td>
<td>548 (5.1)</td>
<td>542 (4.5)</td>
<td>523 (7.2)</td>
<td>527 (3.9)</td>
</tr>
<tr>
<td>United States</td>
<td>466 (5.2)</td>
<td>490 (6.8)</td>
<td>492 (6.4)</td>
<td>517 (7.6)</td>
<td>435 (6.2)</td>
<td>474 (6.5)</td>
</tr>
<tr>
<td>Russian Federation</td>
<td>489 (6.5)</td>
<td>501 (6.7)</td>
<td>456 (6.3)</td>
<td>462 (6.3)</td>
<td>492 (6.1)</td>
<td>507 (6.2)</td>
</tr>
<tr>
<td>Portugal</td>
<td>494 (3.0)</td>
<td>495 (3.4)</td>
<td>477 (3.5)</td>
<td>474 (3.8)</td>
<td>457 (4.2)</td>
<td>471 (3.9)</td>
</tr>
<tr>
<td>France</td>
<td>455 (3.4)</td>
<td>482 (3.5)</td>
<td>453 (3.5)</td>
<td>478 (3.6)</td>
<td>426 (4.2)</td>
<td>454 (3.8)</td>
</tr>
<tr>
<td>Slovenia</td>
<td>464 (3.6)</td>
<td>487 (4.9)</td>
<td>425 (4.8)</td>
<td>454 (5.7)</td>
<td>441 (4.4)</td>
<td>478 (5.3)</td>
</tr>
<tr>
<td>Norway</td>
<td>443 (4.5)</td>
<td>449 (5.1)</td>
<td>457 (6.1)</td>
<td>467 (6.0)</td>
<td>466 (5.4)</td>
<td>477 (6.0)</td>
</tr>
<tr>
<td>Sweden</td>
<td>413 (4.7)</td>
<td>428 (4.7)</td>
<td>435 (5.0)</td>
<td>440 (4.7)</td>
<td>421 (4.4)</td>
<td>436 (4.3)</td>
</tr>
<tr>
<td>Italy</td>
<td>420 (6.1)</td>
<td>411 (6.7)</td>
<td>439 (6.1)</td>
<td>429 (6.7)</td>
<td>413 (7.6)</td>
<td>413 (6.7)</td>
</tr>
<tr>
<td>International Avg.</td>
<td>463 (1.6)</td>
<td>474 (1.8)</td>
<td>465 (1.8)</td>
<td>474 (1.9)</td>
<td>453 (1.9)</td>
<td>471 (1.8)</td>
</tr>
</tbody>
</table>

- Average significantly higher than other gender

The Russian Federation 6hr+ results are for a subset of the Russian Federation students. This subset of students are in an Intensive stream that have at least 6 hours of mathematics lessons per week.

See Appendix MC.5 for sampling guidelines and sampling participation notes †, ‡, and ¶.

(1) Standard errors appear in parentheses. Because of rounding some results may appear inconsistent.
### Exhibit M3.3: Achievement in Advanced Mathematics Cognitive Domains

<table>
<thead>
<tr>
<th>Country</th>
<th>Overall Advanced Mathematics Average Scale Score</th>
<th>Knowing (32 items)</th>
<th>Applying (40 items)</th>
<th>Reasoning (29 items)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Average Scale Score</td>
<td>Difference from Overall Advanced Mathematics Score</td>
<td>Average Scale Score</td>
<td>Difference from Overall Advanced Mathematics Score</td>
</tr>
<tr>
<td>Russian Federation 6hr+</td>
<td>540 (7.8)</td>
<td>538 (8.8) -2 (2.0)</td>
<td>544 (8.1) 4 (2.0)</td>
<td>541 (7.2) 1 (2.1)</td>
</tr>
<tr>
<td>Lebanon</td>
<td>532 (3.1)</td>
<td>543 (4.5) 11 (2.9)</td>
<td>529 (3.8) -3 (2.8)</td>
<td>527 (3.9) -5 (2.2)</td>
</tr>
<tr>
<td>United States</td>
<td>485 (5.2)</td>
<td>488 (5.7) 3 (2.3)</td>
<td>480 (5.5) -5 (2.0)</td>
<td>484 (5.3) -1 (2.2)</td>
</tr>
<tr>
<td>Russian Federation</td>
<td>485 (5.7)</td>
<td>478 (6.7) -7 (1.7)</td>
<td>491 (6.1) 6 (1.7)</td>
<td>484 (5.3) -1 (1.2)</td>
</tr>
<tr>
<td>Portugal</td>
<td>482 (2.5)</td>
<td>479 (3.0) -3 (1.6)</td>
<td>476 (2.9) -6 (1.8)</td>
<td>488 (3.5) 6 (2.2)</td>
</tr>
<tr>
<td>France</td>
<td>463 (3.1)</td>
<td>475 (2.7) 13 (2.0)</td>
<td>449 (3.4) -14 (1.5)</td>
<td>462 (3.1) 0 (0.9)</td>
</tr>
<tr>
<td>Slovenia</td>
<td>460 (3.4)</td>
<td>466 (3.5) 6 (1.7)</td>
<td>465 (4.0) 5 (2.1)</td>
<td>442 (4.0) -17 (1.6)</td>
</tr>
<tr>
<td>Norway</td>
<td>459 (4.6)</td>
<td>445 (4.1) -14 (1.8)</td>
<td>459 (5.1) 0 (2.0)</td>
<td>469 (4.4) 9 (1.4)</td>
</tr>
<tr>
<td>Sweden</td>
<td>431 (4.0)</td>
<td>405 (4.7) -26 (1.4)</td>
<td>434 (3.6) 3 (1.5)</td>
<td>447 (3.9) 16 (2.0)</td>
</tr>
<tr>
<td>Italy</td>
<td>422 (5.3)</td>
<td>423 (5.5) 1 (1.9)</td>
<td>425 (5.4) 3 (2.2)</td>
<td>411 (5.9) -11 (3.1)</td>
</tr>
</tbody>
</table>

The Russian Federation 6hr+ results are for a subset of the Russian Federation students. This subset of students are in an Intensive stream that have at least 6 hours of mathematics lessons per week.

See Appendix MC.5 for sampling guidelines and sampling participation notes 1, 4, and 6.

( ) Standard errors appear in parentheses. Because of rounding some results may appear inconsistent.

---

SOURCE: IEA’s Trends in International Mathematics and Science Study – TIMSS Advanced 2015
### Exhibit M3.4: Achievement in Advanced Mathematics Cognitive Domains by Gender

<table>
<thead>
<tr>
<th>Country</th>
<th>Knowing</th>
<th></th>
<th>Applying</th>
<th></th>
<th>Reasoning</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Females</td>
<td>Males</td>
<td>Females</td>
<td>Males</td>
<td>Females</td>
<td>Males</td>
</tr>
<tr>
<td>Russian Federation 6hr+</td>
<td>527 (10.0)</td>
<td>547 (8.6)</td>
<td>535 (9.4)</td>
<td>552 (7.7)</td>
<td>530 (8.1)</td>
<td>550 (7.1)</td>
</tr>
<tr>
<td>Lebanon</td>
<td>540 (7.2)</td>
<td>544 (4.4)</td>
<td>534 (5.1)</td>
<td>527 (4.9)</td>
<td>525 (6.1)</td>
<td>527 (4.2)</td>
</tr>
<tr>
<td>United States</td>
<td>474 (6.1)</td>
<td>502 (7.0)</td>
<td>468 (5.7)</td>
<td>491 (6.6)</td>
<td>468 (5.7)</td>
<td>501 (6.6)</td>
</tr>
<tr>
<td>Russian Federation</td>
<td>474 (7.3)</td>
<td>482 (7.0)</td>
<td>487 (6.7)</td>
<td>495 (6.4)</td>
<td>478 (5.5)</td>
<td>490 (5.9)</td>
</tr>
<tr>
<td>Portugal</td>
<td>480 (3.4)</td>
<td>479 (3.5)</td>
<td>475 (3.4)</td>
<td>476 (3.3)</td>
<td>485 (4.0)</td>
<td>491 (3.9)</td>
</tr>
<tr>
<td>France</td>
<td>465 (2.9)</td>
<td>485 (3.3)</td>
<td>434 (3.7)</td>
<td>463 (4.0)</td>
<td>446 (3.6)</td>
<td>477 (3.7)</td>
</tr>
<tr>
<td>Slovenia</td>
<td>456 (3.8)</td>
<td>481 (4.9)</td>
<td>455 (3.3)</td>
<td>480 (6.8)</td>
<td>428 (4.9)</td>
<td>464 (5.8)</td>
</tr>
<tr>
<td>Norway</td>
<td>439 (5.3)</td>
<td>449 (5.2)</td>
<td>456 (6.4)</td>
<td>461 (5.7)</td>
<td>461 (4.9)</td>
<td>473 (5.2)</td>
</tr>
<tr>
<td>Sweden</td>
<td>395 (5.7)</td>
<td>412 (5.3)</td>
<td>429 (4.5)</td>
<td>437 (4.9)</td>
<td>438 (5.5)</td>
<td>453 (4.0)</td>
</tr>
<tr>
<td>Italy</td>
<td>431 (5.9)</td>
<td>418 (7.0)</td>
<td>431 (6.3)</td>
<td>422 (6.6)</td>
<td>410 (7.2)</td>
<td>412 (7.4)</td>
</tr>
<tr>
<td>International Avg.</td>
<td>461 (1.8)</td>
<td>472 (1.8)</td>
<td>463 (1.7)</td>
<td>472 (1.9)</td>
<td>460 (1.8)</td>
<td>476 (1.8)</td>
</tr>
</tbody>
</table>

The Russian Federation 6hr+ results are for a subset of the Russian Federation students. This subset of students are in an Intensive stream that have at least 6 hours of mathematics lessons per week.

See Appendix MC.5 for sampling guidelines and sampling participation notes †, ‡, and ¶.

( ) Standard errors appear in parentheses. Because of rounding some results may appear inconsistent.
Students’ Plans for Future Study
Nearly all the Advanced Mathematics students planned to continue their education after finishing secondary school and the vast majority intend to obtain advanced degrees.

Higher percentages of the Females taking advanced mathematics than of the Males expect to obtain an advanced degree.

69% of students expect to obtain an advanced degree

The most popular areas of future study included:

- Engineering/Technology: 37%
- Biological/Biomedical: 27%

Education trailed behind (8%) as a future area of study.

Students’ Plans for Future Professions
Students who studied advanced mathematics in secondary school reported considering a number of professions.

A career in Engineering/Technology was the most popular choice, being considered by 60% on average. More than 40% on average also considered Computer Science, Biological/Biomedical, Education, and Finance.

In every country, more Males were considering the professions of Engineering/Technology and Computer Science.

More Females were considering Biological/Biomedical (7 countries), Environmental Science (5 countries), and Education (6 countries).

### Exhibit M4.1: Home Educational Resources

**Reported by Advanced Mathematics Students**

Students were scored according to their responses concerning the availability of four home resources on the *Home Educational Resources* scale. Students with **Many Resources** had a score of at least 11.6, which is the point on the scale corresponding to students reporting that they had more than 100 books in the home, both of the home study supports, and that at least one parent had finished university and that at least one parent was a professional, on average. Students with **Few Resources** had a score no higher than 6.0, which is the scale point corresponding to students reporting that they had 25 or fewer books in the home, neither of the home study supports, and that neither parent had gone beyond upper-secondary education and that neither parent was a small business owner or had a clerical or professional occupation, on average. All other students were assigned to the **Some Resources** category.

<table>
<thead>
<tr>
<th>Country</th>
<th>Many Resources</th>
<th>Some Resources</th>
<th>Few Resources</th>
<th>Average Scale Score</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Percent of Students</td>
<td>Average Achievement</td>
<td>Percent of Students</td>
<td>Average Achievement</td>
</tr>
<tr>
<td>Norway</td>
<td>49 (2.3)</td>
<td>476 (4.1)</td>
<td>50 (2.1)</td>
<td>444 (4.9)</td>
</tr>
<tr>
<td>Sweden</td>
<td>40 (1.5)</td>
<td>464 (4.7)</td>
<td>58 (1.4)</td>
<td>410 (4.4)</td>
</tr>
<tr>
<td>United States</td>
<td>35 (1.9)</td>
<td>511 (6.5)</td>
<td>62 (1.8)</td>
<td>474 (5.4)</td>
</tr>
<tr>
<td>Russian Federation 6hr+</td>
<td>30 (1.6)</td>
<td>567 (6.7)</td>
<td>70 (1.6)</td>
<td>529 (9.4)</td>
</tr>
<tr>
<td>France</td>
<td>28 (1.1)</td>
<td>493 (3.7)</td>
<td>71 (1.1)</td>
<td>452 (3.2)</td>
</tr>
<tr>
<td>Slovenia</td>
<td>23 (1.1)</td>
<td>489 (6.1)</td>
<td>77 (1.1)</td>
<td>452 (3.6)</td>
</tr>
<tr>
<td>Portugal</td>
<td>20 (1.1)</td>
<td>513 (3.5)</td>
<td>73 (1.1)</td>
<td>476 (2.6)</td>
</tr>
<tr>
<td>Russian Federation</td>
<td>20 (1.0)</td>
<td>514 (5.2)</td>
<td>80 (1.0)</td>
<td>477 (6.2)</td>
</tr>
<tr>
<td>Italy</td>
<td>16 (1.0)</td>
<td>471 (8.3)</td>
<td>79 (1.0)</td>
<td>416 (5.5)</td>
</tr>
<tr>
<td>Lebanon</td>
<td>8 (0.8)</td>
<td>546 (13.9)</td>
<td>82 (1.2)</td>
<td>535 (3.1)</td>
</tr>
<tr>
<td>International Avg.</td>
<td>27 (0.5)</td>
<td>497 (2.3)</td>
<td>70 (0.5)</td>
<td>460 (1.5)</td>
</tr>
</tbody>
</table>

The Russian Federation 6hr+ results are for a subset of the Russian Federation students. This subset of students are in an intensive stream that have at least 6 hours of mathematics lessons per week.

This TIMSS Advanced questionnaire scale was established in 2015 based on the combined response distribution of all countries that participated in TIMSS Advanced 2015. To provide a point of reference for country comparisons, the scale centerpoint of 10 was located at the mean of the combined distribution. The units of the scale were chosen so that 2 scale score points corresponded to the standard deviation of the distribution.

( ) Standard errors appear in parentheses. Because of rounding some results may appear inconsistent.

A tilde (~) indicates insufficient data to report achievement.
## Exhibit M4.2: Students Working at a Paid Job on a Regular Basis During the School Year

**Reported by Advanced Mathematics Students**

<table>
<thead>
<tr>
<th>Country</th>
<th>Time Spent Working at a Paid Job per Week</th>
<th>No Time</th>
<th>Less than 5 Hours</th>
<th>5 to 10 Hours</th>
<th>More than 10 Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Percent of Students</td>
<td>Average Achievement</td>
<td>Percent of Students</td>
<td>Average Achievement</td>
<td>Percent of Students</td>
</tr>
<tr>
<td>France</td>
<td>96 (0.3)</td>
<td>463 (3.1)</td>
<td>2 (0.2)</td>
<td>~ ~</td>
<td>1 (0.2)</td>
</tr>
<tr>
<td>Italy</td>
<td>91 (0.8)</td>
<td>423 (5.3)</td>
<td>3 (0.4)</td>
<td>440 (13.3)</td>
<td>4 (0.4)</td>
</tr>
<tr>
<td>Lebanon</td>
<td>92 (1.1)</td>
<td>536 (3.5)</td>
<td>2 (0.5)</td>
<td>~ ~</td>
<td>2 (0.5)</td>
</tr>
<tr>
<td>Norway</td>
<td>47 (1.7)</td>
<td>467 (5.2)</td>
<td>13 (1.0)</td>
<td>467 (5.9)</td>
<td>23 (1.2)</td>
</tr>
<tr>
<td>Portugal</td>
<td>93 (0.5)</td>
<td>485 (2.5)</td>
<td>2 (0.3)</td>
<td>~ ~</td>
<td>3 (0.3)</td>
</tr>
<tr>
<td>Russian Federation</td>
<td>93 (0.4)</td>
<td>487 (5.7)</td>
<td>2 (0.2)</td>
<td>~ ~</td>
<td>2 (0.2)</td>
</tr>
<tr>
<td>Russian Federation 6hr+</td>
<td>93 (0.6)</td>
<td>541 (7.7)</td>
<td>2 (0.4)</td>
<td>~ ~</td>
<td>2 (0.3)</td>
</tr>
<tr>
<td>Slovenia</td>
<td>81 (0.8)</td>
<td>467 (3.2)</td>
<td>7 (0.5)</td>
<td>449 (8.0)</td>
<td>7 (0.5)</td>
</tr>
<tr>
<td>Sweden</td>
<td>71 (1.3)</td>
<td>430 (4.4)</td>
<td>11 (0.7)</td>
<td>450 (6.4)</td>
<td>13 (0.8)</td>
</tr>
<tr>
<td>United States</td>
<td>65 (1.8)</td>
<td>491 (6.4)</td>
<td>4 (0.5)</td>
<td>473 (15.4)</td>
<td>10 (1.0)</td>
</tr>
<tr>
<td>International Avg.</td>
<td>81 (0.4)</td>
<td>472 (1.5)</td>
<td>5 (0.2)</td>
<td>456 (4.7)</td>
<td>7 (0.2)</td>
</tr>
</tbody>
</table>

The Russian Federation 6hr+ results are for a subset of the Russian Federation students. This subset of students are in an intensive stream that have at least 6 hours of mathematics lessons per week.

( ) Standard errors appear in parentheses. Because of rounding some results may appear inconsistent.

A tilde (~) indicates insufficient data to report achievement.
### Exhibit M4.3: Students Speak the Language of the Test at Home

**Reported by Advanced Mathematics Students**

<table>
<thead>
<tr>
<th>Country</th>
<th>Always</th>
<th></th>
<th></th>
<th>Sometimes</th>
<th></th>
<th></th>
<th>Never</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Percent of Students</td>
<td>Average Achievement</td>
<td>Percent of Students</td>
<td>Average Achievement</td>
<td>Percent of Students</td>
<td>Average Achievement</td>
<td>Percent of Students</td>
</tr>
<tr>
<td>France</td>
<td>89 (0.9)</td>
<td>465 (2.9)</td>
<td>8 (0.7)</td>
<td>446 (7.4)</td>
<td>2 (0.3)</td>
<td>~ ~</td>
<td>1 (0.2)</td>
</tr>
<tr>
<td>Italy</td>
<td>72 (1.4)</td>
<td>439 (4.9)</td>
<td>19 (1.2)</td>
<td>386 (8.2)</td>
<td>7 (0.7)</td>
<td>345 (15.1)</td>
<td>1 (0.5)</td>
</tr>
<tr>
<td>Lebanon</td>
<td>5 (0.7)</td>
<td>527 (12.6)</td>
<td>12 (1.2)</td>
<td>540 (7.8)</td>
<td>65 (1.7)</td>
<td>529 (3.7)</td>
<td>19 (1.6)</td>
</tr>
<tr>
<td>Norway</td>
<td>85 (1.4)</td>
<td>462 (4.7)</td>
<td>9 (1.0)</td>
<td>449 (8.5)</td>
<td>4 (0.5)</td>
<td>433 (7.5)</td>
<td>2 (0.4)</td>
</tr>
<tr>
<td>Portugal</td>
<td>91 (0.6)</td>
<td>483 (2.6)</td>
<td>7 (0.5)</td>
<td>478 (5.5)</td>
<td>2 (0.2)</td>
<td>~ ~</td>
<td>0 (0.1)</td>
</tr>
<tr>
<td>Russian Federation</td>
<td>86 (1.2)</td>
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<tr>
<td>Russian Federation 6hr+</td>
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<td>540 (8.4)</td>
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<td>547 (8.5)</td>
<td>2 (0.3)</td>
<td>~ ~</td>
<td>0 (0.1)</td>
</tr>
<tr>
<td>Slovenia</td>
<td>88 (0.7)</td>
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<td>9 (0.7)</td>
<td>454 (8.0)</td>
<td>2 (0.3)</td>
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<td>1 (0.2)</td>
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<tr>
<td>Sweden</td>
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<td>463 (12.0)</td>
<td>3 (0.9)</td>
</tr>
<tr>
<td>International Avg.</td>
<td>74 (0.4)</td>
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<td>458 (2.8)</td>
<td>11 (0.3)</td>
<td>428 (4.8)</td>
<td>3 (0.2)</td>
</tr>
</tbody>
</table>

The Russian Federation 6hr+ results are for a subset of the Russian Federation students. This subset of students are in an Intensive stream that have at least 6 hours of mathematics lessons per week.

(*) Standard errors appear in parentheses. Because of rounding some results may appear inconsistent.

A tilde (~) indicates insufficient data to report achievement.

SOURCE: IEA’s Trends in International Mathematics and Science Study – TIMSS Advanced 2015
### Exhibit M4.4: Students’ Expectations for Further Education

**Reported by Advanced Mathematics Students**

<table>
<thead>
<tr>
<th>Country</th>
<th>Doctoral Degree</th>
<th>Master’s Degree</th>
<th>Bachelor’s Degree</th>
<th>Post-Secondary Education but Not Bachelor’s Degree</th>
<th>Upper-Secondary Education</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Percent of Students</td>
<td>Average Achievement</td>
<td>Percent of Students</td>
<td>Average Achievement</td>
<td>Percent of Students</td>
</tr>
<tr>
<td>Lebanon</td>
<td>58 (2.1)</td>
<td>538 (3.9)</td>
<td>35 (2.0)</td>
<td>530 (4.3)</td>
<td>4 (0.6)</td>
</tr>
<tr>
<td>Portugal</td>
<td>24 (0.9)</td>
<td>504 (3.2)</td>
<td>47 (0.9)</td>
<td>495 (3.0)</td>
<td>23 (0.8)</td>
</tr>
<tr>
<td>United States</td>
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<td>494 (5.2)</td>
<td>27 (1.3)</td>
</tr>
<tr>
<td>France</td>
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<td>476 (3.9)</td>
<td>54 (1.0)</td>
<td>475 (3.3)</td>
<td>13 (0.8)</td>
</tr>
<tr>
<td>Slovenia</td>
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<td>499 (6.3)</td>
<td>48 (1.0)</td>
<td>469 (3.2)</td>
<td>22 (1.1)</td>
</tr>
<tr>
<td>Italy</td>
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<td>19 (0.9)</td>
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<td>586 (10.4)</td>
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<td>25 (1.2)</td>
</tr>
<tr>
<td>Sweden</td>
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<tr>
<td>Russian Federation</td>
<td>8 (0.6)</td>
<td>529 (9.9)</td>
<td>58 (1.1)</td>
<td>492 (5.4)</td>
<td>31 (1.0)</td>
</tr>
<tr>
<td>Norway</td>
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<td>495 (5.6)</td>
<td>70 (1.7)</td>
<td>469 (4.8)</td>
<td>40 (1.5)</td>
</tr>
<tr>
<td>International Avg.</td>
<td>20 (0.4)</td>
<td>493 (2.4)</td>
<td>49 (0.4)</td>
<td>479 (1.5)</td>
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</table>

**Students’ Expectations for Further Education by Gender**

**Reported by Advanced Mathematics Students**

<table>
<thead>
<tr>
<th>Country</th>
<th>Doctoral Degree</th>
<th>Master’s Degree</th>
<th>Bachelor’s Degree</th>
<th>Post-Secondary Education but Not Bachelor’s Degree</th>
<th>Upper-Secondary Education</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Percent of Females</td>
<td>Percent of Males</td>
<td>Percent of Females</td>
<td>Percent of Males</td>
<td>Percent of Females</td>
</tr>
<tr>
<td>Lebanon</td>
<td>65 (3.7)</td>
<td>54 (2.3)</td>
<td>32 (3.6)</td>
<td>37 (2.2)</td>
<td>3 (0.8)</td>
</tr>
<tr>
<td>Portugal</td>
<td>27 (1.3)</td>
<td>21 (1.3)</td>
<td>49 (1.3)</td>
<td>45 (1.2)</td>
<td>21 (1.1)</td>
</tr>
<tr>
<td>United States</td>
<td>25 (2.1)</td>
<td>21 (1.6)</td>
<td>51 (2.1)</td>
<td>48 (2.9)</td>
<td>24 (1.6)</td>
</tr>
<tr>
<td>France</td>
<td>26 (1.2)</td>
<td>16 (1.0)</td>
<td>47 (1.3)</td>
<td>60 (1.2)</td>
<td>13 (1.0)</td>
</tr>
<tr>
<td>Slovenia</td>
<td>17 (1.6)</td>
<td>19 (1.7)</td>
<td>53 (1.5)</td>
<td>40 (1.4)</td>
<td>21 (1.4)</td>
</tr>
<tr>
<td>Italy</td>
<td>13 (1.2)</td>
<td>14 (0.9)</td>
<td>26 (1.4)</td>
<td>15 (1.0)</td>
<td>44 (1.6)</td>
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<tr>
<td>Russian Federation 6hr+</td>
<td>10 (1.0)</td>
<td>15 (2.0)</td>
<td>64 (1.5)</td>
<td>60 (1.9)</td>
<td>26 (1.7)</td>
</tr>
<tr>
<td>Sweden</td>
<td>10 (1.1)</td>
<td>7 (0.6)</td>
<td>63 (1.6)</td>
<td>59 (1.4)</td>
<td>25 (1.5)</td>
</tr>
<tr>
<td>Russian Federation</td>
<td>7 (0.7)</td>
<td>9 (0.8)</td>
<td>59 (1.4)</td>
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<td>31 (1.2)</td>
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<tr>
<td>Norway</td>
<td>8 (0.8)</td>
<td>8 (1.1)</td>
<td>75 (1.6)</td>
<td>67 (2.1)</td>
<td>17 (1.5)</td>
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<tr>
<td>International Avg.</td>
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<td>19 (0.5)</td>
<td>50 (0.6)</td>
<td>47 (0.6)</td>
<td>22 (0.4)</td>
</tr>
</tbody>
</table>

- Percent significantly higher than other gender

---

The Russian Federation 6hr+ results are for a subset of the Russian Federation students. This subset of students are in an intensive stream that have at least 6 hours of mathematics lessons per week.

( ) Standard errors appear in parentheses. Because of rounding some results may appear inconsistent.

A tilde (~) indicates insufficient data to report achievement.
### Exhibit M4.5: Intended Areas of Study for Students Planning to Continue Their Education

Reported by Advanced Mathematics Students

Students could indicate more than one area of study.

<table>
<thead>
<tr>
<th>Country</th>
<th>Mathematics or Statistics</th>
<th>Physics</th>
<th>Engineering and Engineering Technologies</th>
<th>Computer and Information Sciences</th>
<th>Chemistry</th>
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<tbody>
<tr>
<td></td>
<td>Percent of Students</td>
<td>Average Achievement</td>
<td>Percent of Students</td>
<td>Average Achievement</td>
<td>Percent of Students</td>
</tr>
<tr>
<td>France</td>
<td>15 (0.7)</td>
<td>520 (4.5)</td>
<td>14 (0.6)</td>
<td>512 (4.5)</td>
<td>23 (0.8)</td>
</tr>
<tr>
<td>Italy</td>
<td>9 (0.6)</td>
<td>473 (12.2)</td>
<td>6 (0.5)</td>
<td>514 (12.2)</td>
<td>25 (1.2)</td>
</tr>
<tr>
<td>Lebanon</td>
<td>23 (1.1)</td>
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<td>18 (1.3)</td>
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<tr>
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<td>68 (1.4)</td>
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<tr>
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<td>28 (1.4)</td>
<td>520 (6.8)</td>
<td>27 (1.3)</td>
</tr>
<tr>
<td>Russian Federation 6hr+</td>
<td>41 (1.9)</td>
<td>575 (7.1)</td>
<td>36 (1.4)</td>
<td>572 (7.3)</td>
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</tr>
<tr>
<td>Slovenia</td>
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<td>528 (8.6)</td>
<td>5 (0.5)</td>
<td>523 (7.4)</td>
<td>14 (1.0)</td>
</tr>
<tr>
<td>Sweden</td>
<td>18 (0.9)</td>
<td>487 (4.9)</td>
<td>15 (0.9)</td>
<td>492 (5.9)</td>
<td>47 (0.9)</td>
</tr>
<tr>
<td>United States</td>
<td>26 (1.1)</td>
<td>512 (10.8)</td>
<td>15 (1.0)</td>
<td>525 (16.7)</td>
<td>28 (1.6)</td>
</tr>
<tr>
<td>International Avg.</td>
<td>18 (0.3)</td>
<td>511 (2.4)</td>
<td>16 (0.3)</td>
<td>517 (2.9)</td>
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<table>
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<th>Other</th>
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<td>Average Achievement</td>
<td>Percent of Students</td>
<td>Average Achievement</td>
</tr>
<tr>
<td>France</td>
<td>40 (1.0)</td>
<td>449 (3.1)</td>
<td>7 (0.5)</td>
<td>432 (5.9)</td>
</tr>
<tr>
<td>Italy</td>
<td>33 (1.2)</td>
<td>440 (6.0)</td>
<td>12 (0.8)</td>
<td>414 (9.7)</td>
</tr>
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<td>Lebanon</td>
<td>5 (0.7)</td>
<td>535 (12.7)</td>
<td>2 (0.4)</td>
<td>~ ~</td>
</tr>
<tr>
<td>Norway</td>
<td>24 (0.9)</td>
<td>453 (5.3)</td>
<td>11 (0.7)</td>
<td>457 (5.7)</td>
</tr>
<tr>
<td>Portugal</td>
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<td>3 (0.2)</td>
<td>441 (7.7)</td>
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<tr>
<td>Russian Federation</td>
<td>15 (0.8)</td>
<td>475 (8.4)</td>
<td>11 (0.6)</td>
<td>472 (9.4)</td>
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<tr>
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</tr>
<tr>
<td>Slovenia</td>
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<tr>
<td>Sweden</td>
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<tr>
<td>International Avg.</td>
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<td>8 (0.2)</td>
<td>445 (2.7)</td>
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</tbody>
</table>

The Russian Federation 6hr+ results are for a subset of the Russian Federation students. This subset of students are in an Intensive stream that have at least 6 hours of mathematics lessons per week.

( ) Standard errors appear in parentheses. Because of rounding some results may appear inconsistent.

A tilde (~) indicates insufficient data to report achievement.
### Exhibit M4.6: Students’ Intended Future Profession

**Reported by Advanced Mathematics Students**

Students indicated either "yes" or "maybe" when asked if they wanted to work in the professional fields shown below.

<table>
<thead>
<tr>
<th>Country</th>
<th>Engineering and Engineering Technologies</th>
<th>Computer and Information Sciences</th>
<th>Biological and Biomedical Sciences</th>
<th>Environmental Sciences</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Percent of Students</td>
<td>Average Achievement</td>
<td>Percent of Students</td>
<td>Average Achievement</td>
</tr>
<tr>
<td>France</td>
<td>48 (1.0)</td>
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<td>28 (0.9)</td>
<td>488 (3.7)</td>
</tr>
<tr>
<td>Italy</td>
<td>43 (1.4)</td>
<td>444 (7.1)</td>
<td>32 (1.5)</td>
<td>424 (7.9)</td>
</tr>
<tr>
<td>Lebanon</td>
<td>93 (0.8)</td>
<td>535 (3.1) s</td>
<td>61 (2.1)</td>
<td>536 (4.2)</td>
</tr>
<tr>
<td>Norway</td>
<td>89 (0.7)</td>
<td>462 (4.9)</td>
<td>55 (1.5)</td>
<td>465 (5.6)</td>
</tr>
<tr>
<td>Portugal</td>
<td>43 (1.4)</td>
<td>497 (3.9)</td>
<td>37 (1.1)</td>
<td>485 (4.0)</td>
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<td>34 (1.3)</td>
<td>475 (4.9)</td>
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<tr>
<td>Sweden</td>
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<td>500 (8.3)</td>
</tr>
<tr>
<td>International Avg.</td>
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<td>44 (0.5)</td>
<td>479 (1.9)</td>
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<table>
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<th>Agriculture and Agricultural Sciences</th>
<th>Education</th>
<th>Finance/Banking</th>
<th>Actuarial Sciences</th>
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<td>Percent of Students</td>
<td>Average Achievement</td>
<td>Percent of Students</td>
<td>Average Achievement</td>
</tr>
<tr>
<td>France</td>
<td>11 (0.6)</td>
<td>464 (5.2)</td>
<td>46 (0.9)</td>
<td>471 (3.3)</td>
</tr>
<tr>
<td>Italy</td>
<td>21 (0.9)</td>
<td>414 (9.3)</td>
<td>41 (1.3)</td>
<td>435 (5.5)</td>
</tr>
<tr>
<td>Lebanon</td>
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<td>523 (6.2) r</td>
<td>57 (2.3)</td>
<td>540 (4.4)</td>
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<tr>
<td>Norway</td>
<td>17 (1.1)</td>
<td>453 (4.7)</td>
<td>56 (1.5)</td>
<td>467 (4.6)</td>
</tr>
<tr>
<td>Portugal</td>
<td>16 (0.7)</td>
<td>468 (4.0)</td>
<td>27 (0.9)</td>
<td>494 (3.9)</td>
</tr>
<tr>
<td>Russian Federation</td>
<td>20 (0.9)</td>
<td>472 (3.7)</td>
<td>40 (0.9)</td>
<td>493 (6.9)</td>
</tr>
<tr>
<td>Russian Federation 6hr+</td>
<td>16 (1.1)</td>
<td>522 (11.8)</td>
<td>38 (1.4)</td>
<td>550 (9.4)</td>
</tr>
<tr>
<td>Slovenia</td>
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<tr>
<td>Sweden</td>
<td>18 (0.7)</td>
<td>425 (6.1)</td>
<td>46 (1.0)</td>
<td>448 (3.8)</td>
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<tr>
<td>United States</td>
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<td>467 (14.8)</td>
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<td>492 (5.2)</td>
</tr>
<tr>
<td>International Avg.</td>
<td>18 (0.3)</td>
<td>462 (2.5)</td>
<td>46 (0.4)</td>
<td>478 (1.6)</td>
</tr>
</tbody>
</table>

The Russian Federation 6hr+ results are for a subset of the Russian Federation students. This subset of students are in an Intensive stream that have at least 6 hours of mathematics lessons per week.

( ) Standard errors appear in parentheses. Because of rounding some results may appear inconsistent.

An "r" indicates data are available for at least 70% but less than 85% of the students. An "s" indicates data are available for at least 50% but less than 70% of the students.
## Exhibit M4.7: Students’ Intended Future Profession by Gender

**Reported by Advanced Mathematics Students**

Students indicated either "yes" or "maybe" when asked if they wanted to work in the professional fields shown below. The Percent of Females column shows the percent of female advanced mathematics students choosing that professional field and the Percent of Males column shows the percent of male advanced mathematics students choosing that professional field.

### Engineering and Engineering Technologies

<table>
<thead>
<tr>
<th>Country</th>
<th>Engineering and Engineering Technologies</th>
<th>Computer and Information Sciences</th>
<th>Biological and Biomedical Sciences</th>
<th>Environmental Sciences</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Percent of Females</td>
<td>Percent of Males</td>
<td>Percent of Females</td>
<td>Percent of Males</td>
</tr>
<tr>
<td>France</td>
<td>32 (1.2)</td>
<td>63 (1.2)</td>
<td>10 (0.7)</td>
<td>45 (1.3)</td>
</tr>
<tr>
<td>Italy</td>
<td>25 (1.7)</td>
<td>54 (1.6)</td>
<td>13 (1.1)</td>
<td>43 (1.9)</td>
</tr>
<tr>
<td>Lebanon</td>
<td>89 (1.7)</td>
<td>95 (0.9)</td>
<td>54 (3.7)</td>
<td>66 (2.4)</td>
</tr>
<tr>
<td>Norway</td>
<td>83 (1.3)</td>
<td>92 (0.6)</td>
<td>35 (1.9)</td>
<td>68 (1.8)</td>
</tr>
<tr>
<td>Portugal</td>
<td>25 (1.3)</td>
<td>60 (2.0)</td>
<td>17 (1.0)</td>
<td>58 (1.5)</td>
</tr>
<tr>
<td>Russian Federation</td>
<td>37 (1.8)</td>
<td>73 (1.6)</td>
<td>39 (1.3)</td>
<td>71 (1.6)</td>
</tr>
<tr>
<td>Russian Federation 6hr+</td>
<td>46 (2.4)</td>
<td>76 (1.8)</td>
<td>48 (2.0)</td>
<td>75 (1.5)</td>
</tr>
<tr>
<td>Slovenia</td>
<td>24 (1.0)</td>
<td>61 (2.0)</td>
<td>20 (1.4)</td>
<td>55 (1.7)</td>
</tr>
<tr>
<td>Sweden</td>
<td>68 (1.5)</td>
<td>87 (0.8)</td>
<td>32 (1.8)</td>
<td>70 (1.4)</td>
</tr>
<tr>
<td>United States</td>
<td>35 (2.2)</td>
<td>68 (1.4)</td>
<td>25 (2.0)</td>
<td>54 (2.1)</td>
</tr>
<tr>
<td>International Avg.</td>
<td>46 (0.5)</td>
<td>73 (0.5)</td>
<td>27 (0.6)</td>
<td>59 (0.6)</td>
</tr>
</tbody>
</table>

### Agriculture and Agricultural Sciences

<table>
<thead>
<tr>
<th>Country</th>
<th>Agriculture and Agricultural Sciences</th>
<th>Education</th>
<th>Finance/Banking</th>
<th>Actuarial Sciences</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Percent of Females</td>
<td>Percent of Males</td>
<td>Percent of Females</td>
<td>Percent of Males</td>
</tr>
<tr>
<td>France</td>
<td>12 (0.7)</td>
<td>10 (0.8)</td>
<td>49 (1.3)</td>
<td>43 (1.3)</td>
</tr>
<tr>
<td>Italy</td>
<td>13 (1.2)</td>
<td>25 (1.3)</td>
<td>46 (2.2)</td>
<td>38 (1.5)</td>
</tr>
<tr>
<td>Lebanon</td>
<td>18 (2.2)</td>
<td>20 (2.0)</td>
<td>64 (2.4)</td>
<td>52 (3.1)</td>
</tr>
<tr>
<td>Norway</td>
<td>19 (1.6)</td>
<td>15 (1.2)</td>
<td>57 (1.9)</td>
<td>55 (1.7)</td>
</tr>
<tr>
<td>Portugal</td>
<td>14 (0.9)</td>
<td>18 (1.0)</td>
<td>28 (1.2)</td>
<td>25 (1.4)</td>
</tr>
<tr>
<td>Russian Federation</td>
<td>18 (1.2)</td>
<td>22 (1.0)</td>
<td>51 (1.2)</td>
<td>29 (1.2)</td>
</tr>
<tr>
<td>Russian Federation 6hr+</td>
<td>14 (1.6)</td>
<td>18 (1.2)</td>
<td>48 (2.2)</td>
<td>29 (1.7)</td>
</tr>
<tr>
<td>Slovenia</td>
<td>21 (1.4)</td>
<td>26 (1.4)</td>
<td>63 (1.4)</td>
<td>53 (2.1)</td>
</tr>
<tr>
<td>Sweden</td>
<td>19 (1.2)</td>
<td>17 (0.9)</td>
<td>49 (1.5)</td>
<td>44 (1.5)</td>
</tr>
<tr>
<td>United States</td>
<td>14 (1.4)</td>
<td>18 (1.9)</td>
<td>48 (2.1)</td>
<td>43 (2.0)</td>
</tr>
<tr>
<td>International Avg.</td>
<td>17 (0.5)</td>
<td>19 (0.4)</td>
<td>50 (0.6)</td>
<td>42 (0.6)</td>
</tr>
</tbody>
</table>

* Percent significantly higher than other gender

The Russian Federation 6hr+ results are for a subset of the Russian Federation students. This subset of students are in an intensive stream that have at least 6 hours of mathematics lessons per week.

( ) Standard errors appear in parentheses. Because of rounding some results may appear inconsistent.

An “r” indicates data are available for at least 70% but less than 85% of the students. An “s” indicates data are available for at least 50% but less than 70% of the students.
CHAPTER M5: SCHOOL COMPOSITION

TIMSS ADVANCED 2015 INTERNATIONAL RESULTS IN ADVANCED MATHEMATICS AND PHYSICS
Socioeconomic Composition of Schools

In nearly all the TIMSS Advanced countries, students attending schools with more affluent than disadvantaged students had higher average mathematics achievement.

## Exhibit M5.1: School Composition by Economic Background of the Student Body

*Reported by Principals*

<table>
<thead>
<tr>
<th>Country</th>
<th>Percent of Students</th>
<th>Average Achievement</th>
<th>Percent of Students</th>
<th>Average Achievement</th>
<th>Percent of Students</th>
<th>Average Achievement</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>More Affluent</strong> - Schools where more than 25% of the student body comes from economically affluent homes and not more than 25% from economically disadvantaged homes</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>France</td>
<td>50 (4.1)</td>
<td>471 (4.0)</td>
<td>28 (3.9)</td>
<td>462 (5.5)</td>
<td>22 (3.4)</td>
<td>437 (6.1)</td>
</tr>
<tr>
<td>Italy</td>
<td>48 (4.2)</td>
<td>442 (7.4)</td>
<td>40 (4.8)</td>
<td>423 (11.0)</td>
<td>12 (3.4)</td>
<td>331 (17.7)</td>
</tr>
<tr>
<td>Lebanon</td>
<td>34 (5.1)</td>
<td>554 (7.1)</td>
<td>29 (4.6)</td>
<td>529 (8.4)</td>
<td>37 (3.1)</td>
<td>515 (4.0)</td>
</tr>
<tr>
<td>Norway</td>
<td>r</td>
<td>77 (5.5)</td>
<td>554 (7.1)</td>
<td>29 (4.6)</td>
<td>529 (8.4)</td>
<td>37 (3.1)</td>
</tr>
<tr>
<td>Portugal</td>
<td>r</td>
<td>18 (3.3)</td>
<td>490 (6.5)</td>
<td>36 (3.5)</td>
<td>479 (4.5)</td>
<td>46 (4.1)</td>
</tr>
<tr>
<td>Russian Federation</td>
<td>r</td>
<td>80 (3.2)</td>
<td>492 (6.1)</td>
<td>15 (2.5)</td>
<td>454 (15.6)</td>
<td>5 (1.4)</td>
</tr>
<tr>
<td>Russian Federation 6hr+</td>
<td>r</td>
<td>91 (2.4)</td>
<td>546 (8.2)</td>
<td>8 (2.3)</td>
<td>507 (29.7)</td>
<td>1 (0.7)</td>
</tr>
<tr>
<td>Slovenia</td>
<td>64 (5.0)</td>
<td>474 (5.0)</td>
<td>24 (4.9)</td>
<td>438 (8.1)</td>
<td>12 (2.2)</td>
<td>427 (11.9)</td>
</tr>
<tr>
<td>Sweden</td>
<td>r</td>
<td>80 (3.7)</td>
<td>442 (4.1)</td>
<td>13 (2.6)</td>
<td>379 (12.9)</td>
<td>7 (2.7)</td>
</tr>
<tr>
<td>United States</td>
<td>34 (4.6)</td>
<td>509 (10.8)</td>
<td>28 (4.2)</td>
<td>498 (8.6)</td>
<td>38 (3.9)</td>
<td>458 (9.4)</td>
</tr>
<tr>
<td>International Avg.</td>
<td>54 (1.4)</td>
<td>482 (2.2)</td>
<td>26 (1.4)</td>
<td>457 (3.2)</td>
<td>20 (1.0)</td>
<td>432 (6.1)</td>
</tr>
</tbody>
</table>

The Russian Federation 6hr+ results are for a subset of the Russian Federation students. This subset of students are in an Intensive stream that have at least 6 hours of mathematics lessons per week.

2. A tilde (~) indicates insufficient data to report achievement.
3. An “r” indicates data are available for at least 70% but less than 85% of the students.

### Approximately what percentage of students in your school have the following backgrounds?

- **0 to 10%**
- **11 to 25%**
- **26 to 50%**
- **More than 50%**

1. **More Affluent** - Schools where more than 25% of the student body comes from economically affluent homes and not more than 25% from economically disadvantaged homes
2. **More Disadvantaged** - Schools where more than 25% of student body comes from economically disadvantaged homes and not more than 25% from economically affluent homes
3. **Neither More Affluent nor More Disadvantaged** - All other possible response combinations
### Exhibit M5.2: Schools with Students Having the Language of the Test as Their Native Language

*Reported by Principals*

<table>
<thead>
<tr>
<th>Country</th>
<th>School Has More than 90% of Students with Language of Test as Their Native Language</th>
<th>School Has 51-90% of Students with Language of Test as Their Native Language</th>
<th>School Has 50% or Less of Students with Language of Test as Their Native Language</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Percent of Students</td>
<td>Average Achievement</td>
<td>Percent of Students</td>
</tr>
<tr>
<td>France</td>
<td>88 (3.1)</td>
<td>462 (3.1)</td>
<td>11 (3.1)</td>
</tr>
<tr>
<td>Italy</td>
<td>83 (3.2)</td>
<td>426 (5.6)</td>
<td>17 (3.1)</td>
</tr>
<tr>
<td>Lebanon</td>
<td>11 (3.6)</td>
<td>533 (9.0)</td>
<td>12 (2.7)</td>
</tr>
<tr>
<td>Norway</td>
<td>r 72 (8.0)</td>
<td>466 (6.2)</td>
<td>28 (8.0)</td>
</tr>
<tr>
<td>Portugal</td>
<td>92 (2.0)</td>
<td>482 (2.6)</td>
<td>5 (1.2)</td>
</tr>
<tr>
<td>Russian Federation</td>
<td>82 (2.8)</td>
<td>485 (6.0)</td>
<td>12 (2.2)</td>
</tr>
<tr>
<td>Russian Federation 6hr+</td>
<td>91 (3.5)</td>
<td>541 (8.2)</td>
<td>6 (3.2)</td>
</tr>
<tr>
<td>Slovenia</td>
<td>88 (3.8)</td>
<td>462 (3.8)</td>
<td>12 (3.8)</td>
</tr>
<tr>
<td>Sweden</td>
<td>31 (5.2)</td>
<td>450 (5.9)</td>
<td>58 (6.2)</td>
</tr>
<tr>
<td>United States</td>
<td>54 (4.3)</td>
<td>502 (5.5)</td>
<td>32 (3.7)</td>
</tr>
<tr>
<td>International Avg.</td>
<td>67 (1.4)</td>
<td>474 (1.9)</td>
<td>21 (1.4)</td>
</tr>
</tbody>
</table>

The Russian Federation 6hr+ results are for a subset of the Russian Federation students. This subset of students are in an Intensive stream that have at least 6 hours of mathematics lessons per week.

( ) Standard errors appear in parentheses. Because of rounding some results may appear inconsistent.

A tilde (~) indicates insufficient data to report achievement.

An ‘r’ indicates data are available for at least 70% but less than 85% of the students.

**SOURCE:** IEA’s Trends in International Mathematics and Science Study – TIMSS Advanced 2015
CHAPTER M6: SCHOOL CLIMATE

TIMSS ADVANCED 2015 INTERNATIONAL RESULTS IN ADVANCED MATHEMATICS AND PHYSICS
Schools Have Positive Environments

Generally, students taking advanced mathematics courses are in positive school environments, and the more positive the school environment the higher the average achievement.

Principals and teachers agree that high percentages of TIMSS Advanced students attend schools that support advanced mathematics education, although the principals have more positive attitudes than the teachers.

**TEACHERS** of advanced mathematics reported a high degree of job satisfaction. Almost all students (91%) had teachers who were very satisfied or satisfied with their careers.

**STUDENTS** of advanced mathematics reported a positive sense of school belonging.

<table>
<thead>
<tr>
<th>Country</th>
<th>School Partnerships with Industry</th>
<th>School Collaborations with Universities</th>
<th>Contests/Competitions in Advanced Mathematics</th>
</tr>
</thead>
<tbody>
<tr>
<td>France</td>
<td>●</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>Italy</td>
<td>●</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>Lebanon</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>Norway</td>
<td>○</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>Portugal</td>
<td>○</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>Russian Federation</td>
<td>●</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>Slovenia</td>
<td>○</td>
<td>○</td>
<td>●</td>
</tr>
<tr>
<td>Sweden</td>
<td>●</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>United States</td>
<td>●</td>
<td>●</td>
<td>●</td>
</tr>
</tbody>
</table>

- ● Yes
- ○ No

SOURCE: IEA’s Trends in International Mathematics and Science Study – TIMSS Advanced 2015
Exhibit M6.2: School Supports Advanced Mathematics and Physics Education – Principal Version

Reported by Principals

Students were scored according to their principals’ degree of agreement with seven statements on the School Supports Advanced Mathematics and Physics Education scale. Students in schools where their principals reported that the school is **Strongly Supportive** of advanced mathematics and physics education had a score on the scale of at least 11.0, which corresponds to their principals “agreeing a lot” with four of the seven statements and “agreeing a little” with the other three, on average. Students in schools that are **Less than Supportive** of advanced mathematics and physics education had a score no higher than 6.5, which corresponds to their principals “disagreeing a little” with four of the seven statements and “agreeing a little” with the other three, on average. All other students attended schools that are **Supportive** of advanced mathematics and physics education.

<table>
<thead>
<tr>
<th>Country</th>
<th>Strongly Supportive</th>
<th>Supportive</th>
<th>Less than Supportive</th>
<th>Average Scale Score</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Percent of Students</td>
<td>Average Achievement</td>
<td>Percent of Students</td>
<td>Average Achievement</td>
</tr>
<tr>
<td>Russian Federation 6hr+</td>
<td>86 (2.4)</td>
<td>544 (8.6)</td>
<td>14 (2.4)</td>
<td>513 (18.1)</td>
</tr>
<tr>
<td>Russian Federation</td>
<td>73 (3.2)</td>
<td>494 (7.5)</td>
<td>27 (3.2)</td>
<td>460 (11.2)</td>
</tr>
<tr>
<td>Norway</td>
<td>62 (7.2)</td>
<td>474 (6.7)</td>
<td>38 (7.2)</td>
<td>442 (5.3)</td>
</tr>
<tr>
<td>United States</td>
<td>47 (5.2)</td>
<td>495 (7.9)</td>
<td>51 (5.2)</td>
<td>481 (8.5)</td>
</tr>
<tr>
<td>Lebanon</td>
<td>39 (2.5)</td>
<td>536 (4.8)</td>
<td>60 (2.6)</td>
<td>531 (4.0)</td>
</tr>
<tr>
<td>Portugal</td>
<td>35 (3.7)</td>
<td>483 (3.4)</td>
<td>61 (4.0)</td>
<td>484 (3.3)</td>
</tr>
<tr>
<td>Italy</td>
<td>21 (4.2)</td>
<td>437 (13.6)</td>
<td>72 (4.6)</td>
<td>417 (8.1)</td>
</tr>
<tr>
<td>France</td>
<td>8 (2.3)</td>
<td>479 (11.0)</td>
<td>84 (3.4)</td>
<td>460 (3.2)</td>
</tr>
<tr>
<td>Slovenia</td>
<td>7 (4.4)</td>
<td>505 (44.9)</td>
<td>89 (5.2)</td>
<td>458 (5.2)</td>
</tr>
<tr>
<td>Sweden</td>
<td>6 (3.0)</td>
<td>456 (13.6)</td>
<td>80 (4.3)</td>
<td>431 (4.6)</td>
</tr>
<tr>
<td>International Avg.</td>
<td>33 (1.4)</td>
<td>484 (5.8)</td>
<td>62 (1.5)</td>
<td>463 (2.2)</td>
</tr>
</tbody>
</table>

The Russian Federation 6hr+ results are for a subset of the Russian Federation students. This subset of students are in an Intensive stream that have at least 6 hours of mathematics lessons per week.

This TIMSS Advanced questionnaire scale was established in 2015 based on the combined response distribution of all countries that participated in TIMSS Advanced 2015. To provide a point of reference for country comparisons, the scale centerpoint of 10 was located at the mean of the combined distribution. The units of the scale were chosen so that 2 scale score points corresponded to the standard deviation of the distribution.

( ) Standard errors appear in parentheses. Because of rounding some results may appear inconsistent.

A tilde (~) indicates insufficient data to report achievement.

An “r” indicates data are available for at least 70% but less than 85% of the students.

---

How much do you agree with these statements about advanced mathematics and physics education within your school?

1. The school encourages students to study advanced mathematics and physics ———— Agree a lot Agree a little
2. The school promotes professional development for teachers of advanced mathematics and physics ————
3. The school provides students with information about career options in advanced mathematics and physics ————
4. The school has initiatives to promote student interest in advanced mathematics and physics (e.g., student clubs, competitions) ————
5. The school has partnerships with industry/businesses in advanced mathematics and physics ————
6. Advanced mathematics and physics teachers are admired by other teachers in the school ————
7. Students at this school respect students who excel in advanced mathematics and physics ————

SOURCE: IEA’s Trends in International Mathematics and Science Study – TIMSS Advanced 2015
**Exhibit M6.3: School Supports Advanced Mathematics and Physics Education – Teacher Version**

Students were scored according to their teachers’ degree of agreement with seven statements on the School Supports Advanced Mathematics and Physics Education scale. Students in schools where their teachers reported that the school is **Strongly Supportive** of advanced mathematics and physics education had a score on the scale of at least 11.6, which corresponds to their teachers “agreeing a lot” with four of the seven statements and “agreeing a little” with the other three, on average. Students in schools that are **Less than Supportive** of advanced mathematics and physics education had a score no higher than 7.4, which corresponds to their teachers “disagreeing a little” with four of the seven statements and “agreeing a little” with the other three, on average. All other students attended schools that are **Supportive** of advanced mathematics and physics education.

<table>
<thead>
<tr>
<th>Country</th>
<th>Strongly Supportive</th>
<th>Supportive</th>
<th>Less than Supportive</th>
<th>Average Scale Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Russian Federation 6hr+</td>
<td>62 (4.4)</td>
<td>38 (4.4)</td>
<td>0 (0.0)</td>
<td>12.1 (0.15)</td>
</tr>
<tr>
<td>Russian Federation</td>
<td>52 (2.5)</td>
<td>48 (2.5)</td>
<td>1 (0.5)</td>
<td>11.5 (0.11)</td>
</tr>
<tr>
<td>Lebanon</td>
<td>46 (3.2)</td>
<td>52 (3.3)</td>
<td>1 (0.2)</td>
<td>11.5 (0.10)</td>
</tr>
<tr>
<td>United States</td>
<td>40 (4.0)</td>
<td>56 (3.9)</td>
<td>4 (1.1)</td>
<td>10.9 (0.17)</td>
</tr>
<tr>
<td>Norway</td>
<td>28 (6.5)</td>
<td>70 (7.1)</td>
<td>3 (1.5)</td>
<td>10.6 (0.17)</td>
</tr>
<tr>
<td>Portugal</td>
<td>24 (3.1)</td>
<td>72 (3.5)</td>
<td>5 (1.5)</td>
<td>10.3 (0.12)</td>
</tr>
<tr>
<td>Italy</td>
<td>6 (1.7)</td>
<td>69 (3.3)</td>
<td>25 (3.2)</td>
<td>8.8 (0.13)</td>
</tr>
<tr>
<td>France</td>
<td>4 (1.2)</td>
<td>87 (2.1)</td>
<td>9 (1.7)</td>
<td>9.2 (0.08)</td>
</tr>
<tr>
<td>Sweden</td>
<td>3 (1.1)</td>
<td>77 (3.2)</td>
<td>20 (3.3)</td>
<td>8.8 (0.11)</td>
</tr>
<tr>
<td>Slovenia</td>
<td>2 (0.1)</td>
<td>~</td>
<td>22 (2.7)</td>
<td>8.4 (0.08)</td>
</tr>
<tr>
<td>International Avg.</td>
<td>23 (1.1)</td>
<td>67 (1.2)</td>
<td>10 (0.7)</td>
<td>444 (6.5)</td>
</tr>
</tbody>
</table>

The Russian Federation 6hr+ results are for a subset of the Russian Federation students. This subset of students are in an intensive stream that have at least 6 hours of mathematics lessons per week.

This TIMSS Advanced questionnaire scale was established in 2015 based on the combined response distribution of all countries that participated in TIMSS Advanced 2015. To provide a point of reference for country comparisons, the scale centerpoint of 10 was located at the mean of the combined distribution. The units of the scale were chosen so that 2 scale score points corresponded to the standard deviation of the distribution.

( ) Standard errors appear in parentheses. Because of rounding some results may appear inconsistent.
A tilde (~) indicates insufficient data to report achievement.
An “r” indicates data are available for at least 70% but less than 85% of the students.

---

**How much do you agree with these statements about advanced mathematics and physics education within your school?**

1. The school encourages students to study advanced mathematics and physics
2. The school promotes professional development for teachers of advanced mathematics and physics
3. The school provides students with information about career options in advanced mathematics and physics
4. Advanced mathematics and physics teachers are admired by other teachers in the school
5. Teachers have high expectations for student achievement in advanced mathematics and physics
6. Students at this school respect students who excel in advanced mathematics and physics
7. Parents expect their children to study advanced mathematics and physics

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The Russian Federation 6hr+ results are for a subset of the Russian Federation students. This subset of students are in an Intensive stream that have at least 6 hours of mathematics lessons per week.
### Exhibit M6.4: Teacher Job Satisfaction

**Reported by Advanced Mathematics Teachers**

Students were scored according to how often their teachers responded positively to the seven statements on the *Teacher Job Satisfaction* scale. Students with **Very Satisfied** teachers had a score on the scale of at least 10.5, which corresponds to their teachers responding “very often” to four of the seven statements and responding “often” to the other three, on average. Students with **Less than Satisfied** teachers had a score no higher than 7.2, which corresponds to their teachers responding “sometimes” to four of the seven statements and responding “often” to the other three, on average. All other students had **Satisfied** teachers.

<table>
<thead>
<tr>
<th>Country</th>
<th>Very Satisfied</th>
<th>Satisfied</th>
<th>Less than Satisfied</th>
<th>Average Scale Score</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Percent of Students</td>
<td>Average Achievement</td>
<td>Percent of Students</td>
<td>Average Achievement</td>
</tr>
<tr>
<td>Lebanon</td>
<td>79 (3.5)</td>
<td>534 (3.7)</td>
<td>19 (3.5)</td>
<td>529 (6.8)</td>
</tr>
<tr>
<td>United States</td>
<td>63 (3.8)</td>
<td>481 (8.0)</td>
<td>32 (3.5)</td>
<td>489 (7.3)</td>
</tr>
<tr>
<td>Norway</td>
<td>60 (4.8)</td>
<td>473 (6.0)</td>
<td>36 (4.7)</td>
<td>446 (5.6)</td>
</tr>
<tr>
<td>Russian Federation 6hr+</td>
<td>54 (4.8)</td>
<td>540 (11.7)</td>
<td>44 (4.6)</td>
<td>543 (11.3)</td>
</tr>
<tr>
<td>Russian Federation</td>
<td>42 (2.9)</td>
<td>505 (7.3)</td>
<td>55 (3.0)</td>
<td>471 (8.4)</td>
</tr>
<tr>
<td>France</td>
<td>36 (2.9)</td>
<td>465 (4.5)</td>
<td>50 (2.8)</td>
<td>459 (4.3)</td>
</tr>
<tr>
<td>Portugal</td>
<td>34 (3.3)</td>
<td>486 (4.6)</td>
<td>55 (3.5)</td>
<td>481 (3.8)</td>
</tr>
<tr>
<td>Slovenia</td>
<td>31 (4.4)</td>
<td>476 (6.4)</td>
<td>56 (4.9)</td>
<td>452 (7.3)</td>
</tr>
<tr>
<td>Sweden</td>
<td>29 (3.5)</td>
<td>436 (6.4)</td>
<td>60 (4.2)</td>
<td>437 (5.8)</td>
</tr>
<tr>
<td>Italy</td>
<td>28 (3.1)</td>
<td>417 (11.2)</td>
<td>52 (3.4)</td>
<td>435 (9.1)</td>
</tr>
<tr>
<td>International Avg.</td>
<td>45 (1.2)</td>
<td>475 (2.3)</td>
<td>46 (1.3)</td>
<td>467 (2.2)</td>
</tr>
</tbody>
</table>

The Russian Federation 6hr+ results are for a subset of the Russian Federation students. This subset of students are in an Intensive stream that have at least 6 hours of mathematics lessons per week.

This TIMSS Advanced questionnaire scale was established in 2015 based on the combined response distribution of all countries that participated in TIMSS Advanced 2015. To provide a point of reference for country comparisons, the scale centerpoint of 10 was located at the mean of the combined distribution. The units of the scale were chosen so that 2 scale score points corresponded to the standard deviation of the distribution.

( ) Standard errors appear in parentheses. Because of rounding some results may appear inconsistent.

A tilde (~) indicates insufficient data to report achievement.

An "r" indicates data are available for at least 70% but less than 85% of the students.

---

### How often do you feel the following way about being a teacher?

<table>
<thead>
<tr>
<th>Statement</th>
<th>Very often</th>
<th>Often</th>
<th>Sometimes</th>
<th>Never or almost never</th>
</tr>
</thead>
<tbody>
<tr>
<td>1) I am content with my profession as a teacher</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2) I am satisfied with being a teacher at this school</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3) I find my work full of meaning and purpose</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4) I am enthusiastic about my job</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5) My work inspires me</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6) I am proud of the work I do</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7) I am going to continue teaching for as long as I can</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Average Scale Score**

- **Very Satisfied**: 10.5
- **Satisfied**: 7.2
- **Less than Satisfied**: ~
### Exhibit M6.5: Students’ Sense of School Belonging

Reported by Advanced Mathematics Students

Students were scored according to their agreement to nine statements about their Sense of School Belonging. Students with a **High Sense of School Belonging** had a score on the scale of at least 10.6, which corresponds to their "agreeing a lot" to five of the nine statements and "agreeing a little" to each of the other four statements, on average. Students with a **Little Sense of School Belonging** had a score no higher than 7.7, which corresponds to their "disagreeing a little" to five of the nine statements and "agreeing a little" to each of the other four statements, on average. All other students had a **Sense of School Belonging**.

<table>
<thead>
<tr>
<th>Country</th>
<th>High Sense of School Belonging</th>
<th>Sense of School Belonging</th>
<th>Little Sense of School Belonging</th>
<th>Average Scale Score</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Percent of Students</td>
<td>Average Achievement</td>
<td>Percent of Students</td>
<td>Average Achievement</td>
</tr>
<tr>
<td>Norway</td>
<td>59 (1.7)</td>
<td>468 (4.6)</td>
<td>38 (1.6)</td>
<td>450 (4.9)</td>
</tr>
<tr>
<td>Sweden</td>
<td>54 (1.4)</td>
<td>446 (4.1)</td>
<td>41 (1.3)</td>
<td>421 (5.0)</td>
</tr>
<tr>
<td>Russian Federation</td>
<td>49 (1.6)</td>
<td>494 (6.4)</td>
<td>43 (1.3)</td>
<td>480 (5.9)</td>
</tr>
<tr>
<td>Russian Federation 6hr+</td>
<td>49 (2.1)</td>
<td>547 (8.5)</td>
<td>43 (1.8)</td>
<td>537 (7.5)</td>
</tr>
<tr>
<td>United States</td>
<td>46 (2.0)</td>
<td>492 (6.9)</td>
<td>47 (1.8)</td>
<td>485 (5.3)</td>
</tr>
<tr>
<td>Lebanon</td>
<td>43 (2.1)</td>
<td>542 (4.1)</td>
<td>48 (1.9)</td>
<td>528 (4.3)</td>
</tr>
<tr>
<td>Portugal</td>
<td>38 (1.3)</td>
<td>489 (3.9)</td>
<td>53 (1.1)</td>
<td>480 (2.8)</td>
</tr>
<tr>
<td>France</td>
<td>20 (1.2)</td>
<td>479 (4.4)</td>
<td>73 (1.0)</td>
<td>463 (3.0)</td>
</tr>
<tr>
<td>Italy</td>
<td>16 (1.1)</td>
<td>424 (11.9)</td>
<td>61 (1.2)</td>
<td>427 (5.4)</td>
</tr>
<tr>
<td>Slovenia</td>
<td>11 (0.9)</td>
<td>493 (6.4)</td>
<td>69 (0.9)</td>
<td>464 (4.0)</td>
</tr>
<tr>
<td>International Avg.</td>
<td>37 (0.5)</td>
<td>481 (2.1)</td>
<td>53 (0.5)</td>
<td>466 (1.5)</td>
</tr>
</tbody>
</table>

The Russian Federation 6hr+ results are for a subset of the Russian Federation students. This subset of students are in an intensive stream that have at least 6 hours of mathematics lessons per week.

This TIMSS Advanced questionnaire scale was established in 2015 based on the combined response distribution of all countries that participated in TIMSS Advanced 2015. To provide a point of reference for country comparisons, the scale centerpoint of 10 was located at the mean of the combined distribution. The units of the scale were chosen so that 2 scale score points corresponded to the standard deviation of the distribution.

( ) Standard errors appear in parentheses. Because of rounding some results may appear inconsistent.

---

**What do you think about your school? Tell how much you agree with these statements.**

1) I enjoy school...
2) I feel safe when I am at school...
3) I feel like I belong at this school...
4) I like to see my classmates at school...
5) Teachers at my school are fair to me...
6) I am proud to go to this school...
7) I learn a lot in school...
8) My classmates respect students who excel in school subjects...
9) My classmates respect students who struggle learning school subjects...

---

**High Sense of School Belonging** 10.6

**Sense of School Belonging** 7.7

**Little Sense of School Belonging**
CHAPTER M7: SCHOOL SAFETY

TIMSS ADVANCED 2015 INTERNATIONAL RESULTS IN ADVANCED MATHEMATICS AND PHYSICS
Students Are in Safe Schools
Principals and teachers agreed that ALMOST ALL the TIMSS Advanced students were in safe school environments.

**Principals’ Reports**

<table>
<thead>
<tr>
<th>% of Students</th>
<th>Average Achievement</th>
</tr>
</thead>
<tbody>
<tr>
<td>57%</td>
<td>478</td>
</tr>
<tr>
<td>36%</td>
<td>459</td>
</tr>
<tr>
<td>7%</td>
<td>465</td>
</tr>
</tbody>
</table>

**Teachers’ Reports**

<table>
<thead>
<tr>
<th>% of Students</th>
<th>Average Achievement</th>
</tr>
</thead>
<tbody>
<tr>
<td>54%</td>
<td>477</td>
</tr>
<tr>
<td>42%</td>
<td>463</td>
</tr>
<tr>
<td>4%</td>
<td>418</td>
</tr>
</tbody>
</table>

### Exhibit M7.1: School Discipline Problems – Principals’ Reports

Reported by Principals

Students were scored according to their principals’ responses concerning eleven potential school problems on the School Discipline Problems scale. Students in schools with **Hardly Any Problems** had a score on the scale of at least 10.0, which corresponds to their principals reporting “not a problem” for six of the eleven issues and “minor problem” for the other five, on average. Students in schools with **Moderate to Severe Problems** had a score no higher than 7.2, which corresponds to their principals reporting “moderate problem” for six of the eleven issues and “minor problem” for the other five, on average. All other students attended schools with **Minor Problems**.

<table>
<thead>
<tr>
<th>Country</th>
<th>Hardly Any Problems</th>
<th>Minor Problems</th>
<th>Moderate to Severe Problems</th>
<th>Average Scale Score</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Percent of Students</td>
<td>Average Achievement</td>
<td>Percent of Students</td>
<td>Average Achievement</td>
</tr>
<tr>
<td>Russian Federation</td>
<td>85 (2.2)</td>
<td>486 (6.2)</td>
<td>15 (2.2)</td>
<td>474 (14.4)</td>
</tr>
<tr>
<td>Russian Federation 6hr+</td>
<td>82 (3.5)</td>
<td>538 (9.0)</td>
<td>18 (3.5)</td>
<td>548 (15.7)</td>
</tr>
<tr>
<td>Norway</td>
<td>66 (8.0)</td>
<td>467 (7.1)</td>
<td>33 (8.0)</td>
<td>453 (6.5)</td>
</tr>
<tr>
<td>France</td>
<td>65 (4.7)</td>
<td>464 (3.6)</td>
<td>31 (4.5)</td>
<td>455 (6.5)</td>
</tr>
<tr>
<td>Slovenia</td>
<td>65 (4.7)</td>
<td>469 (5.5)</td>
<td>34 (4.7)</td>
<td>444 (8.3)</td>
</tr>
<tr>
<td>Portugal</td>
<td>57 (3.9)</td>
<td>483 (3.6)</td>
<td>38 (3.9)</td>
<td>482 (4.8)</td>
</tr>
<tr>
<td>United States</td>
<td>55 (4.4)</td>
<td>494 (6.2)</td>
<td>43 (4.4)</td>
<td>478 (9.7)</td>
</tr>
<tr>
<td>Lebanon</td>
<td>48 (3.6)</td>
<td>540 (5.4)</td>
<td>26 (4.8)</td>
<td>522 (4.6)</td>
</tr>
<tr>
<td>Italy</td>
<td>39 (4.6)</td>
<td>451 (10.4)</td>
<td>39 (4.5)</td>
<td>401 (10.7)</td>
</tr>
<tr>
<td>Sweden</td>
<td>34 (4.6)</td>
<td>447 (5.8)</td>
<td>65 (4.7)</td>
<td>424 (6.5)</td>
</tr>
</tbody>
</table>

| International Avg. | 57 (1.6)            | 478 (2.1)       | 36 (1.6)                   | 459 (2.8)           | 7 (0.6)            | 465 (6.4)          |               |

The Russian Federation 6hr+ results are for a subset of the Russian Federation students. This subset of students are in an Intensive stream that have at least 6 hours of mathematics lessons per week.

This TIMSS Advanced questionnaire scale was established in 2015 based on the combined response distribution of all countries that participated in TIMSS Advanced 2015. To provide a point of reference for country comparisons, the scale centerpoint of 10 was located at the mean of the combined distribution. The units of the scale were chosen so that 2 scale score points corresponded to the standard deviation of the distribution.

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An “r” indicates data are available for at least 70% but less than 85% of the students.

---

**To what degree is each of the following a problem among twelfth grade students in your school?**

1. Arriving late at school
2. Absenteeism (i.e., unjustified absences)
3. Classroom disturbance
4. Cheating
5. Profanity
6. Vandalism
7. Theft
8. Intimidation or verbal abuse among students (including texting, emailing, etc.)
9. Physical injury to other students
10. Intimidation or verbal abuse of teachers or staff (including texting, emailing, etc.)
11. Physical injury to teachers or staff

To what degree is each of the following a problem among twelfth grade students in your school?

- Not a problem
- Minor problem
- Moderate problem
- Serious problem

<table>
<thead>
<tr>
<th></th>
<th>Hardly Any Problems</th>
<th>Minor Problems</th>
<th>Moderate to Severe Problems</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average</td>
<td>10.0</td>
<td>7.2</td>
<td></td>
</tr>
</tbody>
</table>
### Exhibit M7.2: Safe and Orderly School – Teachers’ Reports

**Reported by Advanced Mathematics Teachers**

Students were scored according to their teachers’ degree of agreement with eight statements on the Safe and Orderly School scale. Students in **Very Safe and Orderly** schools had a score on the scale of at least 9.9, which corresponds to their teachers “agreeing a lot” with four of the eight qualities of a safe and orderly school and “agreeing a little” with the other four, on average. Students in **Less than Safe and Orderly** schools had a score no higher than 6.5, which corresponds to their teachers “disagreeing a little” with four of the eight qualities and “agreeing a little” with the other four, on average. All other students attended **Safe and Orderly** schools.

<table>
<thead>
<tr>
<th>Country</th>
<th>Very Safe and Orderly</th>
<th>Safe and Orderly</th>
<th>Less than Safe and Orderly</th>
<th>Average Scale Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Russian Federation 6hr+</td>
<td>78 (4.2)</td>
<td>552 (7.4)</td>
<td>22 (4.2)</td>
<td>99 (19.3)</td>
</tr>
<tr>
<td>Russian Federation</td>
<td>75 (3.2)</td>
<td>495 (7.0)</td>
<td>25 (5.0)</td>
<td>451 (12.2)</td>
</tr>
<tr>
<td>Norway</td>
<td>74 (5.1)</td>
<td>465 (5.0)</td>
<td>25 (5.0)</td>
<td>450 (6.8)</td>
</tr>
<tr>
<td>United States</td>
<td>71 (3.8)</td>
<td>486 (7.4)</td>
<td>26 (3.5)</td>
<td>491 (8.9)</td>
</tr>
<tr>
<td>Portugal</td>
<td>52 (3.4)</td>
<td>484 (4.0)</td>
<td>41 (3.7)</td>
<td>481 (3.5)</td>
</tr>
<tr>
<td>Sweden</td>
<td>44 (4.3)</td>
<td>446 (4.9)</td>
<td>53 (4.3)</td>
<td>427 (6.2)</td>
</tr>
<tr>
<td>Italy</td>
<td>43 (3.3)</td>
<td>428 (8.0)</td>
<td>51 (3.2)</td>
<td>429 (8.3)</td>
</tr>
<tr>
<td>France</td>
<td>34 (3.1)</td>
<td>473 (5.6)</td>
<td>61 (3.0)</td>
<td>458 (3.3)</td>
</tr>
<tr>
<td>Slovenia</td>
<td>27 (3.4)</td>
<td>482 (8.4)</td>
<td>67 (3.1)</td>
<td>454 (4.0)</td>
</tr>
<tr>
<td>International Avg.</td>
<td>54 (1.3)</td>
<td>477 (2.1)</td>
<td>42 (1.3)</td>
<td>463 (2.4)</td>
</tr>
</tbody>
</table>

The Russian Federation 6hr+ results are for a subset of the Russian Federation students. This subset of students are in an intensive stream that have at least 6 hours of mathematics lessons per week.

This TIMSS Advanced questionnaire scale was established in 2015 based on the combined response distribution of all countries that participated in TIMSS Advanced 2015. To provide a point of reference for country comparisons, the scale centerpoint of 10 was located at the mean of the combined distribution. The units of the scale were chosen so that 2 scale score points corresponded to the standard deviation of the distribution.

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CHAPTER M8: TEACHERS’ AND PRINCIPALS’ PREPARATION

TIMSS ADVANCED 2015 INTERNATIONAL RESULTS IN ADVANCED MATHEMATICS AND PHYSICS
Mathematics teachers of TIMSS Advanced students reported high levels of education and considerable experience. Of students were taught by mathematics teachers with at least a Bachelor's degree. Of students were taught by mathematics teachers with a Master's or Doctorate degree.

On average, students were taught by mathematics teachers with 14 years of experience teaching advanced mathematics. The TIMSS Advanced countries have special requirements for teaching advanced mathematics, so it may be a concern that: Of Advanced Mathematics students were taught by mathematics teachers 40 years old or older who may be thinking about retirement.

Principals of schools with TIMSS Advanced Mathematics students reported high levels of education and experience. Of students had principals with at least a Bachelor's degree. Of students had principals with a Master's or Doctorate degree. On average, principals had 11 years of experience.

<table>
<thead>
<tr>
<th>Country</th>
<th>Requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td>France</td>
<td>Teachers must be qualified to teach secondary school. Secondary school teachers must hold a master’s degree and pass the competitive national examination.</td>
</tr>
<tr>
<td>Italy</td>
<td>Teachers must be officially qualified to teach mathematics in upper-secondary school (graduate in mathematics or physics, statistics, etc. and have a certification for teaching mathematics, released by a university after a 1-year course for teaching qualification).</td>
</tr>
<tr>
<td>Lebanon</td>
<td>Teachers must hold a bachelor’s degree in mathematics, as well as a teaching diploma.</td>
</tr>
<tr>
<td>Norway</td>
<td>Teachers are required to have at least a university bachelor’s degree and have taken at least 1 full year (60 credit points) of mathematics courses. They also need 1 year of teacher education courses, consisting of general pedagogy, mathematics education, and teaching practice in schools. These courses may be taken separately after finishing subject studies, or as an integrated part. The current tendency is that a full master’s degree will be required.</td>
</tr>
<tr>
<td>Portugal</td>
<td>Fully qualified advanced mathematics teachers must have at least a Master of Science degree in mathematical education, which includes a professional internship. They must pass both a general knowledge and a specific (mathematics) teachers’ qualifying examination.</td>
</tr>
<tr>
<td>Russian Federation</td>
<td>Teachers must have a university degree in mathematics education, or any university degree and certificate of additional courses in mathematics education. There are no official requirements for being a teacher of advanced mathematics. Beginning in 2017, according to the new professional standards, teachers of advanced mathematics should have at least a master’s degree.</td>
</tr>
<tr>
<td>Slovenia</td>
<td>All teachers must have an appropriate university degree, pedagogical training, and have successfully completed the teaching certification examination. Teachers for the advanced mathematics program should have a second-level university degree, which means 5 years of mathematics university study, including pedagogical courses.</td>
</tr>
<tr>
<td>Sweden</td>
<td>Teachers must be licensed through a teacher education program. To become a mathematics teacher in upper-secondary school you need at least 1.5 years of mathematics courses at a university. You also need 1.5–2 years of tertiary level studies in one more subject, and 1.5 years of courses in specific and general education. In total, 300 credits for 5–5.5 years are required. After finishing a teacher education program, prospective teachers apply for a license at the Swedish National Agency for Education.</td>
</tr>
<tr>
<td>United States</td>
<td>All public school teachers must be licensed by their state’s department of education, and requirements for licensure vary by state. Secondary school mathematics teachers may have a bachelor’s degree in mathematics (and possibly a master’s degree in education), or a double major in mathematics and education. Additionally, all teachers must be highly qualified, which includes demonstrating of expertise in their subject area by either passing a subject test or completing an undergraduate degree, completing a graduate degree, completing coursework equivalent to an undergraduate major, or completing advanced certification or credentialing.</td>
</tr>
</tbody>
</table>
## Exhibit M8.2: Advanced Mathematics Teachers’ Formal Education*

<table>
<thead>
<tr>
<th>Country</th>
<th>Did Not Complete Bachelor’s Degree</th>
<th>Completed Bachelor’s Degree but Not a Postgraduate Degree</th>
<th>Completed Postgraduate University Degree***</th>
</tr>
</thead>
<tbody>
<tr>
<td>France</td>
<td>0 (0.0)</td>
<td>460 (4.7)</td>
<td>75 (2.9)</td>
</tr>
<tr>
<td>Italy</td>
<td>2 (0.9)</td>
<td>428 (6.4)</td>
<td>11 (2.0)</td>
</tr>
<tr>
<td>Lebanon</td>
<td>7 (1.5)</td>
<td>542 (7.3)</td>
<td>59 (4.1)</td>
</tr>
<tr>
<td>Norway</td>
<td>0 (0.0)</td>
<td>452 (9.4)</td>
<td>77 (3.2)</td>
</tr>
<tr>
<td>Portugal</td>
<td>2 (0.8)</td>
<td>482 (2.9)</td>
<td>20 (2.8)</td>
</tr>
<tr>
<td>Russian Federation</td>
<td>0 (0.0)</td>
<td>485 (12.0)</td>
<td>71 (3.3)</td>
</tr>
<tr>
<td>Russian Federation 6hr+</td>
<td>2 (0.8)</td>
<td>513 (13.4)</td>
<td>81 (2.7)</td>
</tr>
<tr>
<td>Slovenia</td>
<td>0 (0.0)</td>
<td>485 (12.0)</td>
<td>99 (0.8)</td>
</tr>
<tr>
<td>Sweden</td>
<td>2 (0.6)</td>
<td>437 (7.2)</td>
<td>67 (3.5)</td>
</tr>
<tr>
<td>United States</td>
<td>0 (0.0)</td>
<td>464 (13.2)</td>
<td>73 (4.3)</td>
</tr>
<tr>
<td>International Avg.</td>
<td>1 (0.2)</td>
<td>469 (3.0)</td>
<td>61 (1.1)</td>
</tr>
</tbody>
</table>

### Source: IEA’s Trends in International Mathematics and Science Study – TIMSS Advanced 2015

* Based on countries’ categorizations according to UNESCO’s International Standard Classification of Education (Operational Manual for ISCED-2011).

** For example, doctorate, master’s, or other postgraduate degree.

The Russian Federation 6hr+ results are for a subset of the Russian Federation students. This subset of students are in an intensive stream that have at least 6 hours of mathematics lessons per week.

( ) Standard errors appear in parentheses. Because of rounding some results may appear inconsistent.

A tilde (~) indicates insufficient data to report achievement.

An “r” indicates data are available for at least 70% but less than 85% of the students.
### Exhibit M8.3: Advanced Mathematics Teachers Majored in Mathematics and Education

**Reported by Advanced Mathematics Teachers**

<table>
<thead>
<tr>
<th>Country</th>
<th>Major in Mathematics and Mathematics Education</th>
<th>Major in Mathematics but No Major in Mathematics Education</th>
<th>Major in Mathematics Education but No Major in Mathematics</th>
<th>All Other Majors</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Percent of Students</td>
<td>Average Achievement</td>
<td>Percent of Students</td>
<td>Average Achievement</td>
</tr>
<tr>
<td>France</td>
<td>32 (2.7)</td>
<td>465 (4.1)</td>
<td>68 (2.7)</td>
<td>460 (3.9)</td>
</tr>
<tr>
<td>Italy</td>
<td>49 (4.1)</td>
<td>417 (10.9)</td>
<td>41 (3.8)</td>
<td>444 (8.7)</td>
</tr>
<tr>
<td>Lebanon</td>
<td>61 (4.1)</td>
<td>534 (4.6)</td>
<td>33 (2.5)</td>
<td>538 (5.1)</td>
</tr>
<tr>
<td>Norway</td>
<td>18 (3.5)</td>
<td>466 (11.4)</td>
<td>80 (3.7)</td>
<td>461 (4.0)</td>
</tr>
<tr>
<td>Portugal</td>
<td>76 (3.1)</td>
<td>480 (3.4)</td>
<td>19 (2.6)</td>
<td>489 (5.3)</td>
</tr>
<tr>
<td>Russian Federation</td>
<td>60 (3.8)</td>
<td>492 (7.7)</td>
<td>39 (3.8)</td>
<td>468 (7.7)</td>
</tr>
<tr>
<td>Russian Federation 6hr+</td>
<td>69 (5.1)</td>
<td>555 (8.3)</td>
<td>30 (5.0)</td>
<td>505 (16.6)</td>
</tr>
<tr>
<td>Slovenia</td>
<td>56 (4.3)</td>
<td>465 (4.7)</td>
<td>29 (3.5)</td>
<td>452 (8.4)</td>
</tr>
<tr>
<td>Sweden</td>
<td>71 (3.7)</td>
<td>440 (4.8)</td>
<td>20 (3.0)</td>
<td>426 (7.2)</td>
</tr>
<tr>
<td>United States</td>
<td>58 (3.2)</td>
<td>478 (8.2)</td>
<td>22 (2.7)</td>
<td>500 (8.6)</td>
</tr>
<tr>
<td>International Avg.</td>
<td>53 (1.2)</td>
<td>471 (2.4)</td>
<td>39 (1.1)</td>
<td>471 (2.3)</td>
</tr>
</tbody>
</table>

**SOURCE:** IEA’s Trend in International Mathematics and Science Study – TIMSS Advanced 2015

The Russian Federation 6hr+ results are for a subset of the Russian Federation students. This subset of students are in an intensive stream that have at least 6 hours of mathematics lessons per week.

- Standard errors appear in parentheses. Because of rounding some results may appear inconsistent.
- A tilde (~) indicates insufficient data to report achievement.
- An “r” indicates data are available for at least 70% but less than 85% of the students.
### Exhibit M8.4: Advanced Mathematics Teachers’ Gender, Age, and Number of Years Teaching

**Reported by Advanced Mathematics Teachers**

<table>
<thead>
<tr>
<th>Country</th>
<th>Female</th>
<th>Male</th>
<th>29 Years or Under</th>
<th>30-39 Years</th>
<th>40-49 Years</th>
<th>50-59 Years</th>
<th>60 Years or Older</th>
<th>Average Number of Years Teaching</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Gender</td>
<td>Age</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td></td>
<td>Male</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>France</td>
<td>40 (3.2)</td>
<td>60 (3.2)</td>
<td>4 (1.2)</td>
<td>17 (2.3)</td>
<td>43 (3.2)</td>
<td>30 (2.7)</td>
<td>6 (1.4)</td>
<td>23 (0.5)</td>
</tr>
<tr>
<td>Italy</td>
<td>67 (3.6)</td>
<td>33 (3.6)</td>
<td>0 (0.0)</td>
<td>2 (0.7)</td>
<td>31 (3.4)</td>
<td>50 (3.7)</td>
<td>17 (2.6)</td>
<td>25 (0.5)</td>
</tr>
<tr>
<td>Lebanon</td>
<td>18 (1.7)</td>
<td>82 (1.7)</td>
<td>4 (1.4)</td>
<td>21 (2.3)</td>
<td>29 (4.9)</td>
<td>23 (3.7)</td>
<td>23 (2.3)</td>
<td>25 (0.6)</td>
</tr>
<tr>
<td>Norway</td>
<td>25 (4.5)</td>
<td>75 (4.5)</td>
<td>3 (1.5)</td>
<td>24 (4.9)</td>
<td>25 (3.3)</td>
<td>20 (3.1)</td>
<td>29 (5.9)</td>
<td>20 (1.6)</td>
</tr>
<tr>
<td>Portugal</td>
<td>75 (2.8)</td>
<td>25 (2.8)</td>
<td>0 (0.0)</td>
<td>12 (2.6)</td>
<td>44 (3.4)</td>
<td>39 (3.3)</td>
<td>6 (1.6)</td>
<td>25 (0.5)</td>
</tr>
<tr>
<td>Russian Federation</td>
<td>96 (1.2)</td>
<td>4 (1.2)</td>
<td>1 (0.7)</td>
<td>7 (1.5)</td>
<td>35 (3.4)</td>
<td>39 (3.2)</td>
<td>17 (2.8)</td>
<td>28 (0.6)</td>
</tr>
<tr>
<td>Russian Federation 6hr+</td>
<td>91 (2.1)</td>
<td>9 (2.1)</td>
<td>2 (1.1)</td>
<td>5 (1.6)</td>
<td>39 (4.4)</td>
<td>41 (4.8)</td>
<td>14 (2.9)</td>
<td>28 (0.7)</td>
</tr>
<tr>
<td>Slovenia</td>
<td>75 (3.1)</td>
<td>25 (3.1)</td>
<td>1 (0.8)</td>
<td>24 (3.8)</td>
<td>35 (3.9)</td>
<td>34 (4.1)</td>
<td>6 (1.4)</td>
<td>22 (0.8)</td>
</tr>
<tr>
<td>Sweden</td>
<td>30 (4.4)</td>
<td>70 (4.4)</td>
<td>4 (1.7)</td>
<td>20 (3.0)</td>
<td>30 (4.1)</td>
<td>21 (3.4)</td>
<td>24 (2.6)</td>
<td>18 (1.0)</td>
</tr>
<tr>
<td>United States</td>
<td>44 (4.0)</td>
<td>56 (4.0)</td>
<td>7 (2.2)</td>
<td>21 (2.7)</td>
<td>37 (3.1)</td>
<td>19 (2.2)</td>
<td>15 (3.6)</td>
<td>r 20 (0.9)</td>
</tr>
<tr>
<td>International Avg.</td>
<td>52 (1.1)</td>
<td>48 (1.1)</td>
<td>3 (0.4)</td>
<td>17 (1.0)</td>
<td>34 (1.2)</td>
<td>31 (1.1)</td>
<td>16 (1.0)</td>
<td>23 (0.3)</td>
</tr>
</tbody>
</table>

The Russian Federation 6hr+ results are for a subset of the Russian Federation students. This subset of students are in an Intensive stream that have at least 6 hours of mathematics lessons per week.

( ) Standard errors appear in parentheses. Because of rounding, some results may appear inconsistent.

An “r” indicates data are available for at least 70% but less than 85% of the students.
### Exhibit M8.5: Advanced Mathematics Teachers' Participation in Professional Development in Mathematics in the Past Two Years

**Reported by Advanced Mathematics Teachers**

Teachers could indicate participating in more than one area of professional development.

<table>
<thead>
<tr>
<th>Country</th>
<th>Mathematics Content</th>
<th>Mathematics Pedagogy/Instruction</th>
<th>Mathematics Curriculum</th>
<th>Integrating Information Technology into Mathematics</th>
<th>Improving Students' Critical Thinking or Problem Solving Skills</th>
<th>Mathematics Assessment</th>
<th>Addressing Individual Students' Needs</th>
</tr>
</thead>
<tbody>
<tr>
<td>France</td>
<td>33 (3.2)</td>
<td>36 (3.3)</td>
<td>27 (3.0)</td>
<td>32 (3.2)</td>
<td>12 (2.0)</td>
<td>15 (2.9)</td>
<td>12 (2.1)</td>
</tr>
<tr>
<td>Italy</td>
<td>41 (4.0)</td>
<td>50 (3.7)</td>
<td>28 (3.3)</td>
<td>48 (3.6)</td>
<td>12 (2.4)</td>
<td>17 (3.1)</td>
<td>19 (3.3)</td>
</tr>
<tr>
<td>Lebanon</td>
<td>47 (4.8)</td>
<td>54 (3.4)</td>
<td>41 (4.2)</td>
<td>55 (3.2)</td>
<td>49 (3.4)</td>
<td>50 (3.4)</td>
<td>42 (2.8)</td>
</tr>
<tr>
<td>Norway</td>
<td>18 (4.3)</td>
<td>20 (4.3)</td>
<td>26 (3.8)</td>
<td>49 (4.5)</td>
<td>5 (2.3)</td>
<td>28 (4.4)</td>
<td>9 (3.2)</td>
</tr>
<tr>
<td>Portugal</td>
<td>77 (2.9)</td>
<td>55 (3.3)</td>
<td>70 (3.2)</td>
<td>56 (3.5)</td>
<td>14 (2.5)</td>
<td>33 (3.1)</td>
<td>10 (2.0)</td>
</tr>
<tr>
<td>Russian Federation</td>
<td>73 (2.6)</td>
<td>79 (2.3)</td>
<td>78 (2.4)</td>
<td>71 (2.6)</td>
<td>42 (3.5)</td>
<td>56 (3.2)</td>
<td>49 (3.5)</td>
</tr>
<tr>
<td>Russian Federation 6hr+</td>
<td>65 (4.7)</td>
<td>77 (4.4)</td>
<td>68 (4.7)</td>
<td>66 (5.0)</td>
<td>41 (4.5)</td>
<td>54 (3.3)</td>
<td>46 (4.3)</td>
</tr>
<tr>
<td>Slovenia</td>
<td>72 (3.0)</td>
<td>39 (4.3)</td>
<td>24 (3.7)</td>
<td>65 (3.2)</td>
<td>38 (3.1)</td>
<td>22 (3.5)</td>
<td>17 (2.8)</td>
</tr>
<tr>
<td>Sweden</td>
<td>41 (3.9)</td>
<td>67 (4.0)</td>
<td>38 (4.2)</td>
<td>37 (5.3)</td>
<td>41 (4.4)</td>
<td>66 (4.0)</td>
<td>19 (2.3)</td>
</tr>
<tr>
<td>United States</td>
<td>r 66 (3.3)</td>
<td>r 65 (3.4)</td>
<td>r 70 (3.7)</td>
<td>r 56 (3.3)</td>
<td>r 56 (4.2)</td>
<td>r 47 (3.7)</td>
<td>r 53 (4.2)</td>
</tr>
<tr>
<td>International Avg.</td>
<td>52 (1.2)</td>
<td>52 (1.2)</td>
<td>45 (1.2)</td>
<td>52 (1.2)</td>
<td>30 (1.1)</td>
<td>37 (1.2)</td>
<td>25 (1.0)</td>
</tr>
</tbody>
</table>

The Russian Federation 6hr+ results are for a subset of the Russian Federation students. This subset of students are in an intensive stream that have at least 6 hours of mathematics lessons per week.

( ) Standard errors appear in parentheses. Because of rounding some results may appear inconsistent.

An “r” indicates data are available for at least 70% but less than 85% of the students.

**SOURCE:** IEA's Trends in International Mathematics and Science Study – TIMSS Advanced 2015
### Exhibit M8.6: Principals’ Formal Education*

<table>
<thead>
<tr>
<th>Country</th>
<th>Completed Postgraduate University Degree**</th>
<th>Completed Bachelor’s Degree or Equivalent but Not a Postgraduate Degree</th>
<th>Did Not Complete Bachelor’s Degree</th>
</tr>
</thead>
<tbody>
<tr>
<td>France</td>
<td>73 (4.0)</td>
<td>25 (4.0)</td>
<td>1 (1.1)</td>
</tr>
<tr>
<td>Italy</td>
<td>27 (4.5)</td>
<td>69 (4.4)</td>
<td>4 (2.0)</td>
</tr>
<tr>
<td>Lebanon</td>
<td>71 (4.3)</td>
<td>27 (4.2)</td>
<td>3 (0.5)</td>
</tr>
<tr>
<td>Norway</td>
<td>70 (6.1)</td>
<td>30 (6.1)</td>
<td>0 (0.0)</td>
</tr>
<tr>
<td>Portugal</td>
<td>38 (4.0)</td>
<td>62 (4.0)</td>
<td>0 (0.0)</td>
</tr>
<tr>
<td>Russian Federation</td>
<td>85 (2.5)</td>
<td>15 (2.5)</td>
<td>0 (0.0)</td>
</tr>
<tr>
<td>Russian Federation 6hr+</td>
<td>91 (3.8)</td>
<td>9 (3.8)</td>
<td>0 (0.0)</td>
</tr>
<tr>
<td>Slovenia</td>
<td>100 (0.0)</td>
<td>0 (0.0)</td>
<td>0 (0.0)</td>
</tr>
<tr>
<td>Sweden</td>
<td>49 (5.1)</td>
<td>47 (5.1)</td>
<td>4 (1.5)</td>
</tr>
<tr>
<td>United States</td>
<td>99 (0.7)</td>
<td>1 (0.7)</td>
<td>0 (0.0)</td>
</tr>
<tr>
<td>International Avg.</td>
<td>68 (1.3)</td>
<td>31 (1.3)</td>
<td>1 (0.3)</td>
</tr>
</tbody>
</table>

* Based on countries’ categorizations according to UNESCO’s International Standard Classification of Education (Operational Manual for ISCED-2011).

** For example, doctorate, master’s, or other postgraduate degree.

The Russian Federation 6hr+ results are for a subset of the Russian Federation students. This subset of students are in an intensive stream that have at least 6 hours of mathematics lessons per week.

( ) Standard errors appear in parentheses. Because of rounding some results may appear inconsistent.

An “r” indicates data are available for at least 70% but less than 85% of the students.
### Exhibit M8.7: Principals’ Years of Experience

**Reported by Principals**

<table>
<thead>
<tr>
<th>Country</th>
<th>Percent of Students by Principal Years of Experience as a Principal</th>
<th>Average Years of Experience as a Principal</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>20 Years or More</td>
<td>At Least 10 but Less than 20 Years</td>
</tr>
<tr>
<td>France</td>
<td>14 (2.7)</td>
<td>31 (4.1)</td>
</tr>
<tr>
<td>Italy</td>
<td>17 (3.6)</td>
<td>28 (4.5)</td>
</tr>
<tr>
<td>Lebanon</td>
<td>33 (5.1)</td>
<td>20 (2.7)</td>
</tr>
<tr>
<td>Norway</td>
<td>r</td>
<td>37 (9.0)</td>
</tr>
<tr>
<td>Portugal</td>
<td>17 (2.6)</td>
<td>33 (3.4)</td>
</tr>
<tr>
<td>Russian Federation</td>
<td>20 (2.5)</td>
<td>31 (3.6)</td>
</tr>
<tr>
<td>Russian Federation 6hr+</td>
<td>25 (3.9)</td>
<td>35 (4.8)</td>
</tr>
<tr>
<td>Slovenia</td>
<td>12 (3.6)</td>
<td>33 (3.6)</td>
</tr>
<tr>
<td>Sweden</td>
<td>5 (2.5)</td>
<td>29 (3.8)</td>
</tr>
<tr>
<td>United States</td>
<td>r</td>
<td>10 (2.7)</td>
</tr>
<tr>
<td>International Avg.</td>
<td>18 (1.4)</td>
<td>30 (1.5)</td>
</tr>
</tbody>
</table>

**SOURCE:** IEA’s Trends in International Mathematics and Science Study – TIMSS Advanced 2015

The Russian Federation 6hr+ results are for a subset of the Russian Federation students. This subset of students are in an intensive stream that have at least 6 hours of mathematics lessons per week.

( ) Standard errors appear in parentheses. Because of rounding some results may appear inconsistent.

An “r” indicates data are available for at least 70% but less than 85% of the students.
Curriculum

Covering a rigorous curriculum is key in students’ opportunity to learn.

Eight of the nine countries participating in TIMSS Advanced had a national curriculum, with the United States being the exception. All but two (Sweden and the United States) had a “high stakes” test for students nearing the completion of secondary school.

There was variation in topic coverage within content domains. However, according to their teachers, on average, most Advanced Mathematics students had been taught the TIMSS Advanced topics.

Algebra Topics: 94%  
Calculus Topics: 92%  
Geometry Topics: 97%

Instructional Time

Instructional time remains a crucial resource in considering students’ opportunity to learn in their final year, even though there are many factors that influence the effectiveness of an educational system.

There was a considerable range in the yearly number of instructional hours in advanced mathematics.

Across the TIMSS Advanced countries there was a wide range in access to digital devices to use in advanced mathematics lessons, with 78% of students on average having digital devices available.

There was a considerable range in the yearly number of instructional hours in advanced mathematics. Students also studied outside of school: Large percentages of Advanced Mathematics students reported attending extra tutoring outside of school to improve their achievement.

Technology

There is a continuing debate about the role of technology in education, and more particularly in mathematics classes.

Across the TIMSS Advanced countries there was a considerable range in the yearly number of instructional hours in advanced mathematics. Students also studied outside of school: Large percentages of Advanced Mathematics students reported attending extra tutoring outside of school to improve their achievement.

Students used the Internet for their TIMSS Advanced school work primarily to:

- Find information about mathematics concepts or solve problems
- Access course materials and do homework

Teachers have students use their digital devices primarily to draw graphs of functions (68%) and solve equations (63%).
**Exhibit M9.1: Instructional Time Spent on Advanced Mathematics**

*Reported by Principals and Advanced Mathematics Teachers*

<table>
<thead>
<tr>
<th>Country</th>
<th>Total Instructional Hours per Year</th>
<th>Hours per Year for Advanced Mathematics Instruction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lebanon</td>
<td>931 (11.2)</td>
<td>242 (7.8)</td>
</tr>
<tr>
<td>France</td>
<td>1340 (22.5)</td>
<td>r 222 (4.3)</td>
</tr>
<tr>
<td>Russian Federation 6hr+</td>
<td>r 942 (14.4)</td>
<td>207 (4.2)</td>
</tr>
<tr>
<td>Portugal</td>
<td>r 1073 (32.3)</td>
<td>186 (3.6)</td>
</tr>
<tr>
<td>Russian Federation</td>
<td>914 (8.9)</td>
<td>178 (2.1)</td>
</tr>
<tr>
<td>United States</td>
<td>1111 (13.3)</td>
<td>r 156 (4.3)</td>
</tr>
<tr>
<td>Norway</td>
<td>r 1033 (19.8)</td>
<td>r 149 (5.7)</td>
</tr>
<tr>
<td>Sweden</td>
<td>901 (12.9)</td>
<td>141 (4.2)</td>
</tr>
<tr>
<td>Slovenia</td>
<td>902 (10.6)</td>
<td>131 (1.8)</td>
</tr>
<tr>
<td>Italy</td>
<td>r 1036 (9.6)</td>
<td>130 (2.1)</td>
</tr>
<tr>
<td><strong>International Avg.</strong></td>
<td>1027 (5.8)</td>
<td>171 (1.5)</td>
</tr>
</tbody>
</table>

The Russian Federation 6hr+ results are for a subset of the Russian Federation students. This subset of students are in an intensive stream that have at least 6 hours of mathematics lessons per week.

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An "r" indicates data are available for at least 70% but less than 85% of the students.

![Diagram](image)

**SOURCE:** IEA’s Trends in International Mathematics and Science Study – TIMSS Advanced 2015

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**Exhibit M9.1 Diagram Explanation:**

- **Total Instructional Hours per Year**
  - Principal Reports of School Days per Year
  - Teacher Reports of Weekly Advanced Mathematics Instructional Hours
- **Hours per Year for Advanced Mathematics Instruction**
  - Principal Reports of School Days per Week
  - Principal Reports of Instructional Hours per Day
  - Principal Reports of School Days per Year

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**IEA**

**International Study Center**

Lynch School of Education, Boston College

Downloaded from timss2015.org/advanced/download-center/
### Exhibit M9.2: Types of Homework Assignments

**Reported by Advanced Mathematics Teachers**

<table>
<thead>
<tr>
<th>Country</th>
<th>Mathematics Homework Assigned to Class</th>
<th>Percent of Students Whose Teachers “Sometimes” or “Always or Almost Always” Assign Each Type of Homework</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Yes</td>
<td>Average Achievement</td>
</tr>
<tr>
<td>France</td>
<td>100 (0.0)</td>
<td>461 (3.1)</td>
</tr>
<tr>
<td>Italy</td>
<td>98 (0.9)</td>
<td>424 (5.7)</td>
</tr>
<tr>
<td>Lebanon</td>
<td>93 (1.9)</td>
<td>531 (3.2)</td>
</tr>
<tr>
<td>Norway</td>
<td>94 (2.4)</td>
<td>461 (4.7)</td>
</tr>
<tr>
<td>Portugal</td>
<td>96 (1.6)</td>
<td>484 (2.6)</td>
</tr>
<tr>
<td>Russian Federation</td>
<td>100 (0.0)</td>
<td>484 (5.8)</td>
</tr>
<tr>
<td>Russian Federation 6hr+</td>
<td>100 (0.0)</td>
<td>540 (8.1)</td>
</tr>
<tr>
<td>Slovenia</td>
<td>97 (1.0)</td>
<td>460 (3.7)</td>
</tr>
<tr>
<td>Sweden</td>
<td>62 (4.4)</td>
<td>431 (5.4)</td>
</tr>
<tr>
<td>United States</td>
<td>r 98 (1.4)</td>
<td>485 (5.8)</td>
</tr>
<tr>
<td>International Avg.</td>
<td>93 (0.7)</td>
<td>469 (1.5)</td>
</tr>
</tbody>
</table>

The Russian Federation 6hr+ results are for a subset of the Russian Federation students. This subset of students are in an intensive stream that have at least 6 hours of mathematics lessons per week.

( ) Standard errors appear in parentheses. Because of rounding some results may appear inconsistent.

A tilde (~) indicates insufficient data to report achievement.

An “r” indicates data are available for at least 70% but less than 85% of the students.

SOURCE: IEA’s Trends in International Mathematics and Science Study – TIMSS Advanced 2015
### Exhibit M9.3: Students Attended Extra Tutoring in Advanced Mathematics Not Provided by the School

**Reported by Advanced Mathematics Students**

<table>
<thead>
<tr>
<th>Country</th>
<th>Students Did Not Attend Extra Tutoring</th>
<th>Students Attended Extra Tutoring</th>
<th>Reasons for Attending Extra Tutoring (Students Could Indicate More than One)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Percent of Students</td>
<td>Average Achievement</td>
<td>Percent of Students</td>
</tr>
<tr>
<td>France</td>
<td>65 (1.0)</td>
<td>476 (3.2)</td>
<td>35 (1.0)</td>
</tr>
<tr>
<td>Italy</td>
<td>67 (1.2)</td>
<td>434 (5.7)</td>
<td>33 (1.2)</td>
</tr>
<tr>
<td>Lebanon</td>
<td>84 (1.4)</td>
<td>540 (3.0)</td>
<td>16 (1.4)</td>
</tr>
<tr>
<td>Norway</td>
<td>93 (0.8)</td>
<td>462 (4.6)</td>
<td>7 (0.8)</td>
</tr>
<tr>
<td>Portugal</td>
<td>39 (1.5)</td>
<td>491 (3.4)</td>
<td>61 (1.5)</td>
</tr>
<tr>
<td>Russian Federation</td>
<td>33 (1.3)</td>
<td>491 (7.3)</td>
<td>67 (1.3)</td>
</tr>
<tr>
<td>Russian Federation 6hr+</td>
<td>38 (2.8)</td>
<td>553 (8.6)</td>
<td>62 (2.8)</td>
</tr>
<tr>
<td>Slovenia</td>
<td>70 (1.2)</td>
<td>481 (3.3)</td>
<td>30 (1.2)</td>
</tr>
<tr>
<td>Sweden</td>
<td>89 (0.7)</td>
<td>438 (4.0)</td>
<td>11 (0.7)</td>
</tr>
<tr>
<td>United States</td>
<td>88 (0.9)</td>
<td>489 (5.4)</td>
<td>12 (0.9)</td>
</tr>
<tr>
<td>International Avg.</td>
<td>70 (0.4)</td>
<td>478 (1.5)</td>
<td>30 (0.4)</td>
</tr>
</tbody>
</table>

The Russian Federation 6hr+ results are for a subset of the Russian Federation students. This subset of students are in an intensive stream that have at least 6 hours of mathematics lessons per week.

( ) Standard errors appear in parentheses. Because of rounding some results may appear inconsistent.
### Exhibit M9.4: Examinations with Consequences for Students in Advanced Mathematics Programs (Tracks)

**Reported by National Research Coordinators**

<table>
<thead>
<tr>
<th>Country</th>
<th>Examinations with Consequences for Individual Students</th>
<th>Grades at Which Examinations with Consequences for Individual Students are Given</th>
<th>Format of Examinations with Consequences for Individual Students</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>France</td>
<td>●</td>
<td>Grade 12</td>
<td>Written and/or oral examinations</td>
<td>Each subject examination grade is weighted differently according to the track students are attending. In the scientific track, mathematics and other science grades altogether are weighted as much as half the student’s total grade average.</td>
</tr>
<tr>
<td>Italy</td>
<td>●</td>
<td>Grades 8 and 13</td>
<td>Written and oral examinations</td>
<td>Final examinations for technical and vocational secondary schools (Grade 13) also give students an opportunity to find a job.</td>
</tr>
<tr>
<td>Lebanon</td>
<td>●</td>
<td>Grade 12</td>
<td>Written examinations</td>
<td>At the end of the third year of the secondary cycle or Grade 12, students have to pass the Official Baccalaureate exams for four sections—life sciences, general sciences, economics, and humanities. The purpose of these exams is for the students to be able to continue with their university studies.</td>
</tr>
<tr>
<td>Norway</td>
<td>●</td>
<td>Grades 12 and 13</td>
<td>Written or oral examinations</td>
<td>A written examination is set and marked centrally (at national level) and an oral examination is prepared and marked locally. About 40% of the first year (Mathematics R1) students and about 60% of the second year (Mathematics R2) students are sampled for the national written examination. For the local oral examination, about 5% and 15% of the students in the respective courses are sampled for testing.</td>
</tr>
<tr>
<td>Portugal</td>
<td>●</td>
<td>Grades 9 and 12</td>
<td>Written examinations</td>
<td>Nationwide final examinations are produced by an independent educational assessment public institute (IAVE, I. P.). The application and scoring of the examinations is coordinated by a National Exam Jury Board under the supervision of the General Education Directorate of the Ministry of Education.</td>
</tr>
<tr>
<td>Russian Federation</td>
<td>●</td>
<td>Grade 11</td>
<td>Written examinations</td>
<td>Tests for the compulsory state examination in Grade 11 are given at both the Basic and Profile levels, and all graduates are offered a choice to take one of these exams, no matter what course they studied in Grades 10 and 11.</td>
</tr>
<tr>
<td>Slovenia</td>
<td>●</td>
<td>End of upper-secondary education</td>
<td>There are several examination formats— written only; both written and oral; both written and practical; written, oral and practical; practical only; and an examination presentation.</td>
<td>Achievement on the Matura examination and achievement in the last two years of schooling are used to select students where there is a limit to the number of candidates for a university program. The Matura is prepared and administered by the National Examination Center.</td>
</tr>
<tr>
<td>Sweden</td>
<td>○</td>
<td>n/a</td>
<td>Compulsory national tests are developed by the Swedish National Agency for Education, which is the educational authority appointed by the National Ministry of Education for the administration of the school system. These national tests do not have direct consequences for the students because they are intended only to support teachers’ assessment of students.</td>
<td></td>
</tr>
<tr>
<td>United States</td>
<td>○</td>
<td>n/a</td>
<td>Compulsory national tests are developed by the Swedish National Agency for Education, which is the educational authority appointed by the National Ministry of Education for the administration of the school system. These national tests do not have direct consequences for the students because they are intended only to support teachers’ assessment of students.</td>
<td>Although there are no national exams with consequences for individual students, many high school students take Advanced Placement (AP) or International Baccalaureate (IB) courses that culminate with an end-of-course exam. Students can take these AP or IB written exams at a price and, if they score well, can earn course credit at many colleges and universities. In addition, to apply for admission to most colleges and universities in the United States, students in Grades 11 and 12 take written exams to demonstrate their readiness for college-level work. Private companies (e.g., ACT, College Board) offer these exams in different subjects to students for a price.</td>
</tr>
</tbody>
</table>

○ Yes  
● No
### Exhibit M9.5: Characteristics and Methods Used to Evaluate the Advanced Mathematics Curriculum

**Reported by National Research Coordinators**

<table>
<thead>
<tr>
<th>Country</th>
<th>National Curriculum</th>
<th>Year Introduced</th>
<th>Being Revised</th>
<th>Visits by Inspectors</th>
<th>Research Programs</th>
<th>School Self-Evaluation</th>
<th>National or Regional Assessments</th>
</tr>
</thead>
<tbody>
<tr>
<td>France</td>
<td>●</td>
<td>2011</td>
<td>○</td>
<td>●</td>
<td>○</td>
<td>○</td>
<td>●</td>
</tr>
<tr>
<td>Italy</td>
<td>●</td>
<td>2010</td>
<td>○</td>
<td>○</td>
<td>●</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>Lebanon</td>
<td>●</td>
<td>2001</td>
<td>○</td>
<td>●</td>
<td>○</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>Norway</td>
<td>●</td>
<td>2006</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>●</td>
</tr>
<tr>
<td>Portugal</td>
<td>●</td>
<td>2003</td>
<td>●</td>
<td>○</td>
<td>○</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>Russian Federation</td>
<td>●</td>
<td>2004</td>
<td>●</td>
<td>○</td>
<td>●</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>Slovenia</td>
<td>●</td>
<td>2008</td>
<td>○</td>
<td>○</td>
<td>●</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>Sweden</td>
<td>●</td>
<td>2011</td>
<td>○</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>United States</td>
<td>○</td>
<td></td>
<td>Varies by school and by course</td>
<td>●</td>
<td>Varies by state</td>
<td>●</td>
<td>●</td>
</tr>
</tbody>
</table>

- ● Yes
- ○ No

**Source:** IEA's Trends in International Mathematics and Science Study – TIMSS Advanced 2015
### Exhibit M9.6: Number of TIMSS Advanced Advanced Mathematics Topics in the Intended Curriculum

<table>
<thead>
<tr>
<th>Country</th>
<th>All Advanced Mathematics (19 topics)</th>
<th>Algebra (8 topics)</th>
<th>Calculus (7 topics)</th>
<th>Geometry (4 topics)</th>
</tr>
</thead>
<tbody>
<tr>
<td>France</td>
<td>18</td>
<td>8</td>
<td>6</td>
<td>4</td>
</tr>
<tr>
<td>Italy</td>
<td>19</td>
<td>8</td>
<td>7</td>
<td>4</td>
</tr>
<tr>
<td>Lebanon</td>
<td>19</td>
<td>8</td>
<td>7</td>
<td>4</td>
</tr>
<tr>
<td>Norway</td>
<td>18</td>
<td>7</td>
<td>7</td>
<td>4</td>
</tr>
<tr>
<td>Portugal</td>
<td>18</td>
<td>8</td>
<td>6</td>
<td>4</td>
</tr>
<tr>
<td>Russian Federation</td>
<td>16</td>
<td>8</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Russian Federation 6hr+</td>
<td>19</td>
<td>8</td>
<td>7</td>
<td>4</td>
</tr>
<tr>
<td>Slovenia</td>
<td>19</td>
<td>8</td>
<td>7</td>
<td>4</td>
</tr>
<tr>
<td>Sweden</td>
<td>17</td>
<td>8</td>
<td>5</td>
<td>4</td>
</tr>
<tr>
<td>United States</td>
<td>19</td>
<td>8</td>
<td>7</td>
<td>4</td>
</tr>
</tbody>
</table>

The Russian Federation 6hr+ results are for a subset of the Russian Federation students. This subset of students are in an intensive stream that have at least 6 hours of mathematics lessons per week.

In the United States, the number of TIMSS Advanced mathematics topics covered varies by state and course type. The data shown in this table reflect the maximum number of topics that may be covered in each content domain.

---

**TIMSS Advanced 2015 Advanced Mathematics Topics**

**A. Algebra**
1. Operations with exponential, logarithmic, polynomial, rational, and radical expressions
2. Operations with complex numbers
3. Evaluating algebraic expressions
4. The $n$th term of arithmetic and geometric sequences and the sums of finite and infinite series
5. Linear, simultaneous, and quadratic equations and inequalities; radical expressions, logarithmic, and exponential equations
6. Slopes, $y$-axis intercepts, and points of intersection of straight lines
7. Equivalent representations of functions, including composite functions, as ordered pairs, tables, graphs, formulas, or words
8. Properties of functions including domain and range

**B. Calculus**
1. Limits of functions
2. Conditions for continuity and differentiability of functions
3. Differentiation of functions; differentiation of products, quotients, and composite functions
4. Using derivatives to solve problems
5. Using first and second derivatives to determine slope and local extrema of functions
6. Using derivatives to determine points of inflection of functions
7. Integrating functions; evaluating definite integrals, including calculation of areas

**C. Geometry**
1. Properties of geometric figures in two and three dimensions
2. Properties of vectors and their sums and differences
3. Trigonometric properties of triangles (sine, cosine, and tangent)
4. Trigonometric functions and their graphs
### Exhibit M9.7: Percentages of Students Taught* the TIMSS Advanced Topics in Algebra, Calculus, and Geometry

#### Algebra Topics

*Reported by Advanced Mathematics Teachers*

<table>
<thead>
<tr>
<th>Country</th>
<th>Operations with Expressions</th>
<th>Operations with Complex Numbers</th>
<th>Evaluating Algebraic Expressions</th>
<th>Sequences and Series</th>
<th>Equations and Inequalities</th>
<th>Straight Lines</th>
<th>Representations of Functions</th>
<th>Properties of Functions</th>
</tr>
</thead>
<tbody>
<tr>
<td>France</td>
<td>99 (0.4)</td>
<td>99 (0.4)</td>
<td>98 (0.5)</td>
<td>97 (1.0)</td>
<td>99 (0.4)</td>
<td>96 (1.1)</td>
<td>98 (0.7)</td>
<td></td>
</tr>
<tr>
<td>Italy</td>
<td>100 (0.0)</td>
<td>71 (3.9)</td>
<td>99 (0.6)</td>
<td>48 (3.2)</td>
<td>100 (0.0)</td>
<td>100 (0.0)</td>
<td>94 (1.7)</td>
<td>99 (0.8)</td>
</tr>
<tr>
<td>Lebanon</td>
<td>99 (0.1)</td>
<td>100 (0.1)</td>
<td>99 (0.1)</td>
<td>98 (0.6)</td>
<td>100 (0.0)</td>
<td>98 (0.8)</td>
<td>93 (1.7)</td>
<td>97 (1.2)</td>
</tr>
<tr>
<td>Norway</td>
<td>98 (1.5)</td>
<td>8 (3.1)</td>
<td>98 (1.5)</td>
<td>80 (3.8)</td>
<td>99 (0.4)</td>
<td>98 (1.5)</td>
<td>96 (1.8)</td>
<td>98 (1.5)</td>
</tr>
<tr>
<td>Portugal</td>
<td>100 (0.0)</td>
<td>74 (3.7)</td>
<td>100 (0.0)</td>
<td>68 (3.2)</td>
<td>100 (0.0)</td>
<td>100 (0.0)</td>
<td>100 (0.0)</td>
<td>100 (0.0)</td>
</tr>
<tr>
<td>Russian Federation</td>
<td>- -</td>
<td>- -</td>
<td>- -</td>
<td>- -</td>
<td>- -</td>
<td>- -</td>
<td>- -</td>
<td>- -</td>
</tr>
<tr>
<td>Russian Federation 6hr+</td>
<td>- -</td>
<td>- -</td>
<td>- -</td>
<td>- -</td>
<td>- -</td>
<td>- -</td>
<td>- -</td>
<td>- -</td>
</tr>
<tr>
<td>Slovenia</td>
<td>100 (0.5)</td>
<td>100 (0.5)</td>
<td>100 (0.5)</td>
<td>100 (0.5)</td>
<td>100 (0.5)</td>
<td>100 (0.0)</td>
<td>100 (0.0)</td>
<td>96 (1.5)</td>
</tr>
<tr>
<td>Sweden</td>
<td>100 (0.0)</td>
<td>76 (4.4)</td>
<td>100 (0.3)</td>
<td>45 (4.3)</td>
<td>100 (0.0)</td>
<td>100 (0.0)</td>
<td>100 (0.3)</td>
<td>100 (0.0)</td>
</tr>
<tr>
<td>United States</td>
<td>r 100 (0.3)</td>
<td>r 98 (1.3)</td>
<td>r 100 (0.3)</td>
<td>r 88 (2.8)</td>
<td>r 100 (0.3)</td>
<td>r 100 (0.0)</td>
<td>r 100 (0.0)</td>
<td>r 100 (0.0)</td>
</tr>
<tr>
<td>International Avg.</td>
<td>99 (0.2)</td>
<td>78 (1.0)</td>
<td>99 (0.2)</td>
<td>78 (1.0)</td>
<td>100 (0.1)</td>
<td>99 (0.2)</td>
<td>97 (0.4)</td>
<td>99 (0.3)</td>
</tr>
</tbody>
</table>

* Percentage mostly taught before or in the assessment year.

The Russian Federation 6hr+ results are for a subset of the Russian Federation students. This subset of students are in an intensive stream that have at least 6 hours of mathematics lessons per week.

( ) Standard errors appear in parentheses. Because of rounding some results may appear inconsistent.

A dash (-) indicates comparable data not available.

An “r” indicates data are available for at least 70% but less than 85% of the students.

---

**TIMSS Advanced 2015 Algebra Topics**

1. **Operations with Expressions**: Operations with exponential, logarithmic, polynomial, rational, and radical expressions
2. **Operations with Complex Numbers**
3. **Evaluating Algebraic Expressions**
4. **Sequences and Series**: The n<sup>th</sup> term of arithmetic and geometric sequences and the sums of finite and infinite series
5. **Equations and Inequalities**: Linear, simultaneous, and quadratic equations and inequalities; radical expressions, logarithmic, and exponential functions
6. **Straight Lines**: Slopes, y-axis intercepts, and points of intersection of straight lines
7. **Representations of Functions**: Equivalent representations of functions, including composite functions, as ordered pairs, tables, graphs, formulas, or words
8. **Properties of Functions**: Properties of functions, including domain and range
**Exhibit M9.7: Percentages of Students Taught* the TIMSS Advanced Topics in Algebra, Calculus, and Geometry (Continued)**

**Calculus Topics**

*Reported by Advanced Mathematics Teachers*

<table>
<thead>
<tr>
<th>Country</th>
<th>Limits of Functions</th>
<th>Continuity and Differentiability</th>
<th>Differentiation</th>
<th>Using Derivatives</th>
<th>Slope and Local Extrema</th>
<th>Points of Inflection</th>
<th>Integrating Functions</th>
</tr>
</thead>
<tbody>
<tr>
<td>France</td>
<td>99 (0.4)</td>
<td>94 (1.4)</td>
<td>98 (0.5)</td>
<td>99 (0.4)</td>
<td>90 (2.0)</td>
<td>17 (2.4)</td>
<td>99 (0.4)</td>
</tr>
<tr>
<td>Italy</td>
<td>100 (0.0)</td>
<td>99 (0.3)</td>
<td>100 (0.0)</td>
<td>84 (2.8)</td>
<td>100 (0.3)</td>
<td>99 (0.4)</td>
<td>73 (2.9)</td>
</tr>
<tr>
<td>Lebanon</td>
<td>100 (0.1)</td>
<td>99 (0.1)</td>
<td>97 (0.8)</td>
<td>95 (1.1)</td>
<td>99 (0.5)</td>
<td>100 (0.1)</td>
<td>99 (0.1)</td>
</tr>
<tr>
<td>Norway</td>
<td>98 (1.5)</td>
<td>97 (2.0)</td>
<td>99 (1.4)</td>
<td>98 (1.6)</td>
<td>98 (1.5)</td>
<td>98 (1.5)</td>
<td>96 (1.7)</td>
</tr>
<tr>
<td>Portugal</td>
<td>99 (0.5)</td>
<td>99 (0.7)</td>
<td>96 (1.5)</td>
<td>100 (0.0)</td>
<td>100 (0.1)</td>
<td>100 (0.1)</td>
<td>1 (0.5)</td>
</tr>
<tr>
<td>Russian Federation</td>
<td>- -</td>
<td>- -</td>
<td>- -</td>
<td>- -</td>
<td>- -</td>
<td>- -</td>
<td>- -</td>
</tr>
<tr>
<td>Russian Federation 6hr+</td>
<td>- -</td>
<td>- -</td>
<td>- -</td>
<td>- -</td>
<td>- -</td>
<td>- -</td>
<td>- -</td>
</tr>
<tr>
<td>Slovenia</td>
<td>98 (1.0)</td>
<td>94 (1.9)</td>
<td>97 (0.9)</td>
<td>82 (3.2)</td>
<td>96 (1.4)</td>
<td>77 (3.1)</td>
<td>74 (1.8)</td>
</tr>
<tr>
<td>Sweden</td>
<td>99 (0.6)</td>
<td>97 (1.2)</td>
<td>100 (0.0)</td>
<td>100 (0.4)</td>
<td>100 (0.0)</td>
<td>79 (3.7)</td>
<td>98 (1.1)</td>
</tr>
<tr>
<td>United States</td>
<td>r 99 (0.6)</td>
<td>r 98 (0.7)</td>
<td>r 97 (1.4)</td>
<td>r 96 (1.5)</td>
<td>r 96 (1.7)</td>
<td>r 96 (1.7)</td>
<td>r 89 (2.6)</td>
</tr>
<tr>
<td>International Avg.</td>
<td>99 (0.3)</td>
<td>97 (0.4)</td>
<td>98 (0.4)</td>
<td>94 (0.6)</td>
<td>97 (0.4)</td>
<td>83 (0.7)</td>
<td>79 (0.6)</td>
</tr>
</tbody>
</table>

* Percentage mostly taught before or in the assessment year.

The Russian Federation 6hr+ results are for a subset of the Russian Federation students. This subset of students are in an intensive stream that have at least 6 hours of mathematics lessons per week.

( ) Standard errors appear in parentheses. Because of rounding some results may appear inconsistent.

A dash (-) indicates comparable data not available.

An “r” indicates data are available for at least 70% but less than 85% of the students.

---

**TIMSS Advanced 2015 Calculus Topics**

1. Limits of Functions
2. Continuity and Differentiability: Conditions for continuity and differentiability of functions
3. Differentiation: Differentiation of functions; differentiation of products, quotients, and composite functions
4. Using Derivatives: Using derivatives to solve problems
5. Slope and Local Extrema: Using first and second derivatives to determine slope and local extrema of functions
6. Points of Inflection: Using derivatives to determine points of inflection of functions
7. Integrating Functions: Integrating functions; evaluating definite integrals, including calculation of areas
Exhibit M9.7: Percentages of Students Taught* the TIMSS Advanced Topics in Algebra, Calculus, and Geometry (Continued)

Geometry Topics

Reported by Advanced Mathematics Teachers

<table>
<thead>
<tr>
<th>Country</th>
<th>Properties of Geometric Figures</th>
<th>Properties of Vectors</th>
<th>Triangles</th>
<th>Trigonometric Functions</th>
</tr>
</thead>
<tbody>
<tr>
<td>France</td>
<td>96 (1.2)</td>
<td>99 (0.4)</td>
<td>98 (0.5)</td>
<td>95 (1.3)</td>
</tr>
<tr>
<td>Italy</td>
<td>89 (2.4)</td>
<td>79 (3.2)</td>
<td>99 (0.7)</td>
<td>100 (0.4)</td>
</tr>
<tr>
<td>Lebanon</td>
<td>99 (0.1)</td>
<td>100 (0.0)</td>
<td>100 (0.0)</td>
<td>97 (0.7)</td>
</tr>
<tr>
<td>Norway</td>
<td>98 (1.0)</td>
<td>100 (0.0)</td>
<td>98 (1.5)</td>
<td>100 (0.0)</td>
</tr>
<tr>
<td>Portugal</td>
<td>100 (0.1)</td>
<td>100 (0.0)</td>
<td>100 (0.0)</td>
<td>100 (0.0)</td>
</tr>
<tr>
<td>Russian Federation</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Russian Federation 6hr+</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Slovenia</td>
<td>100 (0.5)</td>
<td>100 (0.5)</td>
<td>100 (0.5)</td>
<td>100 (0.5)</td>
</tr>
<tr>
<td>Sweden</td>
<td>97 (1.1)</td>
<td>93 (1.7)</td>
<td>100 (0.0)</td>
<td>99 (0.6)</td>
</tr>
<tr>
<td>United States</td>
<td>r 97 (0.9)</td>
<td>r 70 (4.5)</td>
<td>r 100 (0.1)</td>
<td>r 99 (0.5)</td>
</tr>
<tr>
<td>International Avg.</td>
<td>97 (0.4)</td>
<td>92 (0.7)</td>
<td>99 (0.2)</td>
<td>99 (0.2)</td>
</tr>
</tbody>
</table>

* Percentage mostly taught before or in the assessment year.

The Russian Federation 6hr+ results are for a subset of the Russian Federation students. This subset of students are in an intensive stream that have at least 6 hours of mathematics lessons per week.

Standard errors appear in parentheses. Because of rounding some results may appear inconsistent.

A dash (-) indicates comparable data not available.

An “r” indicates data are available for at least 70% but less than 85% of the students.

TIMSS Advanced 2015 Geometry Topics

1. Properties of Geometric Figures: Properties of geometric figures in two and three dimensions
2. Properties of Vectors: Properties of vectors and their sums and differences
3. Triangles: Trigonometric properties of triangles (sine, cosine, and tangent)
4. Trigonometric Functions: Trigonometric functions and their graphs
### Exhibit M9.8: Percentages of Students Taught the TIMSS Advanced Advanced Mathematics Topics Averaged Across All Topics and by Content Domain*  
**Reported by Advanced Mathematics Teachers**

<table>
<thead>
<tr>
<th>Country</th>
<th>All Advanced Mathematics (19 topics)</th>
<th>Algebra (8 topics)</th>
<th>Calculus (7 topics)</th>
<th>Geometry (4 topics)</th>
</tr>
</thead>
<tbody>
<tr>
<td>France</td>
<td>93 (0.4)</td>
<td>98 (0.4)</td>
<td>85 (0.6)</td>
<td>97 (0.6)</td>
</tr>
<tr>
<td>Italy</td>
<td>91 (0.6)</td>
<td>89 (0.8)</td>
<td>94 (0.6)</td>
<td>92 (1.2)</td>
</tr>
<tr>
<td>Lebanon</td>
<td>98 (0.2)</td>
<td>98 (0.3)</td>
<td>98 (0.3)</td>
<td>99 (0.2)</td>
</tr>
<tr>
<td>Norway</td>
<td>92 (0.9)</td>
<td>84 (1.0)</td>
<td>98 (1.3)</td>
<td>99 (0.4)</td>
</tr>
<tr>
<td>Portugal</td>
<td>91 (0.3)</td>
<td>93 (0.6)</td>
<td>85 (0.3)</td>
<td>100 (0.0)</td>
</tr>
<tr>
<td>Russian Federation</td>
<td>- -</td>
<td>- -</td>
<td>- -</td>
<td>- -</td>
</tr>
<tr>
<td>Russian Federation 6hr+</td>
<td>- -</td>
<td>- -</td>
<td>- -</td>
<td>- -</td>
</tr>
<tr>
<td>Slovenia</td>
<td>95 (0.5)</td>
<td>99 (0.3)</td>
<td>88 (1.1)</td>
<td>100 (0.5)</td>
</tr>
<tr>
<td>Sweden</td>
<td>94 (0.5)</td>
<td>90 (0.9)</td>
<td>96 (0.6)</td>
<td>97 (0.6)</td>
</tr>
<tr>
<td>United States</td>
<td>r 96 (0.5)</td>
<td>r 98 (0.4)</td>
<td>r 96 (1.2)</td>
<td>r 91 (1.2)</td>
</tr>
<tr>
<td>International Avg.</td>
<td>94 (0.2)</td>
<td>94 (0.2)</td>
<td>92 (0.3)</td>
<td>97 (0.2)</td>
</tr>
</tbody>
</table>

* Percentage mostly taught before or in the assessment year.  
( ) Standard errors appear in parentheses. Because of rounding some results may appear inconsistent.  
A dash (-) indicates comparable data not available.  
An ‘r’ indicates data are available for at least 70% but less than 85% of the students.  

SOURCE: IEA’s Trend in International Mathematics and Science Study – TIMSS Advanced 2015
<table>
<thead>
<tr>
<th>Country</th>
<th>Description of National Policies for Technology Use in Advanced Mathematics Instruction</th>
<th>Description of National Policies for Technology Use in Advanced Mathematics Assessment</th>
</tr>
</thead>
<tbody>
<tr>
<td>France</td>
<td>The policy focuses on using tools such as calculators equipped with Computer Algebra Systems (CAS) in problem solving to focus students on reasoning and strategy rather than technical calculations.</td>
<td>ICT tools are allowed for in-class assessments to assess students’ capacity to use technological aids in the process of problem solving. For national examinations, students may use off-line graphing calculators.</td>
</tr>
<tr>
<td>Italy</td>
<td>Curriculum guidelines emphasize providing opportunities for students to become familiar with ICT tools and their methodological value; they are not treated as a substitute for all mental calculations.</td>
<td>Same</td>
</tr>
<tr>
<td>Lebanon</td>
<td>No policy</td>
<td>No policy</td>
</tr>
<tr>
<td>Norway</td>
<td>Digital skills in advanced mathematics involve using digital tools for comprehensive computations and visualization. This means retrieving, processing, and presenting mathematical information in electronic form. It also means evaluating the suitability, possibilities, and limitations of the digital tool.</td>
<td>Every examination in mathematics is now divided into two parts. The first part (3 hours) is solved by pen and paper only; no technological aids are allowed. The second part (2 hours) not only allows the use of some digital tools, but requires that they are applied, such as dynamic geometry programs. It is specifically stated that students in the second part of the exam shall have sophisticated electronic aids available, as long as they cannot use them to communicate.</td>
</tr>
<tr>
<td>Portugal</td>
<td>Some subjects (such as normal and binomial distributions) are always taught with graphing calculators.</td>
<td>Some advanced mathematics examinations require the use of a graphing calculator.</td>
</tr>
<tr>
<td>Russian Federation</td>
<td>The program has no direct references to the use of electronic devices in advanced mathematics courses. However, the requirements for students' attainment in the subject area “Mathematics and Informatics” include expected learning outcomes for ICT, such as using a computer to construct mathematical models of the proposed situation, conduct experiments, and conduct statistical analysis of data.</td>
<td>No policy. However, during the compulsory state exam in mathematics at Grade 11, students are not allowed to use any calculators or computers. The use of these technological aids in classroom tests depends on the teacher.</td>
</tr>
<tr>
<td>Slovenia</td>
<td>Technology is required to be used in teaching and learning. Students are required to demonstrate use of standard and specific software for mathematics. Calculators are not specifically required or described, but teachers and students should use as many devices as possible. In practice, schools require students to have their own calculator capable of symbolic calculations in two lines but not for drawing graphs.</td>
<td>The curriculum does not define the use of calculators for assessments, but on the Matura examination, for all subjects, non-programmable calculators which cannot be connected to the Internet may be used.</td>
</tr>
<tr>
<td>Sweden</td>
<td>Digital media and tools are addressed in several curriculum statements as problem solving tools. Mathematics 4 has one additional explicit notion of technology in the description of core content–algebraic and graphical methods for determining integrals with and without digital tools, including estimates of magnitudes and probability distributions.</td>
<td>The grading criteria are very similar for all courses and contain only one statement explicitly referring to technology. Students should be able to solve problems with and without digital tools.</td>
</tr>
<tr>
<td>United States</td>
<td>Policies vary by state, but most advanced mathematics courses require graphing calculators and other tools (such as spreadsheets or statistical packages) strategically when solving mathematics problems. Both AP Calculus and IB Mathematics require the use of a graphing calculator to help solve problems, experiment, interpret results, and support conclusions.</td>
<td>Policies vary by state, but some programs (such as AP and IB) have their own specifications about what kinds of calculators are permissible.</td>
</tr>
</tbody>
</table>
### Exhibit M9.10: Availability of Digital Devices in Advanced Mathematics Lessons

Digital devices may include computers, tablets, calculators, or smartphones.

<table>
<thead>
<tr>
<th>Country</th>
<th>Digital Devices Available for Students to Use in Advanced Mathematics Lessons</th>
<th>Percent of Students</th>
<th>Average Achievement</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>France</td>
<td>86</td>
<td>460</td>
<td>470 (6.6)</td>
</tr>
<tr>
<td>Italy</td>
<td>58</td>
<td>430</td>
<td>471 (10.4)</td>
</tr>
<tr>
<td>Lebanon</td>
<td>49</td>
<td>543</td>
<td>521 (3.5)</td>
</tr>
<tr>
<td>Norway</td>
<td>100</td>
<td>462</td>
<td>~ ~</td>
</tr>
<tr>
<td>Portugal</td>
<td>78</td>
<td>485</td>
<td>477 (5.6)</td>
</tr>
<tr>
<td>Russian Federation</td>
<td>64</td>
<td>486</td>
<td>480 (8.0)</td>
</tr>
<tr>
<td>Russian Federation 6hr+</td>
<td>68</td>
<td>542</td>
<td>536 (20.6)</td>
</tr>
<tr>
<td>Slovenia</td>
<td>75</td>
<td>458</td>
<td>465 (6.4)</td>
</tr>
<tr>
<td>Sweden</td>
<td>97</td>
<td>435</td>
<td>445 (8.3)</td>
</tr>
<tr>
<td>United States</td>
<td>r</td>
<td>485</td>
<td>485 (13.6)</td>
</tr>
<tr>
<td>International Avg.</td>
<td>78</td>
<td>472</td>
<td>470 (2.9)</td>
</tr>
</tbody>
</table>

The Russian Federation 6hr+ results are for a subset of the Russian Federation students. This subset of students are in an intensive stream that have at least 6 hours of mathematics lessons per week.

( ) Standard errors appear in parentheses. Because of rounding some results may appear inconsistent.

A tilde (~) indicates insufficient data to report achievement.

An “r” indicates data are available for at least 70% but less than 85% of the students.

Reported by Advanced Mathematics Teachers

For each country, the percent of students in each use category is plotted along a separate axis. The value of each point is represented as the distance from the center of the graph to illustrate the relative emphasis placed on each use of digital devices in advanced mathematics lessons. Digital devices may include computers, tablets, calculators, or smartphones.

The Russian Federation 6hr+ results are for a subset of the Russian Federation students. This subset of students are in an Intensive stream that have at least 6 hours of mathematics lessons per week.

The axis labels correspond with these ways that teachers have their students use digital devices at least monthly:
- Read: Read the Textbook or Course Materials
- Ideas: Look Up Ideas and Information
- Data: Process and Analyze Data
- Graphs: Draw Graphs of Functions
- Solve: Solve Equations
- Algebra: Manipulate Algebraic Expressions
- Models: Conduct Modeling and Simulations
- Integrate: Perform Numerical Integration

The Russian Federation 6hr+ results are for a subset of the Russian Federation students. This subset of students are in an Intensive stream that have at least 6 hours of mathematics lessons per week.

An “r” indicates data are available for at least 70% but less than 85% of the students.
### Exhibit M9.12: Percentages of Students Whose Teachers Have Them Use Digital Devices at Least Monthly in Advanced Mathematics Lessons

**Reported by Advanced Mathematics Teachers**

<table>
<thead>
<tr>
<th>Country</th>
<th>Percent of Students Whose Teachers Have Them Use Digital Devices at Least Monthly</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Read the Textbook or Course Materials</td>
</tr>
<tr>
<td>France</td>
<td>28 (2.9)</td>
</tr>
<tr>
<td>Italy</td>
<td>31 (2.9)</td>
</tr>
<tr>
<td>Lebanon</td>
<td>26 (3.8)</td>
</tr>
<tr>
<td>Norway</td>
<td>48 (6.0)</td>
</tr>
<tr>
<td>Portugal</td>
<td>30 (4.1)</td>
</tr>
<tr>
<td>Russian Federation</td>
<td>55 (4.0)</td>
</tr>
<tr>
<td>Russian Federation 6hr+</td>
<td>60 (5.2)</td>
</tr>
<tr>
<td>Slovenia</td>
<td>22 (2.5)</td>
</tr>
<tr>
<td>Sweden</td>
<td>33 (3.3)</td>
</tr>
<tr>
<td>United States</td>
<td>r 34 (4.2)</td>
</tr>
<tr>
<td>International Avg.</td>
<td>34 (1.3)</td>
</tr>
</tbody>
</table>

The Russian Federation 6hr+ results are for a subset of the Russian Federation students. This subset of students are in an intensive stream that have at least 6 hours of mathematics lessons per week.

(1) Standard errors appear in parentheses. Because of rounding some results may appear inconsistent.

An “r” indicates data are available for at least 70% but less than 85% of the students.

SOURCE: IEA’s Trends in International Mathematics and Science Study – TIMSS Advanced 2015
The Russian Federation 6hr+ results are for a subset of the Russian Federation students. This subset of students are in an Intensive stream that have at least 6 hours of mathematics lessons per week.
Exhibit M9.14: Percentages of Students Who Use the Internet for Advanced Mathematics Schoolwork
Reported by Advanced Mathematics Students

<table>
<thead>
<tr>
<th>Country</th>
<th>Access the Textbook or Other Course Materials</th>
<th>Access Assignments Posted Online by the Teacher</th>
<th>Collaborate with Classmates on Mathematics Assignments or Projects</th>
<th>Communicate with the Teacher</th>
<th>Discuss Mathematics Topics with Other Students</th>
<th>Find Information, Articles, or Tutorials to Aid in Understanding Mathematics Concepts</th>
<th>Find Information, Articles, or Tutorials to Aid in Solving Mathematics Problems</th>
</tr>
</thead>
<tbody>
<tr>
<td>France</td>
<td>50 (1.1)</td>
<td>54 (2.0)</td>
<td>62 (1.1)</td>
<td>29 (1.7)</td>
<td>44 (1.0)</td>
<td>67 (0.9)</td>
<td>74 (0.9)</td>
</tr>
<tr>
<td>Italy</td>
<td>50 (1.3)</td>
<td>39 (2.3)</td>
<td>61 (1.1)</td>
<td>37 (1.6)</td>
<td>52 (1.2)</td>
<td>65 (1.4)</td>
<td>63 (1.4)</td>
</tr>
<tr>
<td>Lebanon</td>
<td>40 (1.7)</td>
<td>27 (1.9)</td>
<td>63 (1.5)</td>
<td>46 (2.1)</td>
<td>62 (1.7)</td>
<td>46 (1.7)</td>
<td>49 (1.6)</td>
</tr>
<tr>
<td>Norway</td>
<td>60 (2.0)</td>
<td>71 (2.6)</td>
<td>47 (1.6)</td>
<td>50 (3.1)</td>
<td>39 (1.7)</td>
<td>74 (1.2)</td>
<td>78 (1.3)</td>
</tr>
<tr>
<td>Portugal</td>
<td>41 (1.3)</td>
<td>57 (2.3)</td>
<td>46 (1.4)</td>
<td>31 (1.7)</td>
<td>44 (1.3)</td>
<td>73 (1.1)</td>
<td>75 (1.0)</td>
</tr>
<tr>
<td>Russian Federation</td>
<td>78 (0.9)</td>
<td>55 (1.8)</td>
<td>73 (1.0)</td>
<td>22 (1.5)</td>
<td>58 (1.1)</td>
<td>89 (0.5)</td>
<td>86 (0.5)</td>
</tr>
<tr>
<td>Russian Federation 6hr+</td>
<td>81 (1.2)</td>
<td>62 (2.6)</td>
<td>76 (1.3)</td>
<td>23 (1.8)</td>
<td>62 (1.3)</td>
<td>88 (0.6)</td>
<td>83 (0.7)</td>
</tr>
<tr>
<td>Slovenia</td>
<td>59 (1.3)</td>
<td>55 (2.2)</td>
<td>62 (1.3)</td>
<td>32 (1.8)</td>
<td>52 (1.2)</td>
<td>65 (1.0)</td>
<td>67 (1.1)</td>
</tr>
<tr>
<td>Sweden</td>
<td>34 (1.1)</td>
<td>40 (1.7)</td>
<td>34 (1.4)</td>
<td>37 (1.8)</td>
<td>34 (1.3)</td>
<td>59 (1.1)</td>
<td>61 (1.2)</td>
</tr>
<tr>
<td>United States</td>
<td>48 (2.2)</td>
<td>54 (2.7)</td>
<td>42 (1.4)</td>
<td>52 (1.9)</td>
<td>33 (1.6)</td>
<td>70 (1.5)</td>
<td>75 (1.6)</td>
</tr>
<tr>
<td>International Avg.</td>
<td>51 (0.5)</td>
<td>50 (0.7)</td>
<td>54 (0.4)</td>
<td>37 (0.6)</td>
<td>47 (0.4)</td>
<td>68 (0.4)</td>
<td>70 (0.4)</td>
</tr>
</tbody>
</table>

The Russian Federation 6hr+ results are for a subset of the Russian Federation students. This subset of students are in an intensive stream that have at least 6 hours of mathematics lessons per week.

(*) Standard errors appear in parentheses. Because of rounding some results may appear inconsistent.
CHAPTER M10: STUDENT ENGAGEMENT AND ATTITUDES

TIMSS ADVANCED 2015 INTERNATIONAL RESULTS IN ADVANCED MATHEMATICS AND PHYSICS
Most students in advanced mathematics courses had positive attitudes toward mathematics and more positive attitudes were associated with higher achievement. Most students (85%) STRONGLY value or value advanced mathematics.

Most students (86%) were positive about their instruction—41% reported VERY engaging teaching and 45% engaging teaching.

Students were least positive about actually learning advanced mathematics. The 18% that liked learning it VERY much had more than 100 points higher achievement than the 33% that did NOT like learning it, again highlighting the strong relationship between excelling at something and liking it.

Exhibit M10.1: Students’ Views on Engaging Teaching in Advanced Mathematics Lessons

Reported by Advanced Mathematics Students

Students were scored according to their degree of agreement with fourteen statements on the Students’ Views on Engaging Teaching in Advanced Mathematics Lessons scale. Students who experienced Very Engaging Teaching in advanced mathematics lessons had a score on the scale of at least 10.4, which corresponds to their “agreeing a lot” with seven of the fourteen statements and “agreeing a little” with the other seven, on average. Students who experienced teaching that was Less Than Engaging Teaching had a score no higher than 7.9, which corresponds to their “disagreeing a little” with seven of the fourteen statements and “agreeing a little” with the other seven, on average. All other students experienced Engaging Teaching in advanced mathematics lessons.

<table>
<thead>
<tr>
<th>Country</th>
<th>Very Engaging Teaching</th>
<th>Engaging Teaching</th>
<th>Less than Engaging Teaching</th>
<th>Average Scale Score</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Percent of Students</td>
<td>Average</td>
<td>Percent of Students</td>
<td>Average</td>
</tr>
<tr>
<td>Lebanon</td>
<td>67 (1.9)</td>
<td>539 (3.3)</td>
<td>28 (1.7)</td>
<td>519 (5.0)</td>
</tr>
<tr>
<td>Russian Federation 6hr+</td>
<td>60 (2.3)</td>
<td>533 (8.4)</td>
<td>35 (2.0)</td>
<td>523 (8.8)</td>
</tr>
<tr>
<td>Russian Federation</td>
<td>54 (2.1)</td>
<td>509 (6.2)</td>
<td>38 (1.5)</td>
<td>464 (5.9)</td>
</tr>
<tr>
<td>United States</td>
<td>54 (1.8)</td>
<td>503 (5.9)</td>
<td>35 (1.4)</td>
<td>473 (8.4)</td>
</tr>
<tr>
<td>Norway</td>
<td>44 (2.3)</td>
<td>477 (4.9)</td>
<td>47 (1.3)</td>
<td>450 (4.5)</td>
</tr>
<tr>
<td>Portugal</td>
<td>42 (1.8)</td>
<td>498 (2.9)</td>
<td>44 (1.4)</td>
<td>480 (2.7)</td>
</tr>
<tr>
<td>France</td>
<td>35 (1.5)</td>
<td>481 (3.5)</td>
<td>57 (1.3)</td>
<td>458 (3.3)</td>
</tr>
<tr>
<td>Sweden</td>
<td>27 (1.6)</td>
<td>471 (5.0)</td>
<td>51 (1.3)</td>
<td>428 (4.2)</td>
</tr>
<tr>
<td>Italy</td>
<td>25 (1.4)</td>
<td>429 (8.0)</td>
<td>52 (1.2)</td>
<td>427 (6.3)</td>
</tr>
<tr>
<td>Slovenia</td>
<td>18 (1.0)</td>
<td>500 (6.4)</td>
<td>57 (1.5)</td>
<td>464 (3.9)</td>
</tr>
<tr>
<td>International Avg.</td>
<td>41 (0.6)</td>
<td>490 (1.8)</td>
<td>45 (0.5)</td>
<td>463 (1.7)</td>
</tr>
</tbody>
</table>

The Russian Federation 6hr+ results are for a subset of the Russian Federation students. This subset of students are in an Intensive stream that have at least 6 hours of mathematics lessons per week.

This TIMSS Advanced questionnaire scale was established in 2015 based on the combined response distribution of all countries that participated in TIMSS Advanced 2015. To provide a point of reference for country comparisons, the scale centerpoint of 10 was located at the mean of the combined distribution. The units of the scale were chosen so that 2 scale score points corresponded to the standard deviation of the distribution.

(Standard errors appear in parentheses. Because of rounding some results may appear inconsistent.)

How much do you agree with these statements about your advanced mathematics lessons?

1) The teacher clearly communicates the purpose of each mathematics lesson
2) I know what my teacher expects me to do
3) My teacher is easy to understand
4) I am interested in what my teacher says
5) My teacher gives me interesting things to do
6) My teacher asks me thought provoking questions
7) My teacher has clear answers to my questions
8) My teacher links new content to what I already know
9) My teacher is good at explaining advanced mathematics
10) My teacher provides the opportunity for me to show what I have learned
11) My teacher encourages me to keep working on advanced mathematics problems until I solve them
12) My teacher provides helpful feedback on my schoolwork (including homework)
13) My teacher uses a variety of teaching methods, tasks, and activities to help us learn
14) My teacher believes that I can learn difficult advanced mathematics material

The Russian Federation 6hr+ results are for a subset of the Russian Federation students. This subset of students are in an Intensive stream that have at least 6 hours of mathematics lessons per week.

SOURCE: IEA’s Trends in International Mathematics and Science Study – TIMSS Advanced 2015

Downloaded from timss2015.org/advanced/download-center/
Exhibit M10.1: Students' Views on Engaging Teaching in Advanced Mathematics Lessons (Continued)

Students’ Views on Engaging Teaching in Advanced Mathematics Lessons by Gender

<table>
<thead>
<tr>
<th>Country</th>
<th>Very Engaging Teaching</th>
<th>Engaging Teaching</th>
<th>Less than Engaging Teaching</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Percent of Students</td>
<td>Average Achievement</td>
<td>Percent of Students</td>
</tr>
<tr>
<td>Lebanon</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Females</td>
<td>69 (3.4)</td>
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<td>Females</td>
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<td>Males</td>
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<td>International Avg.</td>
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<td>Males</td>
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</tr>
</tbody>
</table>

The Russian Federation 6hr+ results are for a subset of the Russian Federation students. This subset of students are in an intensive stream that have at least 6 hours of mathematics lessons per week.

This TIMSS Advanced questionnaire scale was established in 2015 based on the combined response distribution of all countries that participated in TIMSS Advanced 2015. To provide a point of reference for country comparisons, the scale centerpoint of 10 was located at the mean of the combined distribution. The units of the scale were chosen so that 2 scale score points corresponded to the standard deviation of the distribution.

Standard errors appear in parentheses. Because of rounding some results may appear inconsistent.

Students were scored according to their degree of agreement with twelve statements on the Students Like Learning Advanced Mathematics scale. Students who Very Much Like Learning Advanced Mathematics had a score on the scale of at least 11.8, which corresponds to their “agreeing a lot” with six of the twelve statements and “agreeing a little” with the other six, on average. Students who Do Not Like Learning Advanced Mathematics had a score no higher than 9.1, which corresponds to their “disagreeing a little” with six of the twelve statements and “agreeing a little” with the other six, on average. All other students Like Learning Advanced Mathematics.

<table>
<thead>
<tr>
<th>Country</th>
<th>Very Much Like Learning Advanced Mathematics</th>
<th>Like Learning Advanced Mathematics</th>
<th>Do Not Like Learning Advanced Mathematics</th>
<th>Average Scale Score</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Percent of Students</td>
<td>Average Achievement</td>
<td>Percent of Students</td>
<td>Average Achievement</td>
</tr>
<tr>
<td>Lebanon</td>
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<td>542 (7.2)</td>
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<td>490 (5.9)</td>
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<td>Portugal</td>
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<td>490 (2.7)</td>
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<td>International Avg.</td>
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<td>533 (1.9)</td>
<td>49 (0.4)</td>
<td>478 (1.6)</td>
</tr>
</tbody>
</table>

The Russian Federation 6hr+ results are for a subset of the Russian Federation students. This subset of students are in an intensive stream that have at least 6 hours of mathematics lessons per week.

This TIMSS Advanced questionnaire scale was established in 2015 based on the combined response distribution of all countries that participated in TIMSS Advanced 2015. To provide a point of reference for country comparisons, the scale centerpoint of 10 was located at the mean of the combined distribution. The units of the scale were chosen so that 2 scale score points corresponded to the standard deviation of the distribution.

( ) Standard errors appear in parentheses. Because of rounding some results may appear inconsistent.

How much do you agree with these statements about the mathematics you are studying?

1) When I do mathematics problems, I sometimes get completely absorbed
   Agree a lot   Agree a little   Disagree a little   Disagree a lot
2) I get a sense of satisfaction when I solve mathematics problems
   Agree a lot   Agree a little   Disagree a little   Disagree a lot
3) I feel bored when I do my mathematics schoolwork*
   Agree a lot   Agree a little   Disagree a little   Disagree a lot
4) I like studying for my mathematics class outside of school
   Agree a lot   Agree a little   Disagree a little   Disagree a lot
5) It is interesting to learn mathematics theory
   Agree a lot   Agree a little   Disagree a little   Disagree a lot
6) I dread my mathematics class*
   Agree a lot   Agree a little   Disagree a little   Disagree a lot
7) I am studying mathematics because I like to learn new things
   Agree a lot   Agree a little   Disagree a little   Disagree a lot
8) I enjoy figuring out challenging mathematics
   Agree a lot   Agree a little   Disagree a little   Disagree a lot
9) Mathematics is one of my favorite subjects
   Agree a lot   Agree a little   Disagree a little   Disagree a lot
10) Jobs that require advanced mathematics skills seem interesting to me
    Agree a lot   Agree a little   Disagree a little   Disagree a lot
11) I wish I did not have to study mathematics*
    Agree a lot   Agree a little   Disagree a little   Disagree a lot
12) I enjoy thinking about the world in terms of mathematical relationships
    Agree a lot   Agree a little   Disagree a little   Disagree a lot

* Reverse coded

Very Much Like Learning Advanced Mathematics 11.8
Like Learning Advanced Mathematics 10.0
Do Not Like Learning Advanced Mathematics 9.1

## Exhibit M10.2: Students Like Learning Advanced Mathematics (Continued)

### Students Like Learning Advanced Mathematics by Gender

**Reported by Advanced Mathematics Students**

<table>
<thead>
<tr>
<th>Country</th>
<th>Very Much Like Learning Advanced Mathematics</th>
<th>Like Learning Advanced Mathematics</th>
<th>Do Not Like Learning Advanced Mathematics</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Percent of Students</td>
<td>Average Achievement</td>
<td>Percent of Students</td>
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<td>Lebanon</td>
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</tr>
<tr>
<td>Females</td>
<td>44 (3.0)</td>
<td>547 (7.0)</td>
<td>51 (2.8)</td>
</tr>
<tr>
<td>Males</td>
<td>36 (1.9)</td>
<td>557 (4.7)</td>
<td>57 (2.0)</td>
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<tr>
<td>Russian Federation 6hr+</td>
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<td>Females</td>
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<td>49 (1.6)</td>
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<tr>
<td>Males</td>
<td>31 (2.6)</td>
<td>595 (9.0)</td>
<td>49 (2.1)</td>
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<tr>
<td>Norway</td>
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</tr>
<tr>
<td>Females</td>
<td>24 (1.9)</td>
<td>497 (5.8)</td>
<td>56 (1.8)</td>
</tr>
<tr>
<td>Males</td>
<td>25 (1.6)</td>
<td>516 (5.7)</td>
<td>54 (1.6)</td>
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<tr>
<td>Males</td>
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<td>50 (1.2)</td>
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<tr>
<td>Females</td>
<td>18 (1.3)</td>
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<td>48 (1.4)</td>
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<tr>
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<tr>
<td>Males</td>
<td>19 (0.5)</td>
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<td>51 (0.5)</td>
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</table>

The Russian Federation 6hr+ results are for a subset of the Russian Federation students. This subset of students are in an Intensive stream that have at least 6 hours of mathematics lessons per week.

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( ) Standard errors appear in parentheses. Because of rounding some results may appear inconsistent.

## Exhibit M10.3: Students Value Advanced Mathematics

Reported by Advanced Mathematics Students

Students were scored according to their degree of agreement with nine statements on the Students Value Advanced Mathematics scale. Students who **Strongly Value Advanced Mathematics** had a score on the scale of at least 11.0, which corresponds to their “agreeing a lot” with five of the nine statements and “agreeing a little” with the other four, on average. Students who **Do Not Value Advanced Mathematics** had a score no higher than 8.0, which corresponds to their “disagreeing a little” with five of the nine statements and “agreeing a little” with the other four, on average. All other students **Value Advanced Mathematics**.

<table>
<thead>
<tr>
<th>Country</th>
<th>Strongly Value Advanced Mathematics</th>
<th>Value Advanced Mathematics</th>
<th>Do Not Value Advanced Mathematics</th>
<th>Average Scale Score</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Percent of Students</td>
<td>Average Achievement</td>
<td>Percent of Students</td>
<td>Average Achievement</td>
</tr>
<tr>
<td>United States</td>
<td>54 (1.6)</td>
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<tr>
<td>International Avg.</td>
<td>30 (0.4)</td>
<td>498 (1.9)</td>
<td>55 (0.4)</td>
<td>466 (1.5)</td>
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</tbody>
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( ) Standard errors appear in parentheses. Because of rounding some results may appear inconsistent.

A tilde (~) indicates insufficient data to report achievement.

---

**How much do you agree with these statements about the mathematics you are studying?**

1. Learning mathematics will help me get ahead in the world
   - Agree a lot
   - Agree a little
   - Disagree a little
   - Disagree a lot

2. It is important to do well in my mathematics class
   - Agree a lot
   - Agree a little
   - Disagree a little
   - Disagree a lot

3. The mathematics I am studying is not useful for my future
   - Agree a lot
   - Agree a little
   - Disagree a little
   - Disagree a lot

4. My parents are pleased that I am taking advanced mathematics
   - Agree a lot
   - Agree a little
   - Disagree a little
   - Disagree a lot

5. Doing well in mathematics will help me get into the university of my choice
   - Agree a lot
   - Agree a little
   - Disagree a little
   - Disagree a lot

6. Learning advanced mathematics does not seem to be a worthwhile exercise
   - Agree a lot
   - Agree a little
   - Disagree a little
   - Disagree a lot

7. My parents think that it is important that I do well in my mathematics class
   - Agree a lot
   - Agree a little
   - Disagree a little
   - Disagree a lot

8. I like telling people I am studying advanced mathematics
   - Agree a lot
   - Agree a little
   - Disagree a little
   - Disagree a lot

9. Learning advanced mathematics will give me more job opportunities
   - Agree a lot
   - Agree a little
   - Disagree a little
   - Disagree a lot

*Reverse coded*
### Exhibit M10.3: Students Value Advanced Mathematics (Continued)

#### Students Value Advanced Mathematics by Gender

Reported by Advanced Mathematics Students

<table>
<thead>
<tr>
<th>Country</th>
<th>Strongly Value Advanced Mathematics</th>
<th>Value Advanced Mathematics</th>
<th>Do Not Value Advanced Mathematics</th>
</tr>
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<td>Males</td>
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<td>Males</td>
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<td>480 (6.4)</td>
<td>53 (1.4)</td>
</tr>
<tr>
<td>Russian Federation 6hr+</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Females</td>
<td>33 (2.6)</td>
<td>560 (8.4)</td>
<td>53 (1.5)</td>
</tr>
<tr>
<td>Males</td>
<td>39 (2.2)</td>
<td>572 (7.6)</td>
<td>50 (1.7)</td>
</tr>
<tr>
<td>Russian Federation</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Females</td>
<td>23 (1.3)</td>
<td>520 (7.5)</td>
<td>57 (0.9)</td>
</tr>
<tr>
<td>Males</td>
<td>30 (1.6)</td>
<td>529 (7.0)</td>
<td>54 (0.9)</td>
</tr>
<tr>
<td>Sweden</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Females</td>
<td>25 (1.2)</td>
<td>448 (6.5)</td>
<td>65 (1.3)</td>
</tr>
<tr>
<td>Males</td>
<td>27 (1.3)</td>
<td>469 (6.0)</td>
<td>64 (1.4)</td>
</tr>
<tr>
<td>Italy</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Females</td>
<td>16 (1.4)</td>
<td>461 (12.6)</td>
<td>61 (1.5)</td>
</tr>
<tr>
<td>Males</td>
<td>19 (1.0)</td>
<td>456 (8.1)</td>
<td>57 (1.6)</td>
</tr>
<tr>
<td>France</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Females</td>
<td>12 (0.8)</td>
<td>486 (5.1)</td>
<td>70 (1.2)</td>
</tr>
<tr>
<td>Males</td>
<td>17 (0.9)</td>
<td>513 (5.8)</td>
<td>68 (1.1)</td>
</tr>
<tr>
<td>Slovenia</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Females</td>
<td>2 (0.4)</td>
<td>~ ~</td>
<td>44 (1.6)</td>
</tr>
<tr>
<td>Males</td>
<td>3 (0.5)</td>
<td>557 (12.1)</td>
<td>58 (2.4)</td>
</tr>
<tr>
<td>International Avg.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Females</td>
<td>28 (0.5)</td>
<td>490 (2.5)</td>
<td>56 (0.5)</td>
</tr>
<tr>
<td>Males</td>
<td>31 (0.5)</td>
<td>509 (2.5)</td>
<td>55 (0.6)</td>
</tr>
</tbody>
</table>

The Russian Federation 6hr+ results are for a subset of the Russian Federation students. This subset of students are in an intensive stream that have at least 6 hours of mathematics lessons per week.

This TIMSS Advanced questionnaire scale was established in 2015 based on the combined response distribution of all countries that participated in TIMSS Advanced 2015. To provide a point of reference for country comparisons, the scale centerpoint of 10 was located at the mean of the combined distribution. The units of the scale were chosen so that 2 scale score points corresponded to the standard deviation of the distribution.

( ) Standard errors appear in parentheses. Because of rounding some results may appear inconsistent.

A tilde (~) indicates insufficient data to report achievement.
CHAPTER M11: DESCRIPTION OF ADVANCED MATHEMATICS PROGRAMS AND CURRICULUM

TIMSS ADVANCED 2015 INTERNATIONAL RESULTS IN ADVANCED MATHEMATICS AND PHYSICS
Description of the Advanced Mathematics Programs and Curriculum

France

The Grade 11 and 12 scientific track offers robust mathematical knowledge and skills to students aiming for careers in science, technology, engineering, and mathematics (STEM). The mathematics curriculum is meant to develop students’ scientific thinking and strengthen their interest in and affinity for scientific research. Together with introducing new mathematical knowledge and content, the curriculum targets developing students’ skills and mathematical faculties in these areas:

- Implementing mathematical investigations and employing a variety of problem solving strategies
- Mastering a wide range of reasoning processes
- Interpreting and validating mathematical results
- Communicating mathematics both orally and in writing

Mathematical activities assigned to students both in class and for homework are focused on intra-mathematical or contextually diverse problem solving situations. Students are trained in:

- Searching for information, experimenting, and modeling, all using technology
- Choosing and executing calculation techniques
- Implementing algorithms
- Reasoning, proving, and validating results
- Explaining an answer, communicating a result

The mathematical content is organized in three parts: Analysis, Geometry, Probability and Statistics. About half of class time should be devoted to Analysis, one quarter to Geometry, and the last quarter to Probability and Statistics. The topics included in each content area are listed below.

<table>
<thead>
<tr>
<th>Content Area</th>
<th>Topics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Analysis</td>
<td>Quadratic functions: solving quadratic equations, sign of a quadratic function</td>
</tr>
<tr>
<td></td>
<td>Sequences: arithmetic and geometric sequences, induction, finite or infinite limits, bounded sequences</td>
</tr>
<tr>
<td></td>
<td>Function limits: finite or infinite limits, limits of a sum, product, quotient or composite functions, asymptotes</td>
</tr>
<tr>
<td></td>
<td>Continuity on an interval, including the Intermediate Value Theorem</td>
</tr>
<tr>
<td></td>
<td>Differentiation: calculating derivatives, including the derivatives of common functions, derivatives of sums, products, and quotients of functions, and applications of derivatives, including the relationship between the intervals over which a function increases or decreases and the value of its derivative on those intervals and function extrema</td>
</tr>
<tr>
<td>Content Area</td>
<td>Topics</td>
</tr>
<tr>
<td>--------------</td>
<td>--------</td>
</tr>
<tr>
<td>Analysis (Continued)</td>
<td>Sine and cosine functions&lt;br&gt;Exponential functions&lt;br&gt;Natural logarithms&lt;br&gt;Integration on an interval, including the relationship between the definite integral and the area under a curve, notation, the antiderivative of a function, linearity, and the additive property of definite integrals</td>
</tr>
<tr>
<td>Geometry</td>
<td>Complex numbers, including the algebraic form, conjugate, geometric representation, and polar form of a complex number; the sum, product, and quotient of complex numbers, complex solutions to quadratic equations&lt;br&gt;Euclidean vectors, including the characterization of a line and a plane, scalar product, coordinates, equation of a plane&lt;br&gt;Trigonometry, including trigonometric functions defined on the unit circle, radian, the sine and cosine of supplementary and complementary angles</td>
</tr>
<tr>
<td>Probability and Statistics</td>
<td>Descriptive statistics, including variance, standard deviation&lt;br&gt;Conditional probability, independence&lt;br&gt;Probability density functions, including discrete and continuous random variables, probability distributions (normal, Bernoulli, binomial, uniform, exponential), variance, standard deviation&lt;br&gt;Confidence intervals&lt;br&gt;Sampling, confidence interval for a proportion</td>
</tr>
</tbody>
</table>

Starting in Grade 10, scientific track students continue to develop and implement algorithms. Students are trained to:

- Describe algorithms in natural or symbolic language
- Devise basic algorithms using spreadsheets, calculators or specific software programs
- Interpret complex algorithms

Algorithms fit naturally in all mathematical fields. Algorithmic problem solving in each content area is situated in contexts related to academic subject areas and contexts from real life. Students learn how to implement elementary instructions, loops, and conditional instructions as well as to implement validation and control steps in their programs.

Students learn how to use formal mathematical notation (e.g., for functions, derivatives, and integrals) as well as notation for number sets and intervals.

Students learn elements of formal logic, such as the logical operators for “and” and “or”; the concepts of the contrapositive, the converse and the negative of a conditional statement; logical equivalence; types of arguments, such as the counterexample, the logical disjunction, and the contrapositive; and proof by contradiction.
Italy

Students assessed in TIMSS Advanced 2015 have been taught according to the 2010 National Guidelines for upper-secondary schools (Licei, Istituti Tecnici, Istituti Professionali). Only students of *Liceo Scientifico* (high schools specializing in science education) and of *Istituto Tecnico–Settore Tecnologico* (technical high school–technology sector) participated in the TIMSS Advanced 2015 advanced mathematics assessment. In fact, these are the only tracks with elements of advanced mathematics in their curricula, with an appropriate lesson time (4 hours per week, for 33 weeks in a school year).

The mathematics curriculum for upper-secondary school includes four main areas:

- Arithmetic and Algebra
- Geometry
- Relations and Functions
- Statistics and Probability

*Liceo Scientifico* focus on the study of the link between the scientific and the humanistic traditions. They promote the acquisition of knowledge and methods of mathematics, physics, and the natural sciences. At the conclusion of the program of study, students should be able to:

- Understand the formal language of mathematics, know how to use typical mathematical procedures, and know the basic content of the theories underlying the mathematical description of reality
- Use data processing tools critically and in-depth; understand the methodological value of information technology in formalizing and modelling complex processes; and identify procedures that lead to conclusions and judgments about real-world systems modelled by data
- Understand the fundamental structures of mathematical argumentation and demonstrate mathematical processes through the mastery of the language of formal logic; use mathematical argumentation and formal logic to identify and to solve problems of various kinds
- Know how to use computational and representation tools for modelling and solving problems

At the end of the course, students of *Liceo Scientifico* must know the basic concepts and methods of mathematics and apply them to describe and predict phenomena in the physical world. They can situate mathematical theories in historical context and understand their conceptual meaning. The *Liceo Scientifico* five-year curriculum is divided into three parts by grade. The topics taught at each grade are listed below.
The topics taught at each grade at Istituti Tecnici–Settore Tecnologico are essentially the same as those listed above, but have a more applicative orientation at Grades 11, 12 and 13. Also it should be noted that some topics of calculus (function limits, continuity, derivatives) are taught in
Grade 12, instead of Grade 13 as in *Liceo Scientifico*, while the integral calculus is taught in Grade 13 as in *Liceo Scientifico*. In these technical institutes, at Grades 12 and 13, many mathematical topics that serve specific technological applications are taught, such as partial derivatives, Fourier series, Taylor’s formula, spherical trigonometry, etc.

In this type of high school, at the end of the five-year course, the study of mathematics helps students achieve the following learning outcomes:

- Mastery of formal language and demonstration procedures of mathematics
- Possession of the mathematical, statistical, and probability tools necessary for the understanding of scientific disciplines and the ability to work in the field of applied science
- Understanding of the place of mathematics in the history of science
Lebanon

At Grade 12, students receive a solid mathematical foundation with the aim of preparing them to pursue their studies as teachers, engineers, and researchers. The mathematics competencies students must have in each domain are provided in the table below.

<table>
<thead>
<tr>
<th>Domain</th>
<th>Competencies</th>
</tr>
</thead>
</table>
| Mathematical Reasoning  | Recognize the difference between a mathematical explanation and concrete or experimental evidence  
                        | Make conjectures and discover means to test them  
                        | Carry out proofs using various modes of reasoning  
                        | Analyze and prove a statement of necessary and sufficient conditions  
                        | Recognize a universal statement, a statement of existence, and a statement of uniqueness  
                        | Evaluate a mathematical argument and criticize a proof  
                        | Carry out an inductive proof                                                                                                                   |
| Problem Solving         | Formulate a problem out of situations studied in mathematics, in other sciences, or encountered in real life  
                        | Use various mathematical interpretations to represent the information given in a problem, figure out a convenient strategy to solve it, and take various approaches to make this strategy work using mathematical knowledge  
                        | Discuss the validity of obtained solutions                                                                                                     |
| Communication           | Give a summary of a mathematical document  
                        | Take notes on a mathematical lecture  
                        | Critique a mathematical presentation  
                        | Write a proof correctly                                                                                                                      |
| Spatial                 | Prove and apply the properties of solid figures and conics  
                        | Characterize plane or space figures using vector notation  
                        | Study geometric problems analytically  
                        | Determine the effect of transformations on plane figures                                                                                     |
| Numbers and Algebra     | Analyze the extensions of the sets of numbers (natural numbers, integers, rational numbers, real numbers, complex numbers)  
                        | Study the properties of complex numbers and their use in geometry and trigonometry  
                        | Generalize fundamental mathematical notions (set, relation, binary operation, and propositional calculus)  
                        | Acquire an example of structure  
                        | Develop mathematical tools for numerical calculations, and for solutions of systems of equations and inequalities                              |
| Calculus                | Acquire the fundamental concepts of limit, continuity, and differentiability, and use them graphically  
                        | Analyze the graphs of polynomial, rational, irrational, trigonometric, logarithmic, and exponential functions  
                        | Integrate functions and solve simple differential equations                                                                                 |
| Statistics and Probability | Organize information and represent it graphically  
                        | Study the characteristics of a statistical distribution of one variable  
                        | Solve simple probability problems, mainly in discrete cases where the events are equally likely                                               |
Norway

TIMSS 2003 and PISA 2003 showed a decrease in Norwegian students’ performance in mathematics and science in compulsory school compared with TIMSS 1995 and PISA 2000. This resulted in a broad discussion about how to improve the learning outcomes in Norway. A big effort was made to change the curriculum for all subjects in all 13 grades. There was an agreement nationally that something had to be done, and the new curriculum received support across all political parties in the parliament. It was called the Knowledge Promotion Reform, and was implemented in the autumn of 2006. The last cohort using the previous curriculum was in Grade 13 in the 2007–2008 school year, which means that these students were assessed in TIMSS Advanced 2008. Students assessed in TIMSS Advanced 2015 have been taught according to the 2006 curriculum.

In the present curriculum, two features stand out. First, the learning goals are formulated as competencies. Second, there are five basic skills (literacies) which are supposed to be used and developed in all subjects and at all levels: the ability to express oneself orally, the ability to read, the ability to express oneself in writing, the ability to use digital tools, and numeracy. Digital devices are supposed to be widely used in teaching, learning, and testing.

The following table indicates topics taught in the courses Mathematics R1 and Mathematics R2, normally taken in Grades 12 and 13, respectively.

<table>
<thead>
<tr>
<th>Content Area</th>
<th>Topics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Geometry (R1 and R2)</td>
<td>Selected elements of Euclidean plane geometry, including geometric loci and similarity; constructions with compass and straightedge, and with geometry software; the intersection theorems for heights, angle bisectors, perpendicular bisectors and medians in a triangle; various proofs of Pythagoras’ Theorem; vectors in the plane, with and without coordinates; application of vectors to determine lengths, angles, and parallelism and orthogonality of lines; vectors in space, with and without coordinates; application of scalar and vector products to determine distances, angles, areas and volumes; representation of lines, planes, and spheres by equations and in parametric form; calculation of lengths, angles and areas in bodies limited by planes and spheres</td>
</tr>
<tr>
<td>Algebra (R1 and R2)</td>
<td>Division and factorization of polynomials; logarithms; polynomial, rational, and logarithmic equations and inequalities; transformation and simplification of rational functions and other symbolic expressions with and without the use of digital aids; direct and contrapositive proof; proof by induction; number patterns; finite arithmetic series; finite and infinite geometric series; convergence</td>
</tr>
<tr>
<td>Functions (R1 and R2)</td>
<td>Limit, continuity and differentiability; derivatives of polynomial, exponential, and logarithmic functions; derivatives of sums, differences, products, and quotients of functions, and of composite functions; interpretation of functional behavior from the first and second derivatives; interpretation of derivatives in models of practical situations; drawing function graphs by hand and by digital tools; interpretation of a function’s basic properties from its graph; horizontal and vertical asymptotes; vector functions with parameters; velocity and acceleration as derivatives of vector functions; trigonometric functions and equations; derivatives of trigonometric functions;</td>
</tr>
</tbody>
</table>
The previous curriculum for advanced mathematics covered quite a bit of statistics, including binomial, hypergeometric, and normal distributions, confidence intervals, and hypothesis testing. This was an important part of the curriculum in both of the advanced mathematics courses. The present curriculum has much less on statistics. The remaining parts are some combinatorics and probability taught in the first year of the advanced mathematics track (Mathematics R1). Another important change in the curriculum is that mathematical proof is emphasized more in the present curriculum than in the previous one. The new curriculum states that students shall “give an account of implication and equivalence, and implement direct and contrapositive proof” the first year (Mathematics R1) and “implement and give an account of proof by induction” the second year (Mathematics R2).

There have only been minor adjustments made to the curriculum after 2006. Both the new and the previous curricula emphasize the use of digital tools in mathematics. Under previous curricula, a liberal policy was developed to encourage and allow an extensive use of aids in all teaching and testing. Written notes and advanced calculators were normally allowed in local tests as well as in national written examinations. This has changed in the present curriculum. Every exam in mathematics is now divided into two parts. The first part is solved by pen and paper only and no aids are allowed. The second part, however, does not only allow the use of digital tools, but some are even required, like dynamic geometry programs. It is specifically stated that students in the second part of the exam shall have quite sophisticated electronical aids available.

Not all students have to take a national written exam in mathematics. About 40 percent of the first year (Mathematics R1) students are sampled, as are about 60 percent the second year (Mathematics R2) students. For the local oral exam, about 5 percent and 15 percent of the students in the respective courses are sampled for testing.
There is no national certification of teaching materials, such as textbooks, in Norway. The authors and publishers are free to decide the content of a textbook; the responsibility for covering the national curriculum rests on the school and the teacher.

Generally, one may say that the present curriculum emphasizes pure mathematics a little more than the previous one, across all levels. For instance, the present curriculum has a slightly stronger emphasis on algebra in compulsory school. Also, as has already been mentioned, formal proofs are now more emphasized than before in the advanced mathematics courses of upper-secondary school.
Portugal

Advanced Mathematics is a mandatory course for students in the upper-secondary Science and Technology and Socioeconomic Sciences academic tracks. The curriculum is divided into three main subjects: Probability and Combinatorics, Introduction to Differential Calculus II, and Trigonometry and Complex Numbers. The topics included in each main subject are listed below.

<table>
<thead>
<tr>
<th>Main Subject</th>
<th>Topics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Probability and Combinatorics</td>
<td>Introduction to probability: random experiments; outcome spaces; events and operations with events; classical, frequency and axiomatic definitions of probability; conditional probability and independence of events</td>
</tr>
<tr>
<td></td>
<td>Relative frequency and probability distributions: random variables and density functions for discrete variables; sample versus population means and standard-deviations; binomial probability distributions; normal distributions; histograms versus continuous probability density functions</td>
</tr>
<tr>
<td></td>
<td>Combinatorics: enumerative combinatorics; permutations and combinations; Pascal's Triangle and Newton's Binomial expansion; the Binomial Theorem; applications of probability calculations</td>
</tr>
<tr>
<td>Introduction to Differential Calculus II</td>
<td>Exponential and logarithmic functions: analytical and graphical properties of exponential and logarithmic functions; rules for exponents and logarithms; modeling with exponential and logarithmic functions</td>
</tr>
<tr>
<td></td>
<td>Limits theory: Heine's definition of the limit of a function and its properties; notable special limits; indeterminate forms of limits; asymptotes; continuity of functions, Bolzano-Cauchy's Theorem; numerical applications</td>
</tr>
<tr>
<td></td>
<td>Differential calculus: Derivatives rules and applications; concavity and second derivatives; composite functions and their derivatives; properties of simple functions that can be determined by studying derivatives; optimization problems</td>
</tr>
<tr>
<td>Trigonometry and Complex Numbers</td>
<td>Trigonometry: intuitive study of the sine, cosine and tangent functions and their derivatives based on the unit circle; special limits of the sine function; use of trigonometry functions in modeling</td>
</tr>
<tr>
<td></td>
<td>Complex numbers: introduction to complex numbers; the imaginary unit; algebraic form of and operations with complex numbers in this form; trigonometric form of complex numbers and operations with complex numbers in this form; geometric interpretation of operations with complex numbers; complex variables in the geometric plane</td>
</tr>
</tbody>
</table>
Russian Federation

High school programs for mathematics (Grades 10-11) are distinguished by the amount of the material being studied and the amount of instructional time. The Basic level program is designed for those students who plan to learn a profession that is not related to mathematics or plan to use mathematics as an auxiliary “tool” in their professional lives. The Profile level program provides sufficient depth of mathematics study to make it possible for students to enter a profession where mathematics is actively used. It includes a large amount of content and has higher requirements for its mastery. The mastery of this content makes it possible for students to continue to university-level studies in mathematical disciplines. Within the Profile level there is a subset of students in an even more intensive program taking six hours or more of mathematics lessons per week. The sample of students participating in the TIMSS Advanced 2015 Advanced Mathematics assessment included both Profile-level students and Intensive-level students. The results for students in the Intensive level were also reported separately as Russian Federation 6hr+.

The Profile level curriculum includes an explanation of the main goals of the program and provide for the organization and planning of mathematics courses, including:

- General characteristics of the profile course
- Teaching goals
- The number of lessons per week and per year
- General learning skills and activities
- Compulsory content and learning outcomes

The content of the Profile course is divided into two sections: Algebra and Calculus, and Geometry. The topics included in each section are listed below.

<table>
<thead>
<tr>
<th>Content Areas in Algebra and Calculus</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Grade 10</strong></td>
</tr>
<tr>
<td><strong>Polynomials</strong></td>
</tr>
<tr>
<td><strong>Graphs of Functions</strong></td>
</tr>
<tr>
<td><strong>Introduction to Calculus</strong></td>
</tr>
<tr>
<td><strong>Derivatives and their Applications</strong></td>
</tr>
</tbody>
</table>
# Content Areas in Algebra and Calculus

<table>
<thead>
<tr>
<th>Grade 11</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Integral and Differential Equations</strong></td>
<td>Indefinite integrals; definite integrals and their properties, numerical approximation of definite integrals, approximate computation; Newton-Leibniz formula; application of integrals for calculating areas, volumes, and lengths of arcs in physical problems; solutions of simple differential equations</td>
</tr>
<tr>
<td><strong>Exponential and Logarithmic Functions</strong></td>
<td>Properties and graphs of exponential functions; logarithms, definitions, and properties; identical transformations of exponential and logarithmic expressions; exponential and logarithmic equations, inequalities and systems of inequalities, types and methods of solution; derivatives of exponential functions; natural logarithms, radioactive decay</td>
</tr>
<tr>
<td><strong>Complex Numbers</strong></td>
<td>Algebraic form, arithmetic operations, conjugating complex numbers; solutions of quadratic equations with complex coefficients; the complex plane; trigonometric form of complex numbers, multiplication, division, and raising to power; De Moivre’s formula; complex roots of polynomials; the Fundamental Theorem of Algebra</td>
</tr>
<tr>
<td><strong>Elements of Combinatorics</strong></td>
<td>Methods of mathematical induction; proofs of identities; factorials; the basic formulae of combinatorics; combinations and permutations; Binomial Theorem, Dirichlet’s Principle</td>
</tr>
<tr>
<td><strong>Elements of the Theory of Probability and Mathematical Statistics</strong></td>
<td>Classic definition of probability, calculating probabilities using combinatorics; conditional probability, the rules of addition and multiplication of probabilities, independent events, Bernoulli distribution; mathematical expectation and variance; the concept of the law of large numbers and a normal distribution law; parent population and sample, levels of significance and reliability; evaluation of probability using frequency; the concept of statistical hypothesis testing</td>
</tr>
<tr>
<td><strong>Equations, Inequalities, Systems</strong></td>
<td>General methods and approaches for solving equations; irrational equations; generalized method of intervals for solving inequalities; systems of equations and inequalities, basic methods for solving systems of equations; application of graphs to solve equations, inequalities and systems; approximate methods for solving equations; equations, inequalities, and systems with parameters</td>
</tr>
</tbody>
</table>

# Content Areas in Geometry

<table>
<thead>
<tr>
<th>Grade 10</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Axioms of Solid Geometry</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Parallel Lines and Planes</strong></td>
<td>Mutual arrangement of lines and planes in space; theorems of parallelism of lines and planes</td>
</tr>
<tr>
<td><strong>Perpendicularity of Lines and Planes</strong></td>
<td>Theorems of dependences between parallelism and perpendicularity of lines and planes, the Theorem of the Three Perpendiculars; angles between straight lines and a plane</td>
</tr>
<tr>
<td><strong>Coordinates and Vectors in a Space</strong></td>
<td>Rectangular coordinate systems on a plane, the formula for distance between points, equations of straight lines and circumference; Cartesian coordinate system in a space, equations of straight lines and a plane; movements in a space and their properties (central symmetry, parallel translation, rotation), similarity in a space</td>
</tr>
<tr>
<td><strong>Vectors in a Space</strong></td>
<td>Decomposition of vectors into three non-coplanar vectors; scalar products; applications of coordinates and vectors to solve problems</td>
</tr>
</tbody>
</table>
Content Areas in Geometry

Grade 11

<table>
<thead>
<tr>
<th>Polyhedrons</th>
<th>Concepts of polyhedrons, prisms, rectangular parallelepipeds, and pyramids; areas of faces and surfaces; sections; regular polyhedrons; dihedral angles</th>
</tr>
</thead>
<tbody>
<tr>
<td>Solids of Revolution</td>
<td>Bodies and surfaces of revolution, cylinders, cones, axial sections of cylinders and cones; spheres and solid spheres, sections of solid spheres, equation of a sphere; inscribed and circumscribed cylinder, cone, sphere</td>
</tr>
<tr>
<td>Volumes of Bodies</td>
<td>Volumes of polyhedrons (prisms, pyramids) and solids of revolution (cylinder, cone, sphere, part of the sphere)</td>
</tr>
<tr>
<td>The Surface Areas of Solids of Revolution</td>
<td>Areas of spheres, surface areas of cylinders and cones</td>
</tr>
</tbody>
</table>

Learning outcomes are described in terms of what students should know and be able to do in each of these areas. Teachers have some discretion as to the introduction of optional topics.
Slovenia

In curricular documents for teachers and students, mathematics is presented as one of the basic subjects of general gymnasia in which students learn mathematics concepts and structures, critical thinking, and reasoning; develop creativity, formal knowledge and skills; recognize the practical usefulness of mathematics; gain mathematics knowledge and competencies needed for future mathematics studies as well as learning in other subjects and everyday life. The gymnasium mathematics course is compulsory and the same for all future university students, regardless of their area of study. The national curriculum for advanced mathematics is available in the form of printed and e-books containing general goals, contents and topics, expected student outcomes, and recommendations for teaching, including the incorporation of ICT, homework, and assessments into mathematics courses. In addition to the curriculum that is written for teachers’ use, the expected standards, list of topics and examples of questions for basic and advanced level of the mathematics matura examination exist in printed and e-documents for students.

Contents and topics are given in the general order of teaching the advanced mathematics course through four years. For each topic, expected goals for students are followed by list of specified topics to be taught, expected hours of lessons needed for the content, and didactical recommendations about use of ICT. Included also are suggestions and guidelines for connecting the topics with material from other academic areas and how the topics could be presented and taught in these contexts. There are some topics classified as optional or as left to the teacher’s discretion based on the teacher’s expectations for students’ achievement. The prescribed topics in each compulsory and elective content are listed below.

<table>
<thead>
<tr>
<th>Content Area</th>
<th>Topics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sets and Logic</td>
<td>Basics of logic; sets</td>
</tr>
<tr>
<td>Numbers</td>
<td>Number sets with whole, rational, real, and complex numbers (mathematical induction and the polar form of complex numbers are optional topics)</td>
</tr>
<tr>
<td>Algebraic Expressions</td>
<td>Equations and inequalities and their methods of solution (parametric equations are optional); powers and roots</td>
</tr>
<tr>
<td>Geometry</td>
<td>Lines, angles, circles and triangles in a plane and in space; sines and cosines; the areas of 2-D geometric shapes and the volumes of 3-D shapes and sections; Cartesian coordinate systems; vectors in a plane and in space, scalar product (vector product is optional)</td>
</tr>
<tr>
<td>Functions</td>
<td>Limits, continuity, inverse and composite functions; linear functions; solving systems of linear equations; quadratic, exponential, rational, logarithmic and trigonometric functions; conic sections</td>
</tr>
<tr>
<td>Sequences and Series</td>
<td>Differential calculations; integrals; applications of integrals</td>
</tr>
<tr>
<td>Probability and Statistics</td>
<td>Combinatorics</td>
</tr>
</tbody>
</table>
Expected outcomes are given by main topics as a list of content and procedural knowledge, provided in the table below. Procedural knowledge outcomes include general skills and processes linked to mathematical knowledge but transferable also to other areas.

<table>
<thead>
<tr>
<th>Knowledge</th>
<th>Expected Outcomes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Content Knowledge</td>
<td>Calculate with numbers</td>
</tr>
<tr>
<td></td>
<td>Use properties of sets</td>
</tr>
<tr>
<td></td>
<td>Use logic in proofs</td>
</tr>
<tr>
<td></td>
<td>Understand linear, power, root, quadratic, exponential, logarithmic, rational and trigonometric functions and calculate with them</td>
</tr>
<tr>
<td></td>
<td>Draw graphs and use them in modeling</td>
</tr>
<tr>
<td></td>
<td>Use Euclidean geometry and trigonometric functions in the context of Euclidean geometry; link Euclid geometry and vectors</td>
</tr>
<tr>
<td></td>
<td>Use conic sections in problems</td>
</tr>
<tr>
<td></td>
<td>Know and use arithmetic and geometric sequences and series, and apply them in financial mathematics and natural growth context</td>
</tr>
<tr>
<td></td>
<td>Understand and use derivatives and determine tangents and simple extrema problems</td>
</tr>
<tr>
<td></td>
<td>Know the meanings of indefinite and definite integrals; find indefinite integrals in simple situations, and use definite integrals for calculations of the area of a surface of revolution and volume of a solid of revolution</td>
</tr>
<tr>
<td></td>
<td>Understand and use the fundamental principle of counting and other principles of combinatorics</td>
</tr>
<tr>
<td></td>
<td>Know the classic definition of probability and calculate the probability of compound events</td>
</tr>
<tr>
<td></td>
<td>Know statistical concepts, use them in other subject areas, and provide statistical analysis for a given problem</td>
</tr>
<tr>
<td>Procedural Knowledge</td>
<td>Abstract thinking</td>
</tr>
<tr>
<td></td>
<td>Understanding of formal mathematical reasoning</td>
</tr>
<tr>
<td></td>
<td>Analytical problem solving with different strategies</td>
</tr>
<tr>
<td></td>
<td>Use of mathematics in everyday life (geometry, measurement, estimations, data analysis, interest expenses)</td>
</tr>
<tr>
<td></td>
<td>Developing effective reading strategies for future learning</td>
</tr>
<tr>
<td></td>
<td>Communicating mathematics in oral, written and other forms in the mother tongue and in one foreign language</td>
</tr>
<tr>
<td></td>
<td>Designing and carrying out a research study and critically reporting findings</td>
</tr>
<tr>
<td></td>
<td>Formulating research questions and hypotheses</td>
</tr>
<tr>
<td></td>
<td>Thinking about necessary and sufficient conditions</td>
</tr>
<tr>
<td></td>
<td>Using ICT and the Internet responsibly</td>
</tr>
<tr>
<td></td>
<td>Making decisions and giving estimates of risks</td>
</tr>
</tbody>
</table>

Cross-curricular connections are provided as examples of activities that can link together knowledge from different subjects and mathematics.
Didactic recommendations describe the compulsory use of ICT in as many possible forms and activities as possible:

- To develop skills
- To reach new knowledge
- To help students with disabilities
- To help with calculations, statistics and in communication

All available digital devices (computers, tablets, graphic classroom boards, advanced calculators) and specialized software for learning mathematics (geometry simulations, symbolic calculations, drawing) are encouraged to be used for learning mathematics.

Homework is presented as the basic form of self-motivated learning and primary source for discussions in a class. It is said to help student attain better knowledge and may indirectly influence students’ grades. Students should be assessed by at least four written tests and one oral examination in class per year. Other forms are also suggested (projects, research, group work) with the recommendation that students be giving enough opportunities to demonstrate their knowledge in different situations and are encouraged to develop responsibility for their own learning.

For the matura, students can decide whether to take the basic level or advanced level of the compulsory mathematics exam. The curriculum contents for both are the same, but required standards differ. The written test for the advanced level, in addition to compulsory items for the basic level, contains additional advanced level items. For oral examinations, the expected knowledge for the advanced level is specified in the matura standards (i.e. theoretical explanation of the definition of a limit versus the calculation of the limit only). Students receive grades from 1 to 5 for the matura exam at the basic level and from 1 to 8 at the advanced level. The sum of grades from all five matura subjects is used as a criterion for entrance to tertiary-level education programs with a limit on the number of new students.
Sweden

Four consecutive mathematics courses, Mathematics 1–4, comprise the mathematics curriculum covered by Swedish advanced mathematics students in upper-secondary school. In addition, students can choose to take additional mathematics courses. All courses are defined by a national curriculum including the goal of the subject, core content, and assessment criteria. These curricula describe learning objectives in short texts and teachers are expected to interpret the brief descriptions.

The curriculum dictates that mathematics courses should give students the opportunity to develop their ability to:

- Use and describe the meaning of mathematical concepts and their inter-relationships
- Employ procedures and solve standard tasks with and without tools
- Formulate, analyze and solve mathematical problems, and assess selected strategies, methods and results
- Interpret a realistic situation and design a mathematical model, as well as use and assess a model’s properties and limitations
- Follow, apply, and assess mathematical reasoning
- Communicate mathematical thinking orally, in writing, and in action
- Relate mathematics to its importance and use in other subjects, in a professional, social and historical context

These competencies are the same for all courses, but the core content differs.

Algebra is introduced in compulsory school, and given a more comprehensive coverage in upper-secondary school. Early on in upper-secondary school the concept of linear inequality as well as algebraic and graphical methods for solving linear equations and inequalities, and exponential equations are introduced. Students later learn about logarithms. Students learn to solve different kinds of equations, including exponential, second degree polynomial and root equations, as well as systems of linear equations. The core content covers the concept of absolute values, and the concepts of polynomial and rational expressions, and generalization of the laws of arithmetic for dealing with these concepts. Furthermore, the number system is extended through the introduction of the concept of complex numbers in connection with solving second-degree equations. Mathematics 4 gives a more comprehensive coverage of different aspects of complex numbers.

In Geometry, the core content is mostly found in the first two mathematics courses. In Mathematics 1, students are introduced to the concepts of sine, cosine and tangent, as well as vectors and their representations. Students add and subtract vectors and do scalar multiplication. Geometry is used in order to illustrate the concepts of definition, theorem and proof. Students
learn about the properties of the equation of a circle and are introduced to the unit circle in defining trigonometric concepts. In Mathematics 4, the core content contains a deeper coverage of trigonometry, for example methods for solving trigonometric equations.

Content relating to functions and calculus is found under the heading of Relationships and Change in all four mathematics courses. Students are taught about different kinds of functions and their properties. Calculus is added in Mathematics 3, starting with a brief introduction to continuous and discrete functions, as well as the concept of limits. Differentiation and use of the rules of differentiation for power and exponential functions, and also sums of functions, is described in the core content, as are algebraic and graphical methods for determining the value of the derivative of a function. Lessons should cover algebraic and graphical methods for solving extreme value problems using sign tables and second derivatives, and the relationship between the graph of a function and the first and second derivatives of a function. In Mathematics 4, the study of functions is expanded to include properties of trigonometric functions, logarithmic functions, compound functions and absolute values as functions. Lessons in differentiation and the use of the rules of differentiation for trigonometric, logarithmic, exponential and compound functions, and also the product and quotients of functions are included. In addition, students are expected to learn about algebraic and graphical methods for determining integrals with and without digital tools.

The core content also includes some arithmetic as well as probability and statistics, covered in the first two courses, and not as relevant to studies in advanced mathematics.

Problem solving is described as a core content in all four courses taken by advanced mathematics students in Sweden. Lessons cover strategies for mathematical problem solving including the use of digital media and tools, mathematical problems of importance in societal life and applications in other subjects, and mathematical problems related to the cultural history of mathematics.
United States

The United States does not have a uniform curriculum for advanced mathematics. For TIMSS Advanced 2015, students were sampled from courses identified as calculus using the definitions from the School Codes for the Exchange of Data (SCED) course classification system. The SCED courses included two College Board Advanced Placement (AP) courses (AB and BC), two International Baccalaureate (IB) Diploma Programme courses (IB Mathematics Standard Level and IB Mathematics High Level), and other courses implemented at the state, district, or school level. Descriptions of courses and their content in school catalogues were reviewed to determine course eligibility. As a result, the students assessed in TIMSS Advanced 2015 participated in varying curricula. The AP and IB courses have specific curricula that are taught to all students regardless of the state, district or school in which they take them.

In AP Calculus AB, the curriculum is broken into three major topic areas: functions, graphs, and limits; derivatives; and integrals. Under functions, graphs, and limits, the curriculum covers analysis of graphs, limits of functions (including one-sided limits), asymptotic and unbounded behavior, and continuity as a property of functions. Under derivatives, the curriculum covers the concept of a derivative, derivative at a point, derivative as a function, second derivatives, and applications and computation of derivatives. Under integrals, the curriculum covers interpretations and properties of definite integrals, application of integrals, Fundamental Theorem of Calculus, techniques and application of antidifferentiation, and numerical approximation of definite integrals.

AP Calculus BC has a similar curriculum as AP Calculus AB, and covers all of the topics of AP Calculus AB, with additional material. Under functions, graphs, and limits, the AP Calculus BC curriculum additionally covers parametric, polar, and vector functions. AP Calculus BC also has a fourth major topic area: polynomial approximations and series. This topic covers the concept of series, series of constants, and Taylor series.

IB Mathematics Standard Level (SL) has a core curriculum that covers algebra, functions and equations, circular functions and trigonometry, matrices, vectors, statistics and probability, and calculus (differential and integral). The curriculum also requires all students to complete a portfolio of two individual pieces of work, based on mathematical investigation and mathematical modeling. IB Mathematics Higher Level (HL) has the same core curriculum and portfolio requirements as IB Mathematics SL, but additionally requires 40 hours of instruction in one of the following topics: statistics and probability, sets, relations and groups, series and differential equations, or discrete mathematics.

The other courses that students were sampled from are “Calculus and Analytic Geometry” and “Calculus”, with course curricula varying by state, district, or school.
ADVANCED MATHEMATICS
APPENDICES

TIMSS ADVANCED 2015 INTERNATIONAL RESULTS IN
ADVANCED MATHEMATICS AND PHYSICS
### Exhibit MA.1: Countries Participating in the TIMSS Advanced 2015 Advanced Mathematics Assessment and in Earlier TIMSS Advanced Assessments

<table>
<thead>
<tr>
<th>Country</th>
<th>2015</th>
<th>2008</th>
<th>1995</th>
</tr>
</thead>
<tbody>
<tr>
<td>France</td>
<td>●</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>Italy</td>
<td>●</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>Lebanon</td>
<td>●</td>
<td>●</td>
<td></td>
</tr>
<tr>
<td>Norway</td>
<td>●</td>
<td>●</td>
<td></td>
</tr>
<tr>
<td>Portugal</td>
<td>●</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Russian Federation</td>
<td>●</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>Slovenia</td>
<td>●</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>Sweden</td>
<td>●</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>United States</td>
<td>●</td>
<td>●</td>
<td></td>
</tr>
</tbody>
</table>

● Indicates participation in that testing cycle.

The Russian Federation participated in 2015 with an expanded population that included the more specialized students assessed in 1995 and 2008.

**SOURCE:** IEA's Trends in International Mathematics and Science Study – TIMSS Advanced 2015
### Appendix MB.1: Distribution of Items Included in the Advanced Mathematics Assessment by Content Domain, Cognitive Domain, and Item Format

<table>
<thead>
<tr>
<th>Advanced Mathematics Items</th>
<th>Multiple-Choice Items</th>
<th>Constructed Response Items</th>
<th>Total Items</th>
<th>Percentage of Score Points</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Content Domain</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Algebra</td>
<td>19 (20)</td>
<td>18 (23)</td>
<td>37 (43)</td>
<td>35%</td>
</tr>
<tr>
<td>Calculus</td>
<td>21 (23)</td>
<td>13 (21)</td>
<td>34 (44)</td>
<td>36%</td>
</tr>
<tr>
<td>Geometry</td>
<td>19 (19)</td>
<td>12 (17)</td>
<td>31 (36)</td>
<td>29%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>59 (62)</td>
<td>43 (61)</td>
<td>102 (123)</td>
<td>100%</td>
</tr>
<tr>
<td><strong>Percentage of Score Points</strong></td>
<td>50%</td>
<td>50%</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

| Cognitive Domain           |                       |                             |             |                            |
| Knowing                    | 27 (29)               | 6 (7)                       | 33 (36)     | 29%                        |
| Applying                   | 22 (22)               | 18 (28)                     | 40 (50)     | 41%                        |
| Reasoning                  | 10 (11)               | 19 (26)                     | 29 (37)     | 30%                        |
| **Total**                  | 59 (62)               | 43 (61)                     | 102 (123)   | 100%                       |
| **Percentage of Score Points** | 50%                   | 50%                         |             |                            |

Score points are shown in parentheses.
Because of rounding some results may appear inconsistent.

## Appendix MC.1: Coverage of the TIMSS Advanced 2015 Target Population for Advanced Mathematics

<table>
<thead>
<tr>
<th>Country</th>
<th>International Target Population Coverage</th>
<th>Exclusions from National Target Population</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>School-Level Exclusions</td>
</tr>
<tr>
<td>France</td>
<td>100%</td>
<td>4.6%</td>
</tr>
<tr>
<td>Italy</td>
<td>100%</td>
<td>0.5%</td>
</tr>
<tr>
<td>Lebanon</td>
<td>100%</td>
<td>1.3%</td>
</tr>
<tr>
<td>Norway</td>
<td>100%</td>
<td>1.4%</td>
</tr>
<tr>
<td>Portugal</td>
<td>100%</td>
<td>0.0%</td>
</tr>
<tr>
<td>Russian Federation</td>
<td>100%</td>
<td>0.2%</td>
</tr>
<tr>
<td>Russian Federation 6hr+</td>
<td>100%</td>
<td>1.0%</td>
</tr>
<tr>
<td>Slovenia</td>
<td>100%</td>
<td>0.3%</td>
</tr>
<tr>
<td>Sweden</td>
<td>100%</td>
<td>1.6%</td>
</tr>
<tr>
<td>United States</td>
<td>100%</td>
<td>0.0%</td>
</tr>
</tbody>
</table>

1 National Target Population does not include all of the International Target Population.
2 National Defined Population covers 90% to 95% of National Target Population.
3 National Defined population covers less than 90% of National Target population (but at least 77%).

SOURCE: IEA’s Trends in International Mathematics and Science Study - TIMSS Advanced 2015
**Exhibit MC.2: Size of the TIMSS Advanced 2015 Target Population for Advanced Mathematics, the Age Cohort, and the TIMSS Advanced Mathematics Coverage Index**

<table>
<thead>
<tr>
<th>Country</th>
<th>Years of Formal Schooling*</th>
<th>Age Cohort Corresponding to the Final Year of Secondary School</th>
<th>Estimated Size of the Population of Students in the Final Year of Secondary School Taking the Advanced Mathematics Track or Program Targeted by TIMSS Advanced (Derived from TIMSS Advanced Student Sample)</th>
<th>Size of the Age Cohort Corresponding to the TIMSS Advanced Population Based on National Census Figures**</th>
<th>TIMSS Advanced Mathematics Coverage Index—the Percentage of the Entire Corresponding Age Cohort Covered by the TIMSS Advanced Target Population</th>
</tr>
</thead>
<tbody>
<tr>
<td>France</td>
<td>12</td>
<td>18</td>
<td>172,178</td>
<td>801,889</td>
<td>21.5%</td>
</tr>
<tr>
<td>Italy</td>
<td>13</td>
<td>19</td>
<td>141,419</td>
<td>576,506</td>
<td>24.5%</td>
</tr>
<tr>
<td>Lebanon</td>
<td>12</td>
<td>18</td>
<td>4,457</td>
<td>113,204</td>
<td>3.9%</td>
</tr>
<tr>
<td>Norway</td>
<td>13</td>
<td>19</td>
<td>6,751</td>
<td>63,894</td>
<td>10.6%</td>
</tr>
<tr>
<td>Portugal</td>
<td>12</td>
<td>18</td>
<td>31,314</td>
<td>109,984</td>
<td>28.5%</td>
</tr>
<tr>
<td>Russian Federation</td>
<td>11</td>
<td>18</td>
<td>138,548</td>
<td>1,365,790</td>
<td>10.1%</td>
</tr>
<tr>
<td>Russian Federation 6hr+</td>
<td>11</td>
<td>18</td>
<td>25,830</td>
<td>1,365,790</td>
<td>1.9%</td>
</tr>
<tr>
<td>Slovenia</td>
<td>13</td>
<td>19</td>
<td>6,738</td>
<td>19,598</td>
<td>34.4%</td>
</tr>
<tr>
<td>Sweden</td>
<td>12</td>
<td>19</td>
<td>15,285</td>
<td>108,138</td>
<td>14.1%</td>
</tr>
<tr>
<td>United States</td>
<td>12</td>
<td>18</td>
<td>473,405</td>
<td>4,168,000</td>
<td>11.4%</td>
</tr>
</tbody>
</table>

* Represents years of schooling counting from the first year of primary or basic education (first year of ISCED Level 1).

Italy: Value is the total population of 19-year-olds in Italy in 2015. Data retrieved from ISTAT (the National Statistics Institute); http://dati.istat.it/Index.aspx?DataSetCode=DCIS_POPRES1.


Sweden: Value is the total population of 18-year-olds as of December 31, 2014 (Born 1996). Data retrieved from Statistics Sweden; http://www.statistikdatabasen.scb.se/pxweb/sv/ssd/START__BE__BE0101__BE0101A/BefolkningsR1860/table/TableViewLayout1/?ruid=06695d79-5f61-4f1d-81c1-3ae51dc09b76.

United States: Value is the total population of 18-year-olds as of July 1st 2015. Data retrieved from the US Census Annual Estimates of the Resident Population by Single Year of Age and Sex for the United States: April 1, 2010 to July 1, 2013; https://www.census.gov/popest/data/national/ash/2013/. The post-census estimates are as of July 1 of each year. For the 18 year-olds estimate in 2015, the 2015 population was projected using the year to year changes from 2010 to 2013 and extending it to 2015.

The TIMSS Advanced Mathematics Coverage Index (TAMCI) is defined as follows:

$$\text{TAMCI} = \frac{\text{Estimated total number of students in the advanced mathematics target population in 2015}}{\text{Total national population in the corresponding age cohort in 2015}} \times 100\%$$

The numerator is the total number of students eligible for TIMSS Advanced, estimated from the weighted sample data. These are students in the final year of secondary school taking the advanced mathematics track or program targeted by TIMSS Advanced, based on the TIMSS Advanced sample. The denominator is the size of the population age cohort corresponding to the average age of the students in the target populations and is based on national census figures.
### Appendix MC.3: School Sample Sizes - Advanced Mathematics

<table>
<thead>
<tr>
<th>Country</th>
<th>Number of Schools in Original Sample</th>
<th>Number of Eligible Schools in Original Sample</th>
<th>Number of Schools in Original Sample that Participated</th>
<th>Number of Replacement Schools that Participated</th>
<th>Total Number of Schools that Participated</th>
</tr>
</thead>
<tbody>
<tr>
<td>France</td>
<td>146</td>
<td>145</td>
<td>144</td>
<td>0</td>
<td>144</td>
</tr>
<tr>
<td>Italy</td>
<td>120</td>
<td>120</td>
<td>104</td>
<td>9</td>
<td>113</td>
</tr>
<tr>
<td>Lebanon</td>
<td>355</td>
<td>354</td>
<td>251</td>
<td>0</td>
<td>251</td>
</tr>
<tr>
<td>Norway</td>
<td>136</td>
<td>134</td>
<td>133</td>
<td>0</td>
<td>133</td>
</tr>
<tr>
<td>Portugal</td>
<td>251</td>
<td>251</td>
<td>206</td>
<td>15</td>
<td>221</td>
</tr>
<tr>
<td>Russian Federation</td>
<td>346</td>
<td>346</td>
<td>346</td>
<td>0</td>
<td>346</td>
</tr>
<tr>
<td>Russian Federation 6hr+</td>
<td>181</td>
<td>163</td>
<td>163</td>
<td>0</td>
<td>163</td>
</tr>
<tr>
<td>Slovenia</td>
<td>80</td>
<td>77</td>
<td>69</td>
<td>0</td>
<td>69</td>
</tr>
<tr>
<td>Sweden</td>
<td>143</td>
<td>141</td>
<td>139</td>
<td>0</td>
<td>139</td>
</tr>
<tr>
<td>United States</td>
<td>348</td>
<td>316</td>
<td>230</td>
<td>11</td>
<td>241</td>
</tr>
</tbody>
</table>

SOURCE: IEA’s Trends in International Mathematics and Science Study – TIMSS Advanced 2015
### Appendix MC.4: Student Sample Sizes - Advanced Mathematics

<table>
<thead>
<tr>
<th>Country</th>
<th>Within-School Student Participation (Weighted Percentage)</th>
<th>Number of Sampled Students in Participating Schools</th>
<th>Number of Students Withdrawn from Class/School</th>
<th>Number of Students Excluded</th>
<th>Number of Eligible Students</th>
<th>Number of Students Absent</th>
<th>Number of Students Assessed</th>
</tr>
</thead>
<tbody>
<tr>
<td>France</td>
<td>96%</td>
<td>4,310</td>
<td>41</td>
<td>7</td>
<td>4,262</td>
<td>295</td>
<td>3,967</td>
</tr>
<tr>
<td>Italy</td>
<td>97%</td>
<td>3,547</td>
<td>28</td>
<td>30</td>
<td>3,489</td>
<td>171</td>
<td>3,318</td>
</tr>
<tr>
<td>Lebanon</td>
<td>98%</td>
<td>1,222</td>
<td>0</td>
<td>0</td>
<td>1,222</td>
<td>61</td>
<td>1,161</td>
</tr>
<tr>
<td>Norway</td>
<td>93%</td>
<td>2,756</td>
<td>31</td>
<td>1</td>
<td>2,724</td>
<td>187</td>
<td>2,537</td>
</tr>
<tr>
<td>Portugal</td>
<td>93%</td>
<td>4,581</td>
<td>109</td>
<td>15</td>
<td>4,457</td>
<td>389</td>
<td>4,068</td>
</tr>
<tr>
<td>Russian Federation</td>
<td>98%</td>
<td>7,758</td>
<td>2</td>
<td>12</td>
<td>7,744</td>
<td>186</td>
<td>7,558</td>
</tr>
<tr>
<td>Russian Federation 6hr+</td>
<td>98%</td>
<td>3,530</td>
<td>0</td>
<td>3</td>
<td>3,527</td>
<td>96</td>
<td>3,431</td>
</tr>
<tr>
<td>Slovenia</td>
<td>87%</td>
<td>3,360</td>
<td>1</td>
<td>42</td>
<td>3,317</td>
<td>395</td>
<td>2,922</td>
</tr>
<tr>
<td>Sweden</td>
<td>90%</td>
<td>4,450</td>
<td>85</td>
<td>2</td>
<td>4,363</td>
<td>426</td>
<td>3,937</td>
</tr>
<tr>
<td>United States</td>
<td>87%</td>
<td>3,488</td>
<td>57</td>
<td>2</td>
<td>3,429</td>
<td>475</td>
<td>2,954</td>
</tr>
</tbody>
</table>

Students attending a sampled class at the time the sample was chosen but leaving the class before the assessment was administered were classified as "withdrawn."

Students with a disability or language barrier that prevented them from participating in the assessment were classified as "excluded."

Students not present when the assessment was administered, and not subsequently assessed in a make-up session, were classified as "absent."

SOURCE: IEA’s Trends in International Mathematics and Science Study – TIMSS Advanced 2015
### Appendix MC.5: Participation Rates (Weighted) - Advanced Mathematics

<table>
<thead>
<tr>
<th>Country</th>
<th>School Participation</th>
<th>Class Participation</th>
<th>Student Participation</th>
<th>Overall Participation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Before Replacement</td>
<td>After Replacement</td>
<td>Before Replacement</td>
<td>After Replacement</td>
</tr>
<tr>
<td>France</td>
<td>99%</td>
<td>99%</td>
<td>100%</td>
<td>96%</td>
</tr>
<tr>
<td>Italy</td>
<td>88%</td>
<td>94%</td>
<td>99%</td>
<td>97%</td>
</tr>
<tr>
<td>Lebanon</td>
<td>70%</td>
<td>70%</td>
<td>100%</td>
<td>98%</td>
</tr>
<tr>
<td>Norway</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
<td>93%</td>
</tr>
<tr>
<td>Portugal</td>
<td>80%</td>
<td>87%</td>
<td>98%</td>
<td>93%</td>
</tr>
<tr>
<td>Russian Federation</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
<td>98%</td>
</tr>
<tr>
<td>Russian Federation 6hr+</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
<td>98%</td>
</tr>
<tr>
<td>Slovenia</td>
<td>89%</td>
<td>89%</td>
<td>96%</td>
<td>87%</td>
</tr>
<tr>
<td>Sweden</td>
<td>99%</td>
<td>99%</td>
<td>99%</td>
<td>90%</td>
</tr>
<tr>
<td>United States</td>
<td>72%</td>
<td>76%</td>
<td>100%</td>
<td>87%</td>
</tr>
</tbody>
</table>

TIMSS Advanced guidelines for sampling participation: The minimum acceptable participation rates were 85% of both schools and students, or a combined rate (the product of school and student participation) of 75%. Participants not meeting these guidelines were annotated as follows:

† Met guidelines for sample participation rates only after replacement schools were included.

‡ Nearly satisfied guidelines for sample participation rates after replacement schools were included.

¶ Did not satisfy guidelines for sample participation rates.

SOURCE: IEA’s Trends in International Mathematics and Science Study – TIMSS Advanced 2015
**Appendix MC.6: Trends in Student Populations – Advanced Mathematics**

<table>
<thead>
<tr>
<th>Country</th>
<th>Years of Formal Schooling*</th>
<th>Average Age at Time of Testing</th>
<th>Overall Exclusion Rates**</th>
<th>Advanced Mathematics Coverage Index***</th>
<th>Overall Participation Rates</th>
</tr>
</thead>
<tbody>
<tr>
<td>France</td>
<td>12</td>
<td>12</td>
<td></td>
<td>18.0</td>
<td></td>
</tr>
<tr>
<td>Italy</td>
<td>13</td>
<td>13</td>
<td>13</td>
<td>18.9</td>
<td>19.0</td>
</tr>
<tr>
<td>Lebanon</td>
<td>12</td>
<td>12</td>
<td></td>
<td>17.8</td>
<td>17.9</td>
</tr>
<tr>
<td>Norway</td>
<td>13</td>
<td>13</td>
<td></td>
<td>18.7</td>
<td>18.8</td>
</tr>
<tr>
<td>Russian Federation 6hr+</td>
<td>11</td>
<td>10/11</td>
<td>10</td>
<td>17.7</td>
<td>17.0</td>
</tr>
<tr>
<td>Slovenia</td>
<td>13</td>
<td>12</td>
<td>12</td>
<td>18.8</td>
<td>18.8</td>
</tr>
<tr>
<td>Sweden</td>
<td>12</td>
<td>12</td>
<td>12</td>
<td>18.8</td>
<td>18.8</td>
</tr>
<tr>
<td>United States</td>
<td>12</td>
<td>12</td>
<td></td>
<td>18.1</td>
<td></td>
</tr>
</tbody>
</table>

* Represents years of schooling counting from the first year of ISCED Level 1.

** In 1995 exclusion rates for Advanced Mathematics were computed based on exclusion rates among all students in the final year of schooling. In the case of the Russian Federation, the figure presented in the 1995 International Report (43.0%) greatly overestimates the level of exclusions in the advanced mathematics population. The figure presented above (2.0%) includes two regions, North Ossetia and Chechen Republic, as well as non-Russian speaking students.

*** See Appendix MC.2 for a description of the Advanced Mathematics Coverage Index. The 1995 Advanced Mathematics Coverage Index for Italy was recomputed and is different than from the percentage reported in the 1995 International Report.

Russian Federation trend results are available only for the Intensive stream students (6hr+). The United States adjusted the 1995 sample to correspond with the course-taking definitions used in 2015, and the 1995 results were recomputed.

An empty cell indicates a country did not participate in that year’s assessment.

SOURCE: IEA’s Trends in International Mathematics and Science Study – TIMSS Advanced 2015
### Appendix MD.1: Average Percent Correct in the Advanced Mathematics Content and Cognitive Domains

<table>
<thead>
<tr>
<th>Country</th>
<th>Overall Advanced Mathematics</th>
<th>Advanced Mathematics Content Domains</th>
<th>Advanced Mathematics Cognitive Domains</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Algebra</td>
<td>Calculus</td>
</tr>
<tr>
<td>France</td>
<td>36 (0.5)</td>
<td>41 (0.6)</td>
<td>34 (0.6)</td>
</tr>
<tr>
<td>Italy</td>
<td>31 (0.7)</td>
<td>33 (0.8)</td>
<td>32 (0.8)</td>
</tr>
<tr>
<td>Lebanon</td>
<td>50 (0.7)</td>
<td>52 (0.8)</td>
<td>51 (0.7)</td>
</tr>
<tr>
<td>Norway</td>
<td>37 (0.9)</td>
<td>37 (0.9)</td>
<td>35 (0.9)</td>
</tr>
<tr>
<td>Portugal</td>
<td>40 (0.5)</td>
<td>47 (0.6)</td>
<td>35 (0.5)</td>
</tr>
<tr>
<td>Russian Federation</td>
<td>43 (1.1)</td>
<td>48 (1.2)</td>
<td>36 (1.0)</td>
</tr>
<tr>
<td>Russian Federation 6hr+</td>
<td>54 (1.7)</td>
<td>61 (1.7)</td>
<td>46 (1.6)</td>
</tr>
<tr>
<td>Slovenia</td>
<td>37 (0.6)</td>
<td>43 (0.8)</td>
<td>30 (0.7)</td>
</tr>
<tr>
<td>Sweden</td>
<td>33 (0.6)</td>
<td>34 (0.7)</td>
<td>33 (0.6)</td>
</tr>
<tr>
<td>United States</td>
<td>43 (1.0)</td>
<td>45 (1.0)</td>
<td>46 (1.2)</td>
</tr>
<tr>
<td>International Avg.</td>
<td>39 (0.3)</td>
<td>42 (0.3)</td>
<td>37 (0.3)</td>
</tr>
</tbody>
</table>

( ) Standard errors appear in parentheses. Because of rounding some results may appear inconsistent.

SOURCE: IEA’s Trends in International Mathematics and Science Study – TIMSS Advanced 2015
Appendix ME: Test–Curriculum Matching Analysis

TIMSS Advanced 2015 went to great lengths to ensure that comparisons of student achievement across countries would be as fair and equitable as possible. The TIMSS Advanced 2015 Assessment Frameworks were designed to specify the important aspects of advanced mathematics that participating countries agreed should be the focus of an international assessment of student achievement. The assessment items were developed through a collaborative process with national representatives to faithfully represent the specifications in the frameworks and were field tested extensively in participating countries. Finalizing the TIMSS Advanced 2015 advanced mathematics assessment involved a series of reviews by representatives of the participating countries, experts in mathematics, and testing specialists. At the end of this process, the National Research Coordinators (NRCs) from each country formally approved the TIMSS Advanced 2015 advanced mathematics assessment, thus accepting it as being sufficiently fair to compare their students’ advanced mathematics achievement with that of students from other countries.

Although the assessment was developed to represent agreed upon frameworks and was intended to have as much in common across countries as possible, it was unavoidable that the match between the advanced mathematics assessment (or test) and the advanced mathematics curriculum would not be the same in all countries. To restrict test items to just those topics included in the curricula of all participating countries and covered in the same sequence would severely limit test coverage and restrict the research questions that the study is designed to address. The test, therefore, inevitably has some items measuring topics unfamiliar to some students in some countries.

The Test–Curriculum Matching Analysis (TCMA) was conducted to investigate the extent to which the TIMSS Advanced 2015 advanced mathematics assessment matched each country’s curriculum. The TCMA also investigated the impact on a country’s performance of including only achievement items that were judged to be relevant to its own curriculum.¹

To gather data about the extent to which the TIMSS Advanced 2015 advanced mathematics test matched the curricula of the participating countries, National Research Coordinators were asked to examine each achievement item and indicate whether the item was in their country’s intended curriculum for the advanced mathematics program(s) or track(s) assessed by TIMSS Advanced. Since an item might be in the curriculum for some but not all students in a country, coordinators were asked to consider an item included if it was in the intended curriculum for more than 50 percent of the students. All TIMSS Advanced 2015 participants took part in the TCMA analysis.

¹ Because there may also be curriculum areas covered in some countries that are not covered by the TIMSS Advanced 2015 tests, the TCMA does not provide complete information about how well the tests cover the curricula of the countries.
Exhibits ME.1 and ME.2 present the TCMA results for the TIMSS Advanced 2015 advanced mathematics test. Exhibit ME.1 shows the average percent correct on the advanced mathematics items judged appropriate by each country. Exhibit ME.2 shows the standard errors corresponding to the percentages presented in Exhibit ME.1.

In Exhibit ME.1, the bottom row of the exhibit shows the number of items, in terms of score points, identified as appropriate in each country. For advanced mathematics, the maximum number of score points in the assessment was 120 points. Generally, the proportion of items judged appropriate was fairly high. From the bottom row, it can be seen that the United States and Slovenia judged almost all of the items (119 score points) to be appropriate as did Norway (118) and Italy (117). Lebanon (112), Portugal (111), Sweden (111), and France (109) judged over 90 percent of the items to be included in the curriculum, and the Russian Federation (91) judged over 75 percent to be included.

Because most countries indicated that at least some items were not included in their intended curriculum at the grade tested, the data were analyzed to determine whether the inclusion of these items had any effect on the international performance comparisons.

The first data column of Exhibit ME.1 shows the average percent correct on all advanced mathematics test items for each country, together with its standard error. Subsequent columns show the performance of every country on those items judged appropriate by the country listed at the head of the column. Countries are presented in order of their performance based on average percent correct on all of the advanced mathematics items, from highest to lowest. To interpret this exhibit, choosing a country and reading across its row provides the average percent correct for the students in that country on the items selected by each of the countries listed along the top of the exhibit. For example, Lebanon, where the average percent correct was 51 percent on the set of advanced mathematics items that it judged appropriate, had, on average, 49 percent correct on the items selected by the Russian Federation, 50 percent on the items selected by the United States, 51 percent on the items selected by Portugal, and so forth.

The column for a country listed at the top shows how each of the other countries performed on the set of items selected as appropriate for that country’s students. Using the set of advanced mathematics items selected by Portugal as an example, 51 percent of these items, on average, were answered correctly by students in Lebanon, 44 percent by students in the Russian Federation, 43 percent by students in the United States, and so forth. The shaded diagonal element in the exhibit shows how each country performed on the set of items that it selected based on its own curriculum. Thus, students from Portugal averaged 42 percent correct on the set of items identified by Portugal for the analysis.

For each country’s selected items, the international averages across the participating countries are presented in a row in the lower part of the exhibit for each subject. These show that the

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2 The TIMSS Advanced 2015 advanced mathematics assessment contained 102 items yielding 123 score points. However, following item review, the 102 items and 123 score points in the advanced mathematics assessment were reduced to 101 items and 120 score points.

3 It should be noted that the advanced mathematics achievement presented in Exhibits ME.1 is based on average percent correct (the percentage of students in a country answering each item correctly, averaged across all items), which is different from the average scale scores that are presented in main tables of the report.
Exhibit ME.1: Average Percent Correct for the Test-Curriculum Matching Analyses in Advanced Mathematics

Based on a subset of items specifically identified by each country as addressing its curriculum

Read across the row to compare that country’s performance based on the test items included by each of the countries across the top. Read down the column under a country name to compare the performance of the country down the left on the items included by the country listed on the top. Read along the diagonal to compare performance for each different country based on its own decisions about the test items to include.

<table>
<thead>
<tr>
<th>Country</th>
<th>Lebanon</th>
<th>Russian Federation</th>
<th>United States</th>
<th>Norway</th>
<th>Slovenia</th>
<th>France</th>
<th>Sweden</th>
<th>Italy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average Percent Correct on All Items</td>
<td>50 (0.7)</td>
<td>51</td>
<td>49</td>
<td>50</td>
<td>49</td>
<td>50</td>
<td>50</td>
<td>51</td>
</tr>
<tr>
<td>Number of Items (Score Points) Identified*</td>
<td>120</td>
<td>112</td>
<td>91</td>
<td>119</td>
<td>111</td>
<td>118</td>
<td>119</td>
<td>109</td>
</tr>
<tr>
<td>Lebanon</td>
<td></td>
<td>50</td>
<td>49</td>
<td>49</td>
<td>50</td>
<td>49</td>
<td>50</td>
<td>50</td>
</tr>
<tr>
<td>Russian Federation</td>
<td>43 (1.1)</td>
<td>43</td>
<td>44</td>
<td>44</td>
<td>43</td>
<td>43</td>
<td>43</td>
<td>42</td>
</tr>
<tr>
<td>United States</td>
<td>43 (1.0)</td>
<td>43</td>
<td>45</td>
<td>43</td>
<td>43</td>
<td>43</td>
<td>43</td>
<td>42</td>
</tr>
<tr>
<td>Portugal</td>
<td>40 (0.5)</td>
<td>40</td>
<td>39</td>
<td>40</td>
<td>42</td>
<td>40</td>
<td>39</td>
<td>40</td>
</tr>
<tr>
<td>Norway</td>
<td>37 (0.9)</td>
<td>37</td>
<td>37</td>
<td>37</td>
<td>37</td>
<td>37</td>
<td>37</td>
<td>37</td>
</tr>
<tr>
<td>Slovenia</td>
<td>37 (0.6)</td>
<td>37</td>
<td>37</td>
<td>37</td>
<td>37</td>
<td>37</td>
<td>37</td>
<td>37</td>
</tr>
<tr>
<td>France</td>
<td>36 (0.5)</td>
<td>36</td>
<td>36</td>
<td>36</td>
<td>36</td>
<td>36</td>
<td>36</td>
<td>36</td>
</tr>
<tr>
<td>Sweden</td>
<td>33 (0.6)</td>
<td>33</td>
<td>33</td>
<td>33</td>
<td>33</td>
<td>33</td>
<td>33</td>
<td>32</td>
</tr>
<tr>
<td>Italy</td>
<td>31 (0.7)</td>
<td>32</td>
<td>30</td>
<td>32</td>
<td>32</td>
<td>32</td>
<td>31</td>
<td>31</td>
</tr>
<tr>
<td>International Avg.</td>
<td>39 (0.3)</td>
<td>39</td>
<td>38</td>
<td>39</td>
<td>39</td>
<td>39</td>
<td>39</td>
<td>39</td>
</tr>
</tbody>
</table>

* Of the 102 items in the Advanced Mathematics test, some extended-response items were scored on a two-point scale, resulting in 123 score points. Following item review, one item was deleted and the point value of two items were reduced, resulting in 101 items and 120 score points.

Comparing the diagonal element for a country with the overall average percent correct shows the difference between performance on the set of items chosen as appropriate for that country and performance on the test as a whole. Countries generally performed similarly or a little better on their own items when compared to their performance on all items. To illustrate, the average percent correct for the Russian Federation across all the advanced mathematics items was 43 percent. The diagonal element shows that students from the Russian Federation had a slightly greater average percent correct (44 percent) across the set of items selected as appropriate for Russian students than they did overall. Portugal had the biggest difference between the two measures with Portuguese students achieving 42 percent correct on the items judged to be in their curriculum while achieving 40 percent correct on all items.

It is clear that the selection of items did not have a major effect on the relative performance in advanced mathematics among TIMSS Advanced 2015 countries. Countries that had relatively high or low performance across all of the items in the assessment also had relatively high or low
performance on each of the various sets of items selected for the TCMA. For example, Lebanon had the highest average percent correct not only on the assessment as a whole, but also on all of the different item selections, with the Russian Federation, the United States, and Portugal next in order (with some ties) on practically all selections of items.4

The TCMA results provide evidence that the TIMSS Advanced 2015 advanced mathematics assessment constitutes a reasonable basis for comparing the achievement of the participating countries. This result is not unexpected, since making the assessment as fair as possible was a major consideration in test development. The fact that all countries indicated that most items were appropriate for their students means that the different average percent correct estimates were based on many of the same items. Insofar as countries rejected items that would be difficult for their students, these items do not greatly affect the overall pattern of relative performance.

4 Small differences in performance between adjacent countries shown in this exhibit usually are not statistically significant. The standard errors for the average percent correct statistics based on the TIMSS Advanced 2015 sample are provided in Exhibit ME.2. For any sample average shown in Exhibit ME.1, it can be said with 95 percent confidence that the corresponding value in the population falls between the sample estimate plus or minus 2 standard errors.
### Appendix MF.1: Percentiles of Achievement in Advanced Mathematics

<table>
<thead>
<tr>
<th>Country</th>
<th>5th Percentile</th>
<th>10th Percentile</th>
<th>25th Percentile</th>
<th>50th Percentile</th>
<th>75th Percentile</th>
<th>90th Percentile</th>
<th>95th Percentile</th>
</tr>
</thead>
<tbody>
<tr>
<td>France</td>
<td>348 (5.8)</td>
<td>371 (5.4)</td>
<td>413 (3.1)</td>
<td>462 (3.3)</td>
<td>511 (3.5)</td>
<td>555 (4.1)</td>
<td>581 (5.4)</td>
</tr>
<tr>
<td>Italy</td>
<td>238 (9.1)</td>
<td>273 (9.0)</td>
<td>342 (9.1)</td>
<td>428 (6.4)</td>
<td>501 (4.6)</td>
<td>561 (5.8)</td>
<td>594 (7.9)</td>
</tr>
<tr>
<td>Lebanon</td>
<td>419 (5.8)</td>
<td>444 (5.6)</td>
<td>485 (3.9)</td>
<td>532 (3.8)</td>
<td>577 (5.1)</td>
<td>619 (3.6)</td>
<td>645 (7.5)</td>
</tr>
<tr>
<td>Norway</td>
<td>340 (8.1)</td>
<td>369 (5.3)</td>
<td>411 (5.6)</td>
<td>459 (5.0)</td>
<td>508 (5.2)</td>
<td>550 (6.4)</td>
<td>578 (6.3)</td>
</tr>
<tr>
<td>Portugal</td>
<td>363 (5.5)</td>
<td>389 (5.8)</td>
<td>434 (3.7)</td>
<td>482 (3.5)</td>
<td>532 (3.4)</td>
<td>577 (3.2)</td>
<td>601 (4.8)</td>
</tr>
<tr>
<td>Russian Federation</td>
<td>298 (10.2)</td>
<td>335 (8.4)</td>
<td>406 (7.7)</td>
<td>489 (6.9)</td>
<td>564 (6.0)</td>
<td>625 (7.0)</td>
<td>662 (9.4)</td>
</tr>
<tr>
<td>Russian Federation 6hr+</td>
<td>358 (17.3)</td>
<td>405 (16.8)</td>
<td>476 (11.2)</td>
<td>546 (8.4)</td>
<td>610 (7.7)</td>
<td>665 (7.5)</td>
<td>696 (11.6)</td>
</tr>
<tr>
<td>Slovenia</td>
<td>322 (7.0)</td>
<td>353 (6.8)</td>
<td>403 (4.6)</td>
<td>459 (4.0)</td>
<td>515 (4.7)</td>
<td>569 (5.2)</td>
<td>599 (5.9)</td>
</tr>
<tr>
<td>Sweden</td>
<td>267 (10.3)</td>
<td>305 (7.1)</td>
<td>365 (5.5)</td>
<td>433 (5.3)</td>
<td>501 (4.3)</td>
<td>555 (4.5)</td>
<td>584 (5.6)</td>
</tr>
<tr>
<td>United States</td>
<td>315 (12.6)</td>
<td>352 (10.5)</td>
<td>419 (8.3)</td>
<td>491 (5.3)</td>
<td>554 (5.8)</td>
<td>608 (4.8)</td>
<td>640 (8.2)</td>
</tr>
</tbody>
</table>

( ) Standard errors appear in parentheses. Because of rounding some results may appear inconsistent.

Note: Percentiles are defined in terms of percentages of students at or below a point on the scale.

### Appendix MF.2: Standard Deviations of Achievement in Advanced Mathematics

<table>
<thead>
<tr>
<th>Country</th>
<th>Overall</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>Standard Deviation</td>
<td>Mean</td>
<td>Standard Deviation</td>
<td>Mean</td>
<td>Standard Deviation</td>
</tr>
<tr>
<td>France</td>
<td>463 (3.1)</td>
<td>71 (1.5)</td>
<td>449 (3.1)</td>
<td>66 (2.1)</td>
<td>475 (3.4)</td>
<td>74 (1.5)</td>
</tr>
<tr>
<td>Italy</td>
<td>422 (5.3)</td>
<td>110 (3.2)</td>
<td>427 (6.1)</td>
<td>107 (4.1)</td>
<td>419 (6.6)</td>
<td>111 (3.9)</td>
</tr>
<tr>
<td>Lebanon</td>
<td>532 (3.1)</td>
<td>69 (1.8)</td>
<td>533 (4.8)</td>
<td>67 (3.3)</td>
<td>531 (3.9)</td>
<td>71 (2.4)</td>
</tr>
<tr>
<td>Norway</td>
<td>459 (4.6)</td>
<td>72 (2.0)</td>
<td>453 (5.1)</td>
<td>70 (2.3)</td>
<td>463 (5.2)</td>
<td>72 (2.4)</td>
</tr>
<tr>
<td>Portugal</td>
<td>482 (2.5)</td>
<td>73 (1.4)</td>
<td>481 (3.0)</td>
<td>70 (1.4)</td>
<td>483 (3.1)</td>
<td>76 (2.0)</td>
</tr>
<tr>
<td>Russian Federation</td>
<td>485 (5.7)</td>
<td>111 (3.4)</td>
<td>480 (6.0)</td>
<td>109 (3.9)</td>
<td>489 (6.2)</td>
<td>113 (3.8)</td>
</tr>
<tr>
<td>Russian Federation 6hr+</td>
<td>540 (7.8)</td>
<td>101 (5.3)</td>
<td>530 (9.0)</td>
<td>101 (6.0)</td>
<td>549 (7.5)</td>
<td>101 (5.1)</td>
</tr>
<tr>
<td>Slovenia</td>
<td>460 (3.4)</td>
<td>84 (2.6)</td>
<td>449 (3.5)</td>
<td>81 (3.0)</td>
<td>476 (4.9)</td>
<td>85 (3.1)</td>
</tr>
<tr>
<td>Sweden</td>
<td>431 (4.0)</td>
<td>97 (2.2)</td>
<td>424 (5.1)</td>
<td>95 (3.6)</td>
<td>436 (4.6)</td>
<td>98 (2.3)</td>
</tr>
<tr>
<td>United States</td>
<td>485 (5.2)</td>
<td>98 (3.6)</td>
<td>470 (5.3)</td>
<td>94 (3.1)</td>
<td>500 (6.4)</td>
<td>101 (5.9)</td>
</tr>
</tbody>
</table>

Standard errors appear in parentheses. Because of rounding some results may appear inconsistent.
Appendix MG: Organizations and Individuals Responsible for TIMSS Advanced 2015

Introduction
TIMSS Advanced 2015 was a collaborative effort involving hundreds of individuals around the world. This appendix acknowledges the individuals and organizations for their contributions. Given that work on TIMSS Advanced 2015 has spanned approximately four years and has involved so many people and organizations, this list may not include all who contributed. Any omission is inadvertent. TIMSS Advanced 2015 also acknowledges the students, teachers, and school principals who contributed their time and effort to the study. This report would not be possible without them.

Management and Coordination
TIMSS Advanced was conducted by IEA’s TIMSS & PIRLS International Study Center at Boston College, which has responsibility for the direction and management of the TIMSS and PIRLS projects, including design, development, and implementation. Headed by Executive Directors Drs. Ina V.S. Mullis and Michael O. Martin, the study center is located in the Lynch School of Education. In carrying out the project, the TIMSS & PIRLS International Study Center worked closely with the IEA Secretariat in Amsterdam, which managed country participation, was responsible for verification of all translations produced by the participating countries, and coordinated the school visits by International Quality Control Monitors. Staff at the IEA Data Processing and Research Center in Hamburg worked closely with participating countries to organize sampling and data collection operations and to check all data for accuracy and consistency within and across countries; Statistics Canada in Ottawa was responsible for school and student sampling activities; and Educational Testing Service in Princeton, New Jersey consulted on psychometric methodology, provided software for scaling the achievement data, and replicated the achievement scaling for quality assurance.

The Project Management Team, comprising the study directors and representatives from the TIMSS & PIRLS International Study Center, IEA Secretariat and IEA Data Processing and Research Center, Statistics Canada, and ETS met twice a year throughout the study to discuss the study’s progress, procedures, and schedule. In addition, the study directors met with members of IEA’s Technical Executive Group twice yearly to review technical issues.
To work with the international team and coordinate within-country activities, each participating country designates an individual to be the TIMSS National Research Coordinator (NRC). The NRCs have the challenging task of implementing TIMSS in their countries in accordance with the TIMSS guidelines and procedures. In addition, the NRCs provide feedback and contributions throughout the development of the TIMSS assessment. The quality of the TIMSS assessment and data depends on the work of the NRCs and their colleagues in carrying out the complex sampling, data collection, and scoring tasks involved. Continuing the tradition of exemplary work established in previous cycles of TIMSS, the TIMSS Advanced 2015 NRCs performed their many tasks with dedication, competence, energy, and goodwill, and have been commended by the IEA Secretariat, the TIMSS & PIRLS International Study Center, the IEA Data Processing and Research Center, and Statistics Canada for their commitment to the project and the high quality of their work.

Funding

Funding for TIMSS Advanced 2015 was provided primarily by the participating countries. Boston College also is gratefully acknowledged for its generous financial support and stimulating educational environment.
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CHAPTER P1: STUDENT ACHIEVEMENT

TIMSS ADVANCED 2015 INTERNATIONAL RESULTS IN ADVANCED MATHEMATICS AND PHYSICS
Physics in an essential element of STEM education. How many physics students are countries educating to a high level, and how well are they achieving?

- Slovenia, with 8% of its students in TIMSS Advanced physics, had the highest average physics achievement
- The Russian Federation, with 5% of its students in TIMSS Advanced, and Norway with 7% had the next highest achievement
- Portugal (5%) and Sweden (14%) had comparable achievement, followed by the United States (5%)
- Lebanon (4%) had the next highest achievement
- Italy (18%) and France (22%) had the highest percentages of students in TIMSS Advanced physics, but the lowest average achievement

TIMSS Advanced 2015 Reveals Disappointing Trends in Physics Achievement

Of the 6 countries with 20-year trend data, France, Norway, the Russian Federation, and Sweden had lower average achievement in 2015 than in 1995. In Slovenia and the United States, average physics achievement was essentially unchanged since 1995.

Attracting Women to STEM Education Remains a Challenge

More **Males** than **Females** were enrolled in physics programs in all countries.

<table>
<thead>
<tr>
<th>Countries</th>
<th>More Males enrolled</th>
<th>More Females enrolled</th>
</tr>
</thead>
<tbody>
<tr>
<td>France, Italy, Russian Federation, Sweden, the United States, Lebanon, Slovenia, Norway, Portugal</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Males had higher achievement than **Females** in 8 countries.

<table>
<thead>
<tr>
<th>Countries</th>
<th>Males higher achievement</th>
<th>Females higher achievement</th>
</tr>
</thead>
<tbody>
<tr>
<td>France, Italy, Russian Federation, Sweden, the United States, Slovenia, Norway, Portugal</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**SOURCE:** IEA’s Trends in International Mathematics and Science Study – TIMSS Advanced 2015.

Exhibit P1.1: Structural Characteristics of the Physics Programs (Tracks)

Reported by National Research Coordinators

<table>
<thead>
<tr>
<th>Country</th>
<th>Description of How the Programs (Tracks) Fit into the Overall Curriculum</th>
<th>Number of Years Students are Taught in These Programs (Tracks)</th>
<th>Number of Hours of Physics Instruction in Final Year</th>
<th>Criteria for Admission to These Programs (Tracks)</th>
<th>Prerequisites for Admission to These Programs (Tracks)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Norway</td>
<td>Secondary schooling spans Grades 6–12. At the end of Grade 9 students choose either a vocational program or the general program. Students attending the general program choose among four tracks at the end of Grade 10—technological, literary, economic, and social, or scientific. Students choosing the scientific track choose either the engineering sciences or the life and Earth sciences emphasis at Grade 11. At Grade 12, these students additionally choose a specialization among four—life and Earth sciences, mathematics, physics and chemistry, or computational sciences.</td>
<td>2 years</td>
<td>74</td>
<td>Students’ skills and attitudes towards science, their grades in mathematics and science, and teachers’ and principals’ opinions and reports all contribute.</td>
<td>No prerequisites</td>
</tr>
<tr>
<td>France</td>
<td>Secondary education can last 5 years and is given in three types of schools—lyceums, technical schools, and vocational schools. The students assessed by TIMSS Advanced 2015 are in Grade 13 and have taken an advanced mathematics course or an advanced mathematics and physics course. Most of these students are found in general schools with scientific focus on mathematics and physics (Liceo Scientifico), in general schools with a focus on science, mathematics and physics (Liceo Scientifico opzione Scienze Applicate), or in technical institutes and receiving full-time vocational training.</td>
<td>5 years</td>
<td>86</td>
<td>There are no specific criteria for admission.</td>
<td>No prerequisites</td>
</tr>
<tr>
<td>Lebanon</td>
<td>In Grades 1–6 science is merged into one discipline. In Grades 7–12 science becomes separated disciplines—physics, chemistry, and life and Earth science. Students should pass all science exams during the school years to be able to continue science specializations at the university.</td>
<td>6 years</td>
<td>166</td>
<td>There are no specific criteria for admission; all students take physics.</td>
<td>No prerequisites</td>
</tr>
<tr>
<td>Norway</td>
<td>The Norwegian students assessed by TIMSS Advanced 2015 completed 10 years of compulsory education followed by 3 years of upper-secondary education. Upper-secondary education is not compulsory. However, all students have the right to an upper-secondary education. Almost the entire cohort enters this level, approximately half of them in an academic track, the other half in vocational programs. All students in the academic track must take a course in natural science in Grade 11. Those who want to specialize in physics choose this subject in Grades 12 and 13, with the courses Physics 1 and Physics 2. The Norwegian students assessed in physics by TIMSS Advanced 2015 were taking the Physics 2 course in their final year of secondary education.</td>
<td>2 years</td>
<td>140</td>
<td>There are no criteria for admission to the subject, but it is recommended to take the most theoretical mathematics course offered at the same time. The Physics 1 course is a prerequisite for the Physics 2 course.</td>
<td>No prerequisites to enroll in Physics 1</td>
</tr>
<tr>
<td>Portugal</td>
<td>During lower secondary education (Grades 7 to 9) academic track students have mandatory physics and chemistry courses. After completing lower secondary education (Grade 9) students must enroll in upper-secondary education (Grades 10–12). Only students in the Sciences and Technology academic track can choose the optional 2-year physics and chemistry course in Grades 10 and 11. These students may then enroll in the optional physics and/or chemistry courses in Grade 12. The TIMSS Advanced 2015 target population for physics is composed of the students studying physics in Grade 12.</td>
<td>3 years</td>
<td>98</td>
<td>Admission to the physics course at Grade 12 requires successfully completing the 2-year physics and chemistry course in Grades 10 and 11.</td>
<td>2-year physics and chemistry course in Grades 10 and 11</td>
</tr>
<tr>
<td>Russian Federation</td>
<td>All students study physics every year in basic and upper-secondary education. In basic education, all students follow the same curriculum, but in upper-secondary school (Grades 10 and 11), there are two programs: Basic and Profile. The students assessed by TIMSS Advanced 2015 are the Grade 11 students in the Profile physics program, which includes 3 hours or more per week of instruction in physics. These students can be found in lyceums, gymnasiums, special schools for mathematics and physics, and general secondary schools with different profiles at the upper-secondary level.</td>
<td>2 years</td>
<td>90</td>
<td>Although it is not compulsory, it is recommended that students seeking admission to the Profile physics program pass the Basic State Examination in Physics after Grade 9. Schools may ask applicants to pass an interview or oral or written examination in physics.</td>
<td>No prerequisites</td>
</tr>
<tr>
<td>Country</td>
<td>Description of How the Programs (Tracks) Fit into the Overall Curriculum</td>
<td>Number of Years Students are Taught in These Programs (Tracks)</td>
<td>Number of Hours of Physics Instruction per Year</td>
<td>Criteria for Admission to These Programs (Tracks)</td>
<td>Prerequisites for Admission to These Programs (Tracks)</td>
</tr>
<tr>
<td>--------------</td>
<td>---------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
<td>---------------------------------------------------------------</td>
<td>-----------------------------------------------</td>
<td>-------------------------------------------------------------------------------------------------------------------</td>
<td>------------------------------------------------------</td>
</tr>
<tr>
<td>Slovenia</td>
<td>Secondary education consists of two types of programs: general gymnasia; and vocational or technically oriented programs. Only the general gymnasia program offers students the possibility of admission to university studies. Students in the fourth year of general gymnasia programs who chose to take an additional physics course in their final year were the target population for TIMSS Advanced 2015.</td>
<td>4 years</td>
<td>105</td>
<td>Completion of elementary schooling.</td>
<td>No prerequisites</td>
</tr>
<tr>
<td>Sweden</td>
<td>Upper-secondary education starts at Grade 10 and is divided into 18 national 3-year programs. There are 12 vocational programs and 6 programs preparing for studies at the university level. In Swedish upper-secondary school, Physics is taught in consecutive courses at 3 levels: Physics 1, 2, and 3. Students participating in TIMSS Advanced 2015 completed Physics 1 and 2 (250 credits), or completed Physics 1 and about to complete Physics 2. They all belong to either the natural science program or the technology program in upper-secondary school. Physics 1 is compulsory for all students in these programs. Physics 2 is compulsory for the vast majority of the students in the natural science program. For students in the technology program, Physics 2 is compulsory for one track of the program and optional for students within the other tracks.</td>
<td>3 years</td>
<td>Varying, but approximately 110 on average</td>
<td>Completion of 9-year compulsory school with passing grades in Swedish, English, mathematics, biology, physics, chemistry, and at least six other subjects.</td>
<td>No prerequisites</td>
</tr>
<tr>
<td>United States</td>
<td>The physics programs/tracks vary by state and district. All students begin studying science in elementary school with a focus on observation and inquiry and covering basic concepts in the physical, life and Earth sciences. In middle school, science courses are still integrated, but states may place more emphasis on different science subjects across grades (e.g., life science at Grade 6, physical science at Grade 7, and Earth science at Grade 8). In high school, most students begin taking focused courses in specific science disciplines such as biology, chemistry, and physics. The year during which students begin studying physics varies, and generally starts with an introductory physics course in Grade 9 or Grade 10. Students may then progress to more advanced physics courses in Grades 10, 11 and 12, but this is optional. In advanced physics, there are two main programs that are used across many states: College Board's Advanced Placement (AP) Programme and the International Baccalaureate (IB) Diploma Programme. Prior to the 2014-2015 school year, the AP physics program included a second-year algebra-based physics course (Physics B) and two third-year calculus-based physics courses (Physics C—mechanics and Physics C—electricity and magnetism). The AP physics curriculum was changed starting in the 2014-2015 school year. Under new guidelines, AP Physics B was replaced by a two-year course sequence (Physics 1 and Physics 2). Physics 1 has no physics prerequisites; Physics 2 must be preceded by either AP Physics 1 or an introductory or honors physics course as a first-year course; and Physics C requires Physics 1, Physics 2 or Physics B, depending on the area of focus (mechanics or electricity and magnetism). The IB physics program is a comprehensive two-year algebra-based physics course sequence that offers two courses, Standard Level (SL) and High Level (HL), for students to choose between. The TIMSS Advanced physics sample includes Grade 12 students who have taken an advanced physics course (AP, IB or another advanced physics course offered by each state/district) in Grade 12 or in a prior grade.</td>
<td>Varies by district and by school</td>
<td>Varies by school and by course</td>
<td>Varies by school and by course</td>
<td>Varies by school and by course</td>
</tr>
</tbody>
</table>
### Exhibit P1.2: Distribution of Physics Achievement

<table>
<thead>
<tr>
<th>Country</th>
<th>Average Scale Score</th>
<th>Physics Coverage Index*</th>
<th>Physics Achievement Distribution</th>
<th>Years of Formal Schooling**</th>
<th>Average Age at Time of Testing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Slovenia</td>
<td>531 (2.5)</td>
<td>7.6%</td>
<td></td>
<td>13</td>
<td>18.8</td>
</tr>
<tr>
<td>Russian Federation</td>
<td>508 (7.1)</td>
<td>4.9%</td>
<td></td>
<td>11</td>
<td>17.7</td>
</tr>
<tr>
<td>Norway</td>
<td>507 (4.6)</td>
<td>6.5%</td>
<td></td>
<td>13</td>
<td>18.8</td>
</tr>
<tr>
<td><strong>TIMSS Scale Centerpoint</strong></td>
<td>500</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Portugal</td>
<td>467 (4.6)</td>
<td>5.1%</td>
<td></td>
<td>12</td>
<td>18.0</td>
</tr>
<tr>
<td>Sweden</td>
<td>455 (5.9)</td>
<td>14.3%</td>
<td></td>
<td>12</td>
<td>18.8</td>
</tr>
<tr>
<td>United States</td>
<td>437 (9.7)</td>
<td>4.8%</td>
<td></td>
<td>12</td>
<td>18.1</td>
</tr>
<tr>
<td>Lebanon</td>
<td>410 (4.5)</td>
<td>3.9%</td>
<td></td>
<td>12</td>
<td>17.8</td>
</tr>
<tr>
<td>Italy</td>
<td>374 (6.9)</td>
<td>18.2%</td>
<td></td>
<td>13</td>
<td>18.9</td>
</tr>
<tr>
<td>France</td>
<td>373 (4.0)</td>
<td>21.5%</td>
<td></td>
<td>12</td>
<td>18.0</td>
</tr>
</tbody>
</table>

* See Appendix PC.2 for a description of the Physics Coverage Index.

** Represents years of schooling counting from first year of primary or basic education (first year of ISCED Level 1).

The TIMSS Advanced achievement scale was established in 1995 based on the combined achievement distribution of all countries that participated in TIMSS Advanced 1995. To provide a point of reference for country comparisons, the scale centerpoint of 500 was located at the mean of the combined achievement distribution. The units of the scale were chosen so that 100 scale score points corresponded to the standard deviation of the distribution.

See Appendix PC.5 for sampling guidelines and sampling participation notes †, ‡, and ¶.

† Standard errors appear in parentheses. Because of rounding some results may appear inconsistent.

### Average Physics Achievement by Physics Coverage Index*

![Graph showing the average physics achievement by physics coverage index]

** TIMSS Scale Centerpoint

### Source

IEA’s Trends in International Mathematics and Science Study – TIMSS Advanced 2015
### Exhibit P1.3: Multiple Comparisons of Average Physics Achievement

Instructions: Read across the row for a country to compare performance with the countries listed along the top of the chart. The symbols indicate whether the average achievement of the country in the row is significantly lower than that of the comparison country, significantly higher than that of the comparison country, or if there is no statistically significant difference between the average achievement of the two countries.

<table>
<thead>
<tr>
<th>Country</th>
<th>Average Scale Score</th>
<th>Slovenia</th>
<th>Russian Federation</th>
<th>Norway</th>
<th>Portugal</th>
<th>Sweden</th>
<th>United States</th>
<th>Lebanon</th>
<th>Italy</th>
<th>France</th>
</tr>
</thead>
<tbody>
<tr>
<td>Slovenia</td>
<td>531 (2.5)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Russian Federation</td>
<td>508 (7.1)</td>
<td>●</td>
<td></td>
<td>●</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Norway</td>
<td>507 (4.6)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Portugal</td>
<td>467 (4.6)</td>
<td></td>
<td></td>
<td>●</td>
<td>●</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sweden</td>
<td>455 (5.9)</td>
<td></td>
<td></td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>United States</td>
<td>437 (9.7)</td>
<td></td>
<td></td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lebanon</td>
<td>410 (4.5)</td>
<td>●</td>
<td></td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Italy</td>
<td>374 (6.9)</td>
<td>●</td>
<td></td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td></td>
</tr>
<tr>
<td>France</td>
<td>373 (4.0)</td>
<td>●</td>
<td></td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
</tr>
</tbody>
</table>

- ○: Average achievement significantly higher than comparison country
- ●: Average achievement significantly lower than comparison country

Significance tests were not adjusted for multiple comparisons. Five percent of the comparisons would be statistically significant by chance alone.

(*) Standard errors appear in parentheses. Because of rounding some results may appear inconsistent.
Exhibit P1.4: Differences in Physics Achievement Across Assessment Years

Instructions: Read across the row to determine if the performance in the row year is significantly higher (✓) or significantly lower (✘) than the performance in the column year.

<table>
<thead>
<tr>
<th>Country</th>
<th>Physics Coverage Index*</th>
<th>Average Scale Score</th>
<th>Differences Between Years</th>
<th>Physics Achievement Distribution</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>2008</td>
<td>1995</td>
</tr>
<tr>
<td>France</td>
<td></td>
<td></td>
<td>2015</td>
<td>19.3%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>1995</td>
<td>19.9%</td>
</tr>
<tr>
<td>Italy</td>
<td></td>
<td></td>
<td>2015</td>
<td>18.2%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>2008</td>
<td>3.8%</td>
</tr>
<tr>
<td>Lebanon</td>
<td></td>
<td></td>
<td>2015</td>
<td>3.9%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>2008</td>
<td>5.9%</td>
</tr>
<tr>
<td>Norway</td>
<td></td>
<td></td>
<td>2015</td>
<td>6.5%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>2008</td>
<td>6.8%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>1995</td>
<td>8.4%</td>
</tr>
<tr>
<td>Russian Federation</td>
<td></td>
<td></td>
<td>2015</td>
<td>4.9%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>2008</td>
<td>2.6%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>1995</td>
<td>1.5%</td>
</tr>
<tr>
<td>Slovenia</td>
<td></td>
<td></td>
<td>2015</td>
<td>7.6%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>2008</td>
<td>7.3%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>1995</td>
<td>38.6%</td>
</tr>
<tr>
<td>Sweden</td>
<td></td>
<td></td>
<td>2015</td>
<td>14.3%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>2008</td>
<td>11.0%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>1995</td>
<td>16.3%</td>
</tr>
<tr>
<td>United States</td>
<td></td>
<td></td>
<td>2015</td>
<td>4.8%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>1995</td>
<td>2.7%</td>
</tr>
</tbody>
</table>

* See Appendix PC.2 for a description of the Physics Coverage Index.
See Appendix PC.5 for sampling guidelines and sampling participation notes †, ‡, and ¶.

( ) Standard errors appear in parentheses. Because of rounding some results may appear inconsistent.
The United States adjusted the 1995 sample to correspond with the course-taking definitions used in 2015, and the 1995 results were recomputed.
Exhibit P1.5: Relative Achievement of 2015 Physics Cohort at the Eighth and Fourth Grades*

Instructions: To compare relative achievement across grades as the cohort of students assessed at the fourth grade in 2007 moved to eighth grade four years later in 2011 and then to TIMSS Advanced in 2015, start in the upper-left hand panel and follow the darker green arrows pointing diagonally downwards.

### 2007 - TIMSS Fourth Grade

<table>
<thead>
<tr>
<th>Country</th>
<th>Achievement Difference from TIMSS Scale Centerpoint (500)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Russian Federation</td>
<td>52 (5.6)</td>
</tr>
<tr>
<td>United States</td>
<td>35 (3.1)</td>
</tr>
<tr>
<td>Slovenia</td>
<td>28 (2.3)</td>
</tr>
<tr>
<td>Italy</td>
<td>20 (3.6)</td>
</tr>
<tr>
<td>Sweden</td>
<td>9 (3.2)</td>
</tr>
<tr>
<td>Norway (4)</td>
<td>-39 (3.5)</td>
</tr>
<tr>
<td>France</td>
<td>0</td>
</tr>
<tr>
<td>Lebanon</td>
<td>0</td>
</tr>
</tbody>
</table>

### 2008 - TIMSS Advanced

<table>
<thead>
<tr>
<th>Country</th>
<th>Achievement Difference from TIMSS Scale Centerpoint (500)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Slovenia</td>
<td>35 (2.2)</td>
</tr>
<tr>
<td>Norway</td>
<td>34 (4.1)</td>
</tr>
<tr>
<td>Russian Federation</td>
<td>21 (10.1)</td>
</tr>
<tr>
<td>Sweden</td>
<td>-3 (5.3)</td>
</tr>
<tr>
<td>Lebanon</td>
<td>-56 (3.0)</td>
</tr>
<tr>
<td>Italy</td>
<td>-78 (7.4)</td>
</tr>
<tr>
<td>France</td>
<td>0</td>
</tr>
<tr>
<td>United States</td>
<td>0</td>
</tr>
</tbody>
</table>

### 2011 - TIMSS Eighth Grade

<table>
<thead>
<tr>
<th>Country</th>
<th>Achievement Difference from TIMSS Scale Centerpoint (500)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Russian Federation</td>
<td>47 (3.6)</td>
</tr>
<tr>
<td>Slovenia</td>
<td>32 (2.8)</td>
</tr>
<tr>
<td>Sweden</td>
<td>13 (2.5)</td>
</tr>
<tr>
<td>United States</td>
<td>-2 (3.2)</td>
</tr>
<tr>
<td>Italy</td>
<td>-10 (2.8)</td>
</tr>
<tr>
<td>Norway (8)</td>
<td>-19 (3.4)</td>
</tr>
<tr>
<td>Lebanon</td>
<td>-95 (5.4)</td>
</tr>
<tr>
<td>France</td>
<td>0</td>
</tr>
</tbody>
</table>

### 2015 - TIMSS Eighth Grade

<table>
<thead>
<tr>
<th>Country</th>
<th>Achievement Difference from TIMSS Scale Centerpoint (500)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Russian Federation</td>
<td>48 (4.2)</td>
</tr>
<tr>
<td>Slovenia</td>
<td>45 (2.9)</td>
</tr>
<tr>
<td>Sweden</td>
<td>24 (3.7)</td>
</tr>
<tr>
<td>United States</td>
<td>16 (2.9)</td>
</tr>
<tr>
<td>Italy</td>
<td>-4 (2.5)</td>
</tr>
<tr>
<td>Norway (8)</td>
<td>-17 (2.6)</td>
</tr>
<tr>
<td>Lebanon</td>
<td>-88 (6.6)</td>
</tr>
<tr>
<td>France</td>
<td>0</td>
</tr>
</tbody>
</table>

The United States adjusted the 1995 sample to correspond with the course-taking definitions used in 2015, and the 1995 results were recomputed.

A diamond (◊) indicates the country did not participate in this year’s assessment.

TIMSS 2011 data from: TIMSS 2011 International Results in Science
TIMSS 2015 data from: TIMSS 2015 International Results in Science
TIMSS Advanced 2008 data from: TIMSS Advanced 2008 International Report

---

<table>
<thead>
<tr>
<th>Country</th>
<th>Achievement Difference from TIMSS Scale Centerpoint (500)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Russian Federation</td>
<td>67 (3.6)</td>
</tr>
<tr>
<td>Slovenia</td>
<td>46 (2.4)</td>
</tr>
<tr>
<td>United States</td>
<td>37 (2.6)</td>
</tr>
<tr>
<td>Sweden</td>
<td>34 (3.6)</td>
</tr>
<tr>
<td>Italy</td>
<td>13 (2.9)</td>
</tr>
<tr>
<td>France</td>
<td>-18 (2.7)</td>
</tr>
<tr>
<td>Norway (4)</td>
<td>-25 (2.8)</td>
</tr>
<tr>
<td>Lebanon</td>
<td>0</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Country</th>
<th>Achievement Difference from TIMSS Scale Centerpoint (500)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Russia</td>
<td>31 (2.5)</td>
</tr>
<tr>
<td>Russian Federation</td>
<td>8 (7.1)</td>
</tr>
<tr>
<td>Norway</td>
<td>7 (4.6)</td>
</tr>
<tr>
<td>Sweden</td>
<td>-45 (5.9)</td>
</tr>
<tr>
<td>United States</td>
<td>-63 (9.7)</td>
</tr>
<tr>
<td>Lebanon</td>
<td>-90 (4.5)</td>
</tr>
<tr>
<td>Italy</td>
<td>-126 (6.9)</td>
</tr>
<tr>
<td>France</td>
<td>-127 (4.0)</td>
</tr>
</tbody>
</table>
Exhibit P1.6: Physics Participation and Average Achievement by Gender

Participation in Physics by Gender

<table>
<thead>
<tr>
<th>Country</th>
<th>Females</th>
<th>Males</th>
<th>Percent of Students</th>
</tr>
</thead>
<tbody>
<tr>
<td>France</td>
<td>47 (0.9)</td>
<td>53 (0.9)</td>
<td></td>
</tr>
<tr>
<td>Italy</td>
<td>46 (1.1)</td>
<td>54 (1.1)</td>
<td></td>
</tr>
<tr>
<td>Russian Federation</td>
<td>42 (1.2)</td>
<td>58 (1.2)</td>
<td></td>
</tr>
<tr>
<td>Sweden</td>
<td>41 (1.4)</td>
<td>59 (1.4)</td>
<td></td>
</tr>
<tr>
<td>United States</td>
<td>39 (1.6)</td>
<td>61 (1.6)</td>
<td></td>
</tr>
<tr>
<td>Lebanon</td>
<td>37 (1.5)</td>
<td>63 (1.5)</td>
<td></td>
</tr>
<tr>
<td>Slovenia</td>
<td>30 (1.7)</td>
<td>70 (1.7)</td>
<td></td>
</tr>
<tr>
<td>Norway</td>
<td>29 (1.2)</td>
<td>71 (1.2)</td>
<td></td>
</tr>
<tr>
<td>Portugal</td>
<td>25 (1.9)</td>
<td>75 (1.9)</td>
<td></td>
</tr>
</tbody>
</table>

Average Physics Achievement by Gender

<table>
<thead>
<tr>
<th>Country</th>
<th>Females</th>
<th>Males</th>
<th>Absolute Difference</th>
<th>Females Scored Higher</th>
<th>Males Scored Higher</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lebanon</td>
<td>417 (5.2)</td>
<td>406 (6.4)</td>
<td>11 (8.2)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sweden</td>
<td>448 (6.1)</td>
<td>459 (6.6)</td>
<td>11 (4.9)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Portugal</td>
<td>456 (6.2)</td>
<td>470 (5.1)</td>
<td>14 (6.8)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Russian Federation</td>
<td>498 (7.9)</td>
<td>514 (7.3)</td>
<td>16 (5.8)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Norway</td>
<td>489 (6.0)</td>
<td>515 (4.8)</td>
<td>26 (5.3)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Slovenia</td>
<td>510 (6.5)</td>
<td>540 (3.7)</td>
<td>29 (8.6)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Italy</td>
<td>356 (7.3)</td>
<td>389 (8.4)</td>
<td>32 (7.8)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>France</td>
<td>354 (4.2)</td>
<td>390 (4.6)</td>
<td>35 (3.8)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>United States</td>
<td>409 (11.9)</td>
<td>455 (9.3)</td>
<td>46 (7.1)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

See Appendix PC.5 for sampling guidelines and sampling participation notes †, ‡, and ¶.

(·) Standard errors appear in parentheses. Because of rounding some results may appear inconsistent.
### Exhibit P1.7: Differences in Physics Achievement by Gender Across Assessment Years

Instructions: Read across the row to determine if the performance in the row year is significantly higher (●) or significantly lower (▼) than the performance in the column year.

<table>
<thead>
<tr>
<th>Country</th>
<th>Females</th>
<th></th>
<th></th>
<th>Males</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Percent of Students</td>
<td>Average Scale Score</td>
<td>Differences Between Years</td>
<td>Percent of Students</td>
<td>Average Scale Score</td>
</tr>
<tr>
<td>France</td>
<td></td>
<td>2015</td>
<td>47 (0.9)</td>
<td>354 (4.2)</td>
<td>-95 ▼</td>
<td>53 (0.9)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1995</td>
<td>39 (2.0)</td>
<td>449 (7.0)</td>
<td></td>
<td>61 (2.0)</td>
</tr>
<tr>
<td>Italy</td>
<td></td>
<td>2015</td>
<td>46 (1.1)</td>
<td>356 (7.3)</td>
<td>-50 ▼</td>
<td>54 (1.1)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2008</td>
<td>40 (2.4)</td>
<td>407 (10.4)</td>
<td></td>
<td>60 (2.4)</td>
</tr>
<tr>
<td>Lebanon</td>
<td>▲</td>
<td>2015</td>
<td>37 (1.5)</td>
<td>417 (5.2)</td>
<td>-34 ▼</td>
<td>63 (1.5)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2008</td>
<td>29 (1.3)</td>
<td>451 (4.5)</td>
<td></td>
<td>71 (1.3)</td>
</tr>
<tr>
<td>Norway</td>
<td></td>
<td>2015</td>
<td>29 (1.2)</td>
<td>489 (6.0)</td>
<td>-28 ▼</td>
<td>71 (1.2)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2008</td>
<td>29 (1.7)</td>
<td>517 (5.7)</td>
<td>-36 ▼</td>
<td>71 (1.7)</td>
</tr>
<tr>
<td></td>
<td>▲</td>
<td>1995</td>
<td>26 (1.8)</td>
<td>533 (8.7)</td>
<td></td>
<td>74 (1.8)</td>
</tr>
<tr>
<td>Russian Federation</td>
<td></td>
<td>2015</td>
<td>42 (1.2)</td>
<td>498 (7.9)</td>
<td>0 ▲</td>
<td>58 (1.2)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2008</td>
<td>45 (1.3)</td>
<td>498 (10.4)</td>
<td>-9 ▲</td>
<td>55 (1.3)</td>
</tr>
<tr>
<td></td>
<td>▲</td>
<td>1995</td>
<td>46 (2.0)</td>
<td>507 (14.1)</td>
<td></td>
<td>54 (2.0)</td>
</tr>
<tr>
<td>Slovenia</td>
<td>▲</td>
<td>2015</td>
<td>30 (1.7)</td>
<td>510 (6.5)</td>
<td>-25 ▼</td>
<td>32</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2008</td>
<td>27 (1.2)</td>
<td>535 (5.0)</td>
<td>-36 ▼</td>
<td>73 (1.2)</td>
</tr>
<tr>
<td></td>
<td>▲</td>
<td>1995</td>
<td>28 (3.7)</td>
<td>479 (16.8)</td>
<td></td>
<td>72 (3.7)</td>
</tr>
<tr>
<td>Sweden</td>
<td></td>
<td>2015</td>
<td>41 (1.4)</td>
<td>448 (6.1)</td>
<td>-43 ▼</td>
<td>59 (1.4)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2008</td>
<td>35 (2.4)</td>
<td>491 (6.6)</td>
<td>-60 ▼</td>
<td>65 (2.4)</td>
</tr>
<tr>
<td></td>
<td>1995</td>
<td>33 (3.4)</td>
<td>551 (5.6)</td>
<td></td>
<td>67 (3.4)</td>
<td>590 (3.7)</td>
</tr>
<tr>
<td>United States</td>
<td>▲</td>
<td>2015</td>
<td>39 (1.6)</td>
<td>409 (11.9)</td>
<td>-6</td>
<td>61 (1.6)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1995</td>
<td>43 (4.7)</td>
<td>415 (8.6)</td>
<td></td>
<td>57 (4.7)</td>
</tr>
</tbody>
</table>

● More recent year significantly higher
▼ More recent year significantly lower

The United States adjusted the 1995 sample to correspond with the course-taking definitions used in 2015, and the 1995 results were recomputed. See Appendix PC.5 for sampling guidelines and sampling participation notes †, ‡, and ¶.

( ) Standard errors appear in parentheses. Because of rounding some results may appear inconsistent.
### Exhibit P1.7: Differences in Physics Achievement by Gender Across Assessment Years (Continued)

**Trends in Physics Achievement by Gender**

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>France</strong></td>
<td>481*</td>
<td>449</td>
<td>390*</td>
</tr>
<tr>
<td><strong>Italy</strong></td>
<td>432*</td>
<td>407</td>
<td>389*</td>
</tr>
<tr>
<td><strong>Lebanon</strong></td>
<td>451</td>
<td>440</td>
<td>417</td>
</tr>
<tr>
<td><strong>Norway</strong></td>
<td>591*</td>
<td>533</td>
<td>515*</td>
</tr>
<tr>
<td><strong>Russian Federation</strong></td>
<td>578*</td>
<td>540*</td>
<td>514*</td>
</tr>
<tr>
<td><strong>Slovenia</strong></td>
<td>550*</td>
<td>535</td>
<td>540*</td>
</tr>
<tr>
<td><strong>Sweden</strong></td>
<td>590*</td>
<td>551</td>
<td>500</td>
</tr>
<tr>
<td><strong>United States</strong></td>
<td>482*</td>
<td>459*</td>
<td>455*</td>
</tr>
</tbody>
</table>

* Achievement significantly higher than other gender

The United States adjusted the 1995 sample to correspond with the course-taking definitions used in 2015, and the 1995 results were recomputed. Scale interval is 10 points for each country, but the part of the scale shown differs according to each country’s average achievement.
CHAPTER P2: PERFORMANCE AT INTERNATIONAL BENCHMARKS

TIMSS ADVANCED 2015 INTERNATIONAL RESULTS IN ADVANCED MATHEMATICS AND PHYSICS
Students Struggle to Reach the TIMSS Advanced International Benchmarks

TIMSS Advanced describes achievement at three International Benchmarks along the scale: Advanced, High, and Intermediate. There was a range of results across countries, but on average the majority of students found the TIMSS Advanced physics assessment very difficult.

**Percentage of Students Reaching Benchmarks (averaged across countries)**

- **Advanced Benchmark (625)**
  - 5%
  - Students communicate their understanding of laws of physics to solve problems in practical and abstract contexts.
  - In Slovenia, the Russian Federation, and Norway 11-17% reached the Advanced Benchmark, but no more than 6% did in the other countries.

- **High Benchmark (550)**
  - 18%
  - Students apply basic laws of physics in solving problems in a variety of situations.

- **Intermediate Benchmark (475)**
  - 46%
  - Students demonstrate some basic knowledge of the physics underlying a range of phenomena.

The surprisingly low percentages of students reaching the Intermediate Benchmark reflected substantial declines in 4 countries compared to 1995.

### Exhibit P2.1: Descriptions of the TIMSS Advanced 2015 International Benchmarks of Physics Achievement

<table>
<thead>
<tr>
<th>Benchmark Level</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Advanced International Benchmark</strong></td>
<td>Students communicate their understanding of laws of physics to solve problems in practical and abstract contexts. They apply knowledge of the motion of objects in freefall, of heat and temperature, and of electric circuits and electric fields. Students communicate understanding of magnetic fields and of phenomena related to mechanical and electromagnetic waves, and demonstrate understanding of atomic and nuclear physics. Students design experimental procedures and interpret results, synthesize information in complex diagrams and graphs depicting abstract physics concepts to solve problems, provide multi-step calculations of a variety of physical quantities in a range of contexts, draw conclusions about physical phenomena, and provide explanations to communicate scientific knowledge.</td>
</tr>
<tr>
<td><strong>High International Benchmark</strong></td>
<td>Students apply basic laws of physics in solving problems in a variety of situations. They apply knowledge of forces and motion, communicate understanding of the laws of conservation of energy and momentum, and apply knowledge of heat and temperature to solve problems. Students apply knowledge of Ohm’s Law and Joule’s Law to electric circuits, solve problems involving charged particles in magnetic fields, and apply knowledge of magnetic fields and electromagnetic induction to solve problems. They show understanding of phenomena related to electromagnetic waves and knowledge of nuclear reactions. Students interpret information in complex diagrams and graphs depicting abstract concepts, derive formulas and provide calculations of a variety of physical quantities in a range of contexts, evaluate explanations for physical phenomena, and provide brief explanations to communicate scientific knowledge.</td>
</tr>
<tr>
<td><strong>Intermediate International Benchmark</strong></td>
<td>Students demonstrate some basic knowledge of the physics underlying a range of phenomena. They use their knowledge of forces and motion to solve problems, apply knowledge of heat and temperature to energy transfers, and of conservation laws to everyday and abstract contexts. They show knowledge of electric fields, point charges, and electromagnetic induction. Students apply knowledge of phenomena related to mechanical and electromagnetic waves and knowledge of atomic and nuclear physics to solve problems. Students interpret information in diagrams and graphs to solve problems, calculate a variety of physical quantities in a range of contexts, and evaluate statements to identify explanations for physical phenomena.</td>
</tr>
</tbody>
</table>
### Exhibit P2.2: Performance at the International Benchmarks of Physics Achievement

<table>
<thead>
<tr>
<th>Country</th>
<th>Advanced</th>
<th>High</th>
<th>Intermediate</th>
<th>Advanced Benchmark (625)</th>
<th>High Benchmark (550)</th>
<th>Intermediate Benchmark (475)</th>
<th>Physics Coverage Index*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Slovenia</td>
<td>17 (1.4)</td>
<td>43 (1.5)</td>
<td>73 (1.6)</td>
<td>7.6%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Russian Federation</td>
<td>16 (2.2)</td>
<td>38 (2.5)</td>
<td>62 (2.2)</td>
<td>4.9%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Norway</td>
<td>11 (0.9)</td>
<td>35 (1.9)</td>
<td>64 (2.0)</td>
<td>6.5%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sweden</td>
<td>6 (0.8)</td>
<td>21 (1.6)</td>
<td>46 (2.3)</td>
<td>14.3%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>United States</td>
<td>5 (0.9)</td>
<td>18 (2.1)</td>
<td>39 (3.3)</td>
<td>4.8%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Portugal</td>
<td>3 (0.7)</td>
<td>16 (1.6)</td>
<td>46 (3.0)</td>
<td>5.1%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Italy</td>
<td>1 (0.4)</td>
<td>7 (0.8)</td>
<td>22 (1.6)</td>
<td>18.2%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lebanon</td>
<td>1 (0.4)</td>
<td>6 (0.8)</td>
<td>25 (1.9)</td>
<td>3.9%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>France</td>
<td>0 (0.1)</td>
<td>2 (0.4)</td>
<td>13 (1.1)</td>
<td>21.5%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>International Median</td>
<td>5</td>
<td>18</td>
<td>46</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* See Appendix PC.2 for a description of the Physics Coverage Index.

See Appendix PC.5 for sampling guidelines and sampling participation notes †, ‡, and ¶.

( ) Standard errors appear in parentheses. Because of rounding some results may appear inconsistent.
### Exhibit P2.3: Percentages of Students Reaching the International Benchmarks of Physics Achievement Across Assessment Years

<table>
<thead>
<tr>
<th>Country</th>
<th>Advanced International Benchmark (625)</th>
<th>High International Benchmark (550)</th>
<th>Intermediate International Benchmark (475)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Percent of Students</td>
<td>Percent of Students</td>
<td>Percent of Students</td>
</tr>
<tr>
<td>Slovenia</td>
<td>17</td>
<td>12</td>
<td>15</td>
</tr>
<tr>
<td>Russian Federation</td>
<td>16</td>
<td>19</td>
<td>21</td>
</tr>
<tr>
<td>Norway</td>
<td>11</td>
<td>11</td>
<td>28</td>
</tr>
<tr>
<td>Sweden</td>
<td>6</td>
<td>7</td>
<td>25</td>
</tr>
<tr>
<td>United States</td>
<td>5</td>
<td>3</td>
<td>25</td>
</tr>
<tr>
<td>Italy</td>
<td>1</td>
<td>2</td>
<td>7</td>
</tr>
<tr>
<td>Lebanon</td>
<td>1</td>
<td>0</td>
<td>6</td>
</tr>
<tr>
<td>France</td>
<td>0</td>
<td>2</td>
<td>2</td>
</tr>
</tbody>
</table>

- ○ 2015 percent significantly higher
- ▼ 2015 percent significantly lower

The United States adjusted the 1995 sample to correspond with the course-taking definitions used in 2015, and the 1995 results were recomputed. An empty cell indicates a country did not participate in that year’s assessment.
Exhibit P2.4: Description of the TIMSS Advanced 2015 Intermediate International Benchmark (475) of Physics Achievement

Intermediate International Benchmark

Summary

*Students demonstrate some basic knowledge of the physics underlying a range of phenomena.* They use their knowledge of forces and motion to solve problems, apply knowledge of heat and temperature to energy transfers, and of conservation laws to everyday and abstract contexts. They show knowledge of electric fields, point charges, and electromagnetic induction. Students apply knowledge of phenomena related to mechanical and electromagnetic waves and knowledge of atomic and nuclear physics to solve problems. Students interpret information in diagrams and graphs to solve problems, calculate a variety of physical quantities in a range of contexts, and evaluate statements to identify explanations for physical phenomena.

Students use their knowledge of forces and motion to solve problems, identifying the direction of acceleration of objects in linear or circular motion and recognizing properties of these motions. They relate distance and mass of objects to their gravitational attraction. Students apply knowledge of the conservation laws to everyday and abstract contexts, calculating the work done by friction to stop an object and relating internal energy and temperature changes in a gas. They apply knowledge of heat and temperature to energy transformations and transfers, evaluating statements about changes in temperature of a rising air mass, identifying an energy transformation that occurs when a meteor enters Earth's atmosphere, and recognizing a process of energy transfer in the Sun-Earth system.

Students apply knowledge of electric fields and point charges, identifying, for example, the direction of the force on a point charge in an electric field. They also show knowledge of electromagnetic induction, indicating the direction of current induced in a coil and evaluating descriptions of how induction can be used to power a flashlight.

Students apply knowledge of phenomena related to mechanical and electromagnetic waves. They calculate, determine, and compare wavelengths and speeds of waves in different media to solve problems, recognize the range of wavelengths of visible light, and predict the result of increasing the temperature of a black body. Students apply knowledge of atomic and nuclear physics to solve problems in practical and abstract contexts, characterizing electromagnetic radiation, evaluating statements about the distribution of energies in the photoelectric effect, and indicating the number of protons and neutrons in different isotopes.

Students interpret information in diagrams and graphs to solve problems, calculate a variety of physical quantities in a range of contexts, and evaluate statements to identify explanations for physical phenomena.
Exhibit P2.4.1: Intermediate International Benchmark – Example Item 1

<table>
<thead>
<tr>
<th>Country</th>
<th>Percent Correct</th>
<th>Note</th>
</tr>
</thead>
<tbody>
<tr>
<td>Slovenia</td>
<td>64 (2.5)</td>
<td></td>
</tr>
<tr>
<td>Sweden</td>
<td>61 (1.6)</td>
<td></td>
</tr>
<tr>
<td>Portugal</td>
<td>60 (2.3)</td>
<td></td>
</tr>
<tr>
<td>Lebanon</td>
<td>60 (3.8)</td>
<td>♠</td>
</tr>
<tr>
<td>United States</td>
<td>60 (2.0)</td>
<td></td>
</tr>
<tr>
<td>Norway</td>
<td>58 (1.8)</td>
<td></td>
</tr>
<tr>
<td>International Avg.</td>
<td>57 (0.8)</td>
<td></td>
</tr>
<tr>
<td>France</td>
<td>57 (1.6)</td>
<td></td>
</tr>
<tr>
<td>Italy</td>
<td>51 (1.7)</td>
<td>▼</td>
</tr>
<tr>
<td>Russian Federation</td>
<td>45 (2.6)</td>
<td>▼</td>
</tr>
</tbody>
</table>

**Content Domain: Mechanics & Thermodynamics**

**Cognitive Domain: Applying**

**Description:** Selects the graph that best represents the potential energy of a ball rolling up and down an inclined plane.

A ball is given a push and rolls up an inclined plane. After some time, the ball turns around and begins to roll back down the inclined plane. Which graph BEST describes how the ball’s potential energy varies as a function of time?

- **A**
- **B**
- **C**
- **D**

See Appendix PC.5 for sampling guidelines and sampling participation notes †, ‡, and ¶.

( ) Standard errors appear in parentheses. Because of rounding some results may appear inconsistent.
### Exhibit P2.4.1: Intermediate International Benchmark – Example Item 1 (Continued)

<table>
<thead>
<tr>
<th>Country</th>
<th>Percent of Students Responding to Each Answer Option</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>A</td>
</tr>
<tr>
<td>Slovenia</td>
<td>27 (2.6)</td>
</tr>
<tr>
<td>Sweden</td>
<td>19 (1.3)</td>
</tr>
<tr>
<td>Portugal</td>
<td>33 (2.1)</td>
</tr>
<tr>
<td>Lebanon</td>
<td>33 (3.1)</td>
</tr>
<tr>
<td>United States</td>
<td>27 (2.2)</td>
</tr>
<tr>
<td>Norway</td>
<td>33 (1.6)</td>
</tr>
<tr>
<td>France</td>
<td>23 (1.4)</td>
</tr>
<tr>
<td>Italy</td>
<td>31 (1.9)</td>
</tr>
<tr>
<td>Russian Federation</td>
<td>44 (2.5)</td>
</tr>
</tbody>
</table>

* No Response.

See Appendix PC.5 for sampling guidelines and sampling participation notes †, ‡, and ¶.

( ) Standard errors appear in parentheses. Because of rounding some results may appear inconsistent.
### Exhibit P2.4.2: Intermediate International Benchmark – Example Item 2

**Content Domain: Electricity & Magnetism**

**Cognitive Domain: Applying**

**Description:** Part A - Identifies the direction of the force on a point charge in various positions in an electric field

<table>
<thead>
<tr>
<th>Country</th>
<th>Percent Full Credit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Portugal</td>
<td>77 (2.2)</td>
</tr>
<tr>
<td>France</td>
<td>76 (1.2)</td>
</tr>
<tr>
<td>Norway</td>
<td>75 (1.5)</td>
</tr>
<tr>
<td>Russian Federation</td>
<td>73 (2.0)</td>
</tr>
<tr>
<td>United States</td>
<td>68 (2.3)</td>
</tr>
<tr>
<td>International Avg.</td>
<td>68 (0.8)</td>
</tr>
<tr>
<td>Slovenia</td>
<td>67 (3.1)</td>
</tr>
<tr>
<td>Italy</td>
<td>66 (1.9)</td>
</tr>
<tr>
<td>Sweden</td>
<td>66 (1.3)</td>
</tr>
<tr>
<td>‡ Lebanon</td>
<td>41 (3.8)</td>
</tr>
</tbody>
</table>

The electric field lines around two positive point charges are shown in the diagram.

A. A positive test charge is placed at each of the points listed below.

Choose the direction of the arrow which best represents the force the charge would experience at each of the points.

<table>
<thead>
<tr>
<th>Point X</th>
<th>Point Y</th>
<th>Point Z</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>A</td>
<td>A</td>
</tr>
<tr>
<td>•</td>
<td>B</td>
<td></td>
</tr>
<tr>
<td>C</td>
<td>•</td>
<td>C</td>
</tr>
<tr>
<td>D</td>
<td>D</td>
<td>D</td>
</tr>
<tr>
<td>E (no force)</td>
<td>E (no force)</td>
<td>• (no force)</td>
</tr>
</tbody>
</table>

B. List the points X, Y, and Z in order of increasing field strength.

The answer shown illustrates the type of response that would receive full credit (1 point). To receive 1 point for part A, students selected answer options B, C, and E.

Percent significantly higher than international average

Percent significantly lower than international average

---

See Appendix P.C.5 for sampling guidelines and sampling participation notes †, ‡, and ‡.

( ) Standard errors appear in parentheses. Because of rounding some results may appear inconsistent.
### Exhibit P2.4.2: Intermediate International Benchmark – Example Item 2

**Point X**

<table>
<thead>
<tr>
<th>Country</th>
<th>Percent of Students Responding to Each Answer Option</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>A</td>
</tr>
<tr>
<td>Portugal</td>
<td>5 (1.1)</td>
</tr>
<tr>
<td>Norway</td>
<td>5 (0.7)</td>
</tr>
<tr>
<td>France</td>
<td>4 (0.6)</td>
</tr>
<tr>
<td>Russian Federation</td>
<td>6 (0.7)</td>
</tr>
<tr>
<td>United States</td>
<td>5 (0.9)</td>
</tr>
<tr>
<td>Sweden</td>
<td>7 (0.8)</td>
</tr>
<tr>
<td>Slovenia</td>
<td>10 (1.7)</td>
</tr>
<tr>
<td>Italy</td>
<td>6 (0.9)</td>
</tr>
<tr>
<td>Lebanon</td>
<td>6 (1.1)</td>
</tr>
</tbody>
</table>

* No Response.

See Appendix P.C.5 for sampling guidelines and sampling participation notes †, ‡, and ¶.

( ) Standard errors appear in parentheses. Because of rounding some results may appear inconsistent.

### Point Y

<table>
<thead>
<tr>
<th>Country</th>
<th>Percent of Students Responding to Each Answer Option</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>A</td>
</tr>
<tr>
<td>Portugal</td>
<td>1 (0.5)</td>
</tr>
<tr>
<td>France</td>
<td>2 (0.4)</td>
</tr>
<tr>
<td>Norway</td>
<td>3 (0.7)</td>
</tr>
<tr>
<td>Russian Federation</td>
<td>3 (0.7)</td>
</tr>
<tr>
<td>Slovenia</td>
<td>4 (0.9)</td>
</tr>
<tr>
<td>United States</td>
<td>4 (1.3)</td>
</tr>
<tr>
<td>Italy</td>
<td>5 (0.9)</td>
</tr>
<tr>
<td>Sweden</td>
<td>4 (0.6)</td>
</tr>
<tr>
<td>Lebanon</td>
<td>2 (0.6)</td>
</tr>
</tbody>
</table>

### Point Z

<table>
<thead>
<tr>
<th>Country</th>
<th>Percent of Students Responding to Each Answer Option</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>A</td>
</tr>
<tr>
<td>France</td>
<td>1 (0.3)</td>
</tr>
<tr>
<td>Norway</td>
<td>1 (0.3)</td>
</tr>
<tr>
<td>Portugal</td>
<td>1 (0.4)</td>
</tr>
<tr>
<td>Sweden</td>
<td>1 (0.2)</td>
</tr>
<tr>
<td>Russian Federation</td>
<td>1 (0.3)</td>
</tr>
<tr>
<td>Slovenia</td>
<td>2 (0.8)</td>
</tr>
<tr>
<td>Italy</td>
<td>1 (0.4)</td>
</tr>
<tr>
<td>United States</td>
<td>1 (0.4)</td>
</tr>
<tr>
<td>Lebanon</td>
<td>1 (0.4)</td>
</tr>
</tbody>
</table>
### Exhibit P2.4.3: Intermediate International Benchmark – Example Item 3

<table>
<thead>
<tr>
<th>Country</th>
<th>Percent</th>
<th>Full Credit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Portugal</td>
<td>69 (2.8)</td>
<td></td>
</tr>
<tr>
<td>Slovenia</td>
<td>58 (2.7)</td>
<td></td>
</tr>
<tr>
<td>France</td>
<td>54 (2.0)</td>
<td></td>
</tr>
<tr>
<td>International Avg.</td>
<td>50 (0.8)</td>
<td></td>
</tr>
<tr>
<td>Lebanon</td>
<td>50 (3.2)</td>
<td></td>
</tr>
<tr>
<td>Russian Federation</td>
<td>50 (2.3)</td>
<td></td>
</tr>
<tr>
<td>Norway</td>
<td>47 (1.7)</td>
<td></td>
</tr>
<tr>
<td>Sweden</td>
<td>46 (1.4)</td>
<td></td>
</tr>
<tr>
<td>United States</td>
<td>43 (3.4)</td>
<td></td>
</tr>
<tr>
<td>Italy</td>
<td>35 (1.9)</td>
<td></td>
</tr>
</tbody>
</table>

**Content Domain: Electricity & Magnetism**

**Cognitive Domain: Applying**

**Description: Part B - Orders three points in an electric field by increasing field strength**

The electric field lines around two positive point charges are shown in the diagram.

A. A positive test charge is placed at each of the points listed below. Choose the direction of the arrow which best represents the force the charge would experience at each of the points.

<table>
<thead>
<tr>
<th>Point X</th>
<th>Point Y</th>
<th>Point Z</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image" alt="Arrow A" /></td>
<td><img src="image" alt="Arrow B" /></td>
<td><img src="image" alt="Arrow A" /></td>
</tr>
<tr>
<td><img src="image" alt="Arrow C" /></td>
<td><img src="image" alt="Arrow B" /></td>
<td><img src="image" alt="Arrow B" /></td>
</tr>
<tr>
<td><img src="image" alt="Arrow D" /></td>
<td><img src="image" alt="Arrow C" /></td>
<td><img src="image" alt="Arrow C" /></td>
</tr>
<tr>
<td><img src="image" alt="Arrow E" /></td>
<td><img src="image" alt="Arrow E" /></td>
<td><img src="image" alt="Arrow E" /></td>
</tr>
</tbody>
</table>

B. List the points X, Y, and Z in order of increasing field strength.

\[Z, X, Y\]

The answer shown illustrates the type of response that would receive full credit (1 point). To receive 1 point for part B, students ordered the points by increasing field strength: Z, X, Y.

© Percent significantly higher than international average
$\triangleright$ Percent significantly lower than international average

See Appendix PC.5 for sampling guidelines and sampling participation notes †, ‡, and ¶.

( ) Standard errors appear in parentheses. Because of rounding some results may appear inconsistent.
### Exhibit P2.4.3: Intermediate International Benchmark – Example Item 3 (Continued)

#### Scoring Guide

<table>
<thead>
<tr>
<th>Code</th>
<th>Response</th>
<th>Item: PA33102B</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>Z, X, Y</td>
<td></td>
</tr>
<tr>
<td></td>
<td>OR</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Y, X, Z with a clear indication that Y is the strongest.</td>
<td></td>
</tr>
</tbody>
</table>

#### Correct Response

10  

#### Incorrect Response

79  Incorrect (including crossed out, erased, stray marks, illegible, or off task)

#### Nonresponse

NR  Blank

#### Percent of Students in Each Scoring Guide Category

<table>
<thead>
<tr>
<th>Country</th>
<th>Correct Student Response</th>
<th>Incorrect Student Responses</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>10</td>
<td>79</td>
</tr>
<tr>
<td>Portugal</td>
<td>69 (2.8)</td>
<td>30 (2.8)</td>
</tr>
<tr>
<td>Slovenia</td>
<td>58 (2.7)</td>
<td>39 (2.6)</td>
</tr>
<tr>
<td>France</td>
<td>54 (2.0)</td>
<td>41 (1.8)</td>
</tr>
<tr>
<td>*Lebanon</td>
<td>50 (3.2)</td>
<td>31 (2.3)</td>
</tr>
<tr>
<td>Russian Federation</td>
<td>50 (2.3)</td>
<td>39 (2.1)</td>
</tr>
<tr>
<td>Norway</td>
<td>47 (1.7)</td>
<td>42 (1.6)</td>
</tr>
<tr>
<td>Sweden</td>
<td>46 (1.4)</td>
<td>49 (1.5)</td>
</tr>
<tr>
<td>*United States</td>
<td>43 (3.4)</td>
<td>54 (4.0)</td>
</tr>
<tr>
<td>Italy</td>
<td>35 (1.9)</td>
<td>46 (2.1)</td>
</tr>
</tbody>
</table>

* No Response.

See Appendix PC.5 for sampling guidelines and sampling participation notes †, ‡, and ¶.

(1) Standard errors appear in parentheses. Because of rounding some results may appear inconsistent.
A marine animal makes a sound with a frequency of $1.00 \times 10^2$ Hz under the water.

The sound is detected above the surface of the water.

The speed of sound in air at 20 °C and 1 atm is 343 m/s. What is the wavelength of the sound after it enters the air when the temperature is 20 °C?

Answer: $3.43 \text{ m}$
### Exhibit P2.4.4: Intermediate International Benchmark – Example Item 4 (Continued)

#### Scoring Guide

<table>
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<tbody>
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</tr>
<tr>
<td>79</td>
<td><strong>Incorrect Response</strong></td>
<td>Incorrect (including crossed out, erased, stray marks, illegible, or off task)</td>
</tr>
<tr>
<td>NR</td>
<td><strong>Nonresponse</strong></td>
<td>Blank</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Country</th>
<th>Correct Student Response</th>
<th>Incorrect Student Responses</th>
<th>Percent of Students in Each Scoring Guide Category</th>
</tr>
</thead>
<tbody>
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<td>79</td>
<td>NR*</td>
</tr>
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<td>73 (2.5)</td>
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<td>12 (2.0)</td>
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<tr>
<td>Slovenia</td>
<td>72 (2.4)</td>
<td>20 (2.1)</td>
<td>8 (1.5)</td>
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<td>Russian Federation</td>
<td>64 (3.0)</td>
<td>17 (1.6)</td>
<td>19 (2.4)</td>
</tr>
<tr>
<td>Norway</td>
<td>59 (1.9)</td>
<td>24 (1.6)</td>
<td>17 (1.4)</td>
</tr>
<tr>
<td>Lebanon</td>
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<td>19 (2.8)</td>
<td>22 (2.3)</td>
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<tr>
<td>Sweden</td>
<td>53 (2.2)</td>
<td>28 (1.7)</td>
<td>19 (1.6)</td>
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<td>United States</td>
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<td>12 (1.3)</td>
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<td>23 (1.5)</td>
</tr>
<tr>
<td>Italy</td>
<td>43 (2.3)</td>
<td>20 (1.6)</td>
<td>37 (2.2)</td>
</tr>
</tbody>
</table>

* No Response.

See Appendix PC.5 for sampling guidelines and sampling participation notes †, ‡, and ¶.

( ) Standard errors appear in parentheses. Because of rounding some results may appear inconsistent.
### Exhibit P2.4.5: Intermediate International Benchmark – Example Item 5

**Content Domain:** Wave Phenomena & Atomic/Nuclear Physics  
**Cognitive Domain:** Knowing  
**Description:** Completes a table to indicate the number of protons and neutrons in given isotopes

The first eight elements in the periodic table ranked according to atomic number are H, He, Li, Be, B, C, N, O.

Fill in the table below with the number of “Protons” and “Neutrons” in the following isotopes.

<table>
<thead>
<tr>
<th>Isotope</th>
<th>Number of Protons</th>
<th>Number of Neutrons</th>
</tr>
</thead>
<tbody>
<tr>
<td>$^4\text{He}$</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>$^{14}\text{C}$</td>
<td>6</td>
<td>8</td>
</tr>
<tr>
<td>$^{14}\text{N}$</td>
<td>7</td>
<td>7</td>
</tr>
</tbody>
</table>

The answer shown illustrates the type of response that would receive full credit (1 point). To receive 1 point, students entered the correct numbers of protons and neutrons for each isotope in the table.

- percent significantly higher than international average
- percent significantly lower than international average

See Appendix P.C.5 for sampling guidelines and sampling participation notes †, ‡, and ¶.

( ) Standard errors appear in parentheses. Because of rounding some results may appear inconsistent.
### Scoring Guide

<table>
<thead>
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<th>Response</th>
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<tbody>
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<td><strong>Correct Response</strong></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>All six numbers correct:</td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Isotope</strong></td>
<td><strong>Number of protons</strong></td>
</tr>
<tr>
<td></td>
<td>$^4$He</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>$^{14}$C</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>$^{14}$N</td>
<td>7</td>
</tr>
<tr>
<td></td>
<td><strong>Incorrect Response</strong></td>
<td></td>
</tr>
<tr>
<td>70</td>
<td>All protons correct, all neutrons wrong</td>
<td></td>
</tr>
<tr>
<td>71</td>
<td>Any five numbers correct</td>
<td></td>
</tr>
<tr>
<td>79</td>
<td>Other incorrect (including crossed out, erased, stray marks, illegible, or off task)</td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Nonresponse</strong></td>
<td>Blank</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Country</th>
<th>Correct Student Response</th>
<th>Incorrect Student Responses</th>
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<tbody>
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<td></td>
<td>10</td>
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<tr>
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<td>71 (1.9)</td>
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<td>Norway</td>
<td>63 (2.2)</td>
<td>5 (0.9)</td>
</tr>
<tr>
<td>Lebanon</td>
<td>60 (3.3)</td>
<td>2 (0.7)</td>
</tr>
<tr>
<td>Slovenia</td>
<td>55 (2.9)</td>
<td>3 (0.8)</td>
</tr>
<tr>
<td>Sweden</td>
<td>48 (1.9)</td>
<td>4 (0.6)</td>
</tr>
<tr>
<td>United States</td>
<td>35 (3.5)</td>
<td>9 (1.4)</td>
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<tr>
<td>Portugal</td>
<td>35 (2.1)</td>
<td>6 (1.2)</td>
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<tr>
<td>France</td>
<td>22 (1.2)</td>
<td>6 (0.6)</td>
</tr>
<tr>
<td>Italy</td>
<td>20 (1.6)</td>
<td>7 (0.9)</td>
</tr>
</tbody>
</table>

* No Response.

See Appendix PC.5 for sampling guidelines and sampling participation notes †, ‡, and ¶.

( ) Standard errors appear in parentheses. Because of rounding some results may appear inconsistent.

---

**SOURCE:** IEA’s Trends in International Mathematics and Science Study – TIMSS Advanced 2015

TIMSS & PIRLS
International Study Center
Lynch School of Education, Boston College

Downloaded from timss2015.org/advanced/download-center/
Exhibit P2.5: Description of the TIMSS Advanced 2015 High International Benchmark (550) of Physics Achievement

High International Benchmark

Summary

*Students apply basic laws of physics in solving problems in a variety of situations.* They apply knowledge of forces and motion, communicate understanding of the laws of conservation of energy and momentum, and apply knowledge of heat and temperature to solve problems. Students apply knowledge of Ohm’s Law and Joule’s Law to electric circuits, solve problems involving charged particles in magnetic fields, and apply knowledge of magnetic fields and electromagnetic induction to solve problems. They show understanding of phenomena related to electromagnetic waves and knowledge of nuclear reactions. Students interpret information in complex diagrams and graphs depicting abstract concepts, derive formulas and provide calculations of a variety of physical quantities in a range of contexts, evaluate explanations for physical phenomena, and provide brief explanations to communicate scientific knowledge.

Students apply knowledge of forces and motion to solve problems, estimating the coefficient of friction between an object and the ground and the magnitude of the normal force on a body sliding inside a cylinder, and deriving an expression for the speed of an object at the top of a vertical circular path. They communicate understanding of the laws of conservation of energy and momentum, calculating the speed and identifying the direction of motion of colliding objects. Students apply knowledge of heat and temperature to solve problems involving gas laws, pressure-volume graphs, and the energy release of cooling water.

Students apply knowledge of Ohm’s Law and Joule’s Law to electric circuits and solve problems involving the interactions of charged particles with each other and with magnetic fields. They apply knowledge of magnetic fields and electromagnetic induction to solve problems.

Students show understanding of phenomena related to electromagnetic waves by identifying wavelengths of electromagnetic radiation most harmful to humans and by calculating the index of refraction of glass. Students apply knowledge of atomic and nuclear physics, explaining which semiconductor is appropriate to use in solar panels, estimating the age of an organic specimen from the concentration of carbon-14 present, identifying the source of energy used to generate electricity in a nuclear power plant, and recognize what accounts for the difference in mass of an atom before and after a nuclear reaction.

Students interpret information in complex diagrams and graphs depicting abstract concepts, derive formulas and provide calculations of a variety of physical quantities in a range of contexts, evaluate explanations for physical phenomena, and provide brief explanations to communicate scientific knowledge.
### Exhibit P2.5.1: High International Benchmark – Example Item 1

<table>
<thead>
<tr>
<th>Country</th>
<th>Percent Correct</th>
<th>Cognitive Domain: Reasoning</th>
<th>Description: Derives an expression for the speed at the top of the trajectory of an object moving in a vertical circular path</th>
</tr>
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<tbody>
<tr>
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</tr>
<tr>
<td>Slovenia</td>
<td>59 (2.7)</td>
<td></td>
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</tr>
<tr>
<td>Portugal</td>
<td>55 (2.5)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>International Avg.</td>
<td>49 (0.8)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>United States</td>
<td>43 (3.2)</td>
<td></td>
<td></td>
</tr>
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<td>Italy</td>
<td>39 (2.0)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sweden</td>
<td>38 (2.3)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lebanon</td>
<td>34 (2.7)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>France</td>
<td>28 (1.5)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

An aircraft flies in a vertical circular path of radius $R$ at a constant speed. When the aircraft is at the top of the circular path the passengers feel "weightless". Acceleration due to gravity $= g$.

What is the speed of the aircraft at the top of the path?

- **A** $gR$
- **B** $\sqrt{gR}$
- **C** $\frac{g}{R}$
- **D** $\sqrt{\frac{g}{R}}$
- **E** $2gR$

See Appendix PC.5 for sampling guidelines and sampling participation notes †, ‡, and ¶.

( ) Standard errors appear in parentheses. Because of rounding some results may appear inconsistent.
### Exhibit P2.5.1: High International Benchmark – Example Item 1 (Continued)

<table>
<thead>
<tr>
<th>Country</th>
<th>Percent of Students Responding to Each Answer Option</th>
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<tbody>
<tr>
<td></td>
<td>A</td>
</tr>
<tr>
<td>Russian Federation</td>
<td>8 (0.9)</td>
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<td>Norway</td>
<td>5 (0.8)</td>
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<td>Slovenia</td>
<td>9 (1.7)</td>
</tr>
<tr>
<td>Portugal</td>
<td>3 (1.0)</td>
</tr>
<tr>
<td>United States</td>
<td>12 (1.4)</td>
</tr>
<tr>
<td>Italy</td>
<td>18 (1.5)</td>
</tr>
<tr>
<td>Sweden</td>
<td>15 (1.2)</td>
</tr>
<tr>
<td>Lebanon</td>
<td>19 (1.9)</td>
</tr>
<tr>
<td>France</td>
<td>17 (1.2)</td>
</tr>
</tbody>
</table>

* No Response.

See Appendix PC.5 for sampling guidelines and sampling participation notes †, ‡, and ¶.

( ) Standard errors appear in parentheses. Because of rounding some results may appear inconsistent.
### Exhibit P2.5.2: High International Benchmark – Example Item 2

#### Content Domain: Mechanics & Thermodynamics

#### Cognitive Domain: Applying

**Description:** Shows the steps in a calculation of the final velocity of two skiers after they collide inelastically

Robert is skiing down a hill. At the bottom of the hill when his velocity is 5 m/s, he collides with David, who is at rest. They continue together in the same direction. Robert’s mass is 60 kg and David’s mass is 90 kg. Assume no frictional effects.

What is the common velocity of David and Robert right after the collision?

Show your work, including any equations you use.

**Answer:** \[
\frac{2}{\text{m/s}}
\]

\[
\frac{(m_{\text{David}} + m_{\text{Robert}}) \cdot v_f}{m_{\text{David}} + m_{\text{Robert}}} = \frac{m_{\text{David}} \cdot v_{\text{David}} + m_{\text{Robert}} \cdot v_{\text{Robert}}}{m_{\text{David}} + m_{\text{Robert}}}
\]

\[
v_f = \frac{m_{\text{Robert}} \cdot v_{\text{Robert}}}{m_{\text{David}} + m_{\text{Robert}}}
\]

\[
v_f = \frac{(60)(5)}{60 + 90} = 2 \text{ m/s}
\]

The answer shown illustrates the type of response that would receive full credit (2 points). To receive 2 points, student work showed a mathematical statement of the conservation of momentum, substitution of the relevant values, and the final answer.

See Appendix PC.5 for sampling guidelines and sampling participation notes †, ‡, and ¶.

( ) Standard errors appear in parentheses. Because of rounding some results may appear inconsistent.
### Exhibit P2.5.2: High International Benchmark – Example Item 2 (Continued)

#### Scoring Guide

<table>
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</thead>
<tbody>
<tr>
<td>20</td>
<td><strong>Answer: 2</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Student work includes both of these points:</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• The final momentum is equal to the initial momentum:</td>
<td></td>
</tr>
<tr>
<td></td>
<td>[(m_{p_2} + m_R)v_f = m_{p_2}v_{f_2} + m_Rv_R = 0 + m_Rv_R]</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(a mathematical statement of the conservation of momentum)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• [v = \frac{m_{p_2}v_{f_2}}{m_{p_2} + m_R} = \frac{60 \text{ kg} \cdot 5 \text{ m/s}}{60 \text{ kg} + 90 \text{ kg}} \approx 2 \text{ m/s}]</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(substitution of the relevant values and final answer)</td>
<td></td>
</tr>
</tbody>
</table>

#### Partially Correct Response

<table>
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<th>Correct Response</th>
<th>Item: PA33058</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td><strong>Answer: 2</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Student work either does not include both of the points listed for Code 20 above or the work shown for one or both of the points is missing or incomplete.</td>
<td></td>
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#### Incorrect Response

<table>
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<tr>
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<tbody>
<tr>
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<td>Incorrect (including crossed out, erased, stray marks, illegible, or off task)</td>
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#### Nonresponse

<table>
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### Percent of Students in Each Scoring Guide Category

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<th>Incorrect Student Responses</th>
</tr>
</thead>
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</tr>
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<td>Norway</td>
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<td>9 (0.9)</td>
</tr>
<tr>
<td>Slovenia</td>
<td>49 (3.8)</td>
<td>13 (1.6)</td>
</tr>
<tr>
<td>Lebanon</td>
<td>47 (2.9)</td>
<td>12 (1.8)</td>
</tr>
<tr>
<td>Russian Federation</td>
<td>37 (2.4)</td>
<td>32 (1.8)</td>
</tr>
<tr>
<td>United States</td>
<td>35 (2.7)</td>
<td>16 (2.3)</td>
</tr>
<tr>
<td>Portugal</td>
<td>29 (2.9)</td>
<td>4 (0.8)</td>
</tr>
<tr>
<td>Sweden</td>
<td>25 (2.5)</td>
<td>6 (0.9)</td>
</tr>
<tr>
<td>Italy</td>
<td>12 (1.4)</td>
<td>5 (0.8)</td>
</tr>
<tr>
<td>France</td>
<td>11 (1.3)</td>
<td>4 (0.6)</td>
</tr>
</tbody>
</table>

* No Response.
See Appendix PC.5 for sampling guidelines and sampling participation notes †, ‡, and ¶.

(*) Standard errors appear in parentheses. Because of rounding some results may appear inconsistent.
### Exhibit P2.5.3: High International Benchmark – Example Item 3

**Content Domain:** Mechanics & Thermodynamics

**Cognitive Domain:** Applying

Description: Shows the steps in a calculation of the amount of energy required to increase the temperature of water in a given context.

---

<table>
<thead>
<tr>
<th>Country</th>
<th>Percent</th>
<th>Full Credit</th>
</tr>
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<tr>
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<td>77 (2.2)</td>
<td>✨</td>
</tr>
<tr>
<td>Russian Federation</td>
<td>68 (2.4)</td>
<td>✨</td>
</tr>
<tr>
<td>Portugal</td>
<td>57 (2.9)</td>
<td>✨</td>
</tr>
<tr>
<td>Sweden</td>
<td>53 (2.3)</td>
<td>✨</td>
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<tr>
<td>International Avg.</td>
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<td></td>
</tr>
<tr>
<td>Italy</td>
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<td></td>
</tr>
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<td></td>
</tr>
<tr>
<td>United States</td>
<td>26 (2.1)</td>
<td></td>
</tr>
<tr>
<td>Norway</td>
<td>17 (1.4)</td>
<td></td>
</tr>
<tr>
<td>Lebanon</td>
<td>12 (1.8)</td>
<td></td>
</tr>
</tbody>
</table>

Mark drinks 0.50 L of water. The water is at a temperature of 4.0 °C and is then heated to 37.0 °C in his body.

How much energy is required for the increase in the temperature of the water? The specific heat capacity of water is 4.2 kJ/kg°C.

Show your work, including any equations you use.

Answer: \[ Q = \frac{C \cdot m \cdot \Delta T}{\text{kJ}} \]

\[ Q = (4.2)(0.5)(37-4) \]

\[ = 69 \text{ kJ} \]

---

The answer shown illustrates the type of response that would receive full credit (1 point). To receive 1 point, student work showed a mathematical statement relating energy to the specific heat capacity of water, mass, and temperature change; substitution of the relevant values; and the final answer.

- ✨ Percent significantly higher than international average
- ▼ Percent significantly lower than international average

See Appendix P.C.5 for sampling guidelines and sampling participation notes †, ‡, and ¶.

( ) Standard errors appear in parentheses. Because of rounding some results may appear inconsistent.
### Exhibit P2.5.3: High International Benchmark – Example Item 3 (Continued)

<table>
<thead>
<tr>
<th>Scoring Guide</th>
<th>Correct Response</th>
</tr>
</thead>
</table>
| 10 | Answer: 69 (Answers between 69 and 70 are also acceptable.)  
Student work shows the following:  
\[ Q = c \cdot m \cdot \Delta T = (4.2 \text{ kJ/kg} \cdot \text{°C}) \cdot (0.50 \text{ kg}) \cdot (33 \text{ °C}) = 69 \text{ kJ} \] |

<table>
<thead>
<tr>
<th>Incorrect Response</th>
</tr>
</thead>
</table>
| 70 | Answer: 69 (Answers between 69 and 70 are also acceptable.)  
Student does not show the formula (\( Q = c \cdot m \cdot \Delta T \)). |
| 71 | Student writes \( Q = c \cdot m \cdot \Delta T \), but arrives at an incorrect. |
| 79 | Other incorrect (including crossed out, erased, stray marks, illegible, or off task) |
| Nonresponse: Blank |

<table>
<thead>
<tr>
<th>Country</th>
<th>Correct Student Response</th>
<th>Incorrect Student Responses</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>10</td>
<td>70</td>
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<td>Slovenia</td>
<td>77 (2.2)</td>
<td>1 (0.4)</td>
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<tr>
<td>Russian Federation</td>
<td>68 (2.4)</td>
<td>5 (0.8)</td>
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<td>Portugal</td>
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<td>Sweden</td>
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<tr>
<td>Lebanon</td>
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<td>3 (0.8)</td>
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</tbody>
</table>

* No Response.

See Appendix PC.5 for sampling guidelines and sampling participation notes †, ‡, and ¶.

( ) Standard errors appear in parentheses. Because of rounding some results may appear inconsistent.
### Exhibit P2.5.4: High International Benchmark – Example Item 4

<table>
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<th>Percent Correct</th>
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<td>Russian Federation</td>
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</table>

**Content Domain: Electricity & Magnetism**

**Cognitive Domain: Applying**

**Description:** Ranks the equivalent resistance of four different combinations of resistors

The figures above show four different ways of connecting three identical resistors. Which of the following shows the four connections in order of decreasing resistance?

- **A** 1, 2, 3, 4
- **B** 1, 3, 2, 4
- **C** 4, 3, 2, 1
- **D** 4, 2, 3, 1

- Percent significantly higher than international average
- Percent significantly lower than international average

See Appendix P.C.5 for sampling guidelines and sampling participation notes 1, 4, and 7.

(1) Standard errors appear in parentheses. Because of rounding some results may appear inconsistent.
### Exhibit P2.5.4: High International Benchmark – Example Item 4 (Continued)

* Percent of Students Responding to Each Answer Option

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* No Response.

See Appendix PC.5 for sampling guidelines and sampling participation notes †, ‡, and ¶.

(1) Standard errors appear in parentheses. Because of rounding some results may appear inconsistent.
### Exhibit P2.5.5: High International Benchmark – Example Item 5

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</table>

**Content Domain:** Wave Phenomena & Atomic/Nuclear Physics

**Cognitive Domain:** Applying

**Description:** Explains which semiconductor is appropriate to use in a solar panel, given a graph of the performance of each semiconductor across a range of wavelengths of light.

---

The figure below shows the capacity of two semiconductors to convert light into electrical current as a function of the wavelengths of light. Most of the Sun’s energy reaching the Earth’s surface is in the visible part of the spectrum, which is the shaded part of the graph.

![Graph of semiconductor performance](image)

Which material, c-Si or GaAsAl, is the better material to use as the semiconductor in solar panels?

(Check one box.)

- [ ] c-Si
- [x] GaAsAl

Explain your answer.

GaAsAl converts light in the visible spectrum to electricity better than c-Si. Most of the sunlight coming to Earth is in the visible spectrum, so GaAsAl would make a better converter of sunlight to electricity.

The answer shown illustrates the type of response that would receive full credit (1 point). To receive 1 point, students selected GaAsAl and explained that the photons in the visible light region match the light conversion curve for GaAsAl better than the curve for c-Si.

- Percent significantly higher than international average
- Percent significantly lower than international average

---

See Appendix PC.5 for sampling guidelines and sampling participation notes †, ‡, and ¶.

( ) Standard errors appear in parentheses. Because of rounding some results may appear inconsistent.
### Exhibit P2.5.5: High International Benchmark – Example Item 5 (Continued)

#### Scoring Guide

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<td>GaAsAl with the explanation that the photons in the visible light region (or the visible light region of the spectrum of sunlight) have a better match for GaAsAl than for c-Si.</td>
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<table>
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<td></td>
<td>- GaAsAl without an explanation or with an incorrect explanation.</td>
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<td>- c-Si with or without an explanation.</td>
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#### Percent of Students in Each Scoring Guide Category

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* No Response.

See Appendix PC.5 for sampling guidelines and sampling participation notes †, ‡, and ¶.

(1) Standard errors appear in parentheses. Because of rounding some results may appear inconsistent.
Summary

*Students communicate their understanding of laws of physics to solve problems in practical and abstract contexts.* They apply knowledge of the motion of objects in freefall, of heat and temperature, and of electric circuits and electric fields. Students communicate understanding of magnetic fields and of phenomena related to mechanical and electromagnetic waves, and demonstrate understanding of atomic and nuclear physics. Students design experimental procedures and interpret results, synthesize information in complex diagrams and graphs depicting abstract physics concepts to solve problems, provide multi-step calculations of a variety of physical quantities in a range of contexts, draw conclusions about physical phenomena, and provide explanations to communicate scientific knowledge.

Students show knowledge of the motion of objects in freefall. They apply knowledge of heat and temperature to practical problems, calculating, for example, the temperature of a gas after compression, describing a process for calibrating a thermometer, and analyzing a mechanical system run by an electric motor to account for energy loss.

Students apply knowledge about electric circuits and electric fields to, for example, calculations of the force on a charged particle moving between two charged plates, comparisons of the power consumption of different light bulbs in a complex circuit, and interpretations of a current-resistance graph to calculate the internal resistance of a battery. Students communicate understanding of magnetic fields by calculating the magnitude of a magnetic field acting on a proton in motion and predicting the change in the path of an electron beam in the presence of a magnetic field.

Students apply knowledge of phenomena related to electromagnetic waves, evaluating arguments that relate the wavelength of light to the temperature of the emitting body, relating the colors of light emitted by metal bars to explain which is hotter, and recognizing that a red object absorbs light of all wavelengths from a green light source. Students demonstrate basic understanding of atomic and nuclear physics, completing equations for nuclear fission reactions, identifying the most appropriate atomic reactants to use in a fusion reaction, and calculating the mass lost during a fusion reaction.

Students design experimental procedures and interpret results, synthesize information in complex diagrams and graphs depicting abstract physics concepts to solve problems, provide multi-step calculations of a variety of physical quantities in a range of contexts, draw conclusions about physical phenomena, and provide explanations to communicate scientific knowledge.
**Exhibit P2.6.1: Advanced International Benchmark – Example Item 1**

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**Content Domain: Mechanics & Thermodynamics**

**Cognitive Domain: Reasoning**

**Description:** Evaluates a mechanical system run by an electric motor and predicts the difference between the theoretical and actual final temperatures of the system.

The figure below shows a thermally insulated mixing machine that can be used to measure energy transfers. The electric motor turns the paddle, which provides energy to the system. If the input energy from the circuit and the amount of water and its initial temperature are known, it is possible to calculate the change in the temperature of the water for ideal conditions.

![Illustration of a thermally insulated mixing machine](image)

In an actual experiment, the final temperature of the water differs from the value calculated for ideal conditions.

Do you expect the actual temperature to be higher or lower than the calculated value?

(Check one box.)

- ☐ higher than the calculated value
- ✗ lower than the calculated value

Explain what could have caused the difference.

_Not all of the energy goes into heating up the water. Some of it goes into the surroundings and is lost from the system._

The answer shown illustrates the type of response that would receive full credit (1 point). To receive 1 point, students selected _lower than the calculated value_ and explained that some of the energy was transferred to other parts of the system or the surroundings.

- ☑ Percent significantly higher than international average
- ✗ Percent significantly lower than international average

See Appendix P2.5 for sampling guidelines and sampling participation notes 1, 4, and 1.

(*) Standard errors appear in parentheses. Because of rounding some results may appear inconsistent.
### Exhibit P2.6.1: Advanced International Benchmark – Example Item 1 (Continued)

#### Scoring Guide

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<td>Lower than the calculated value with one or more of the following acceptable justifications:</td>
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<tr>
<td></td>
<td>• Not all of the energy goes into heating up the water.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Some of the energy goes into raising the temperature of the motor and/or other mechanical parts of the system.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Some of the energy goes into raising the temperature of the walls.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Some of the energy is transferred to other parts of the system or the surroundings/environment.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Some of the energy transfers to the kinetic energy of the moving paddle and/or moving water.</td>
<td></td>
</tr>
</tbody>
</table>

| Incorrect Response | |
|---|---|---|
| 79 | Incorrect (including crossed out, erased, stray marks, illegible, or off task), including the following responses: |
|     | • Lower than the calculated value without an explanation or with an incorrect explanation |
|     | • Higher than the calculated value with or without an explanation. |

| Nonresponse | |
| NR | Blank |

#### Percent of Students in Each Scoring Guide Category

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* No Response.

See Appendix PC.5 for sampling guidelines and sampling participation notes †, ‡, and ¶.

( ) Standard errors appear in parentheses. Because of rounding some results may appear inconsistent.
Exhibit P2.6.2: Advanced International Benchmark – Example Item 2

**Content Domain: Electricity & Magnetism**
**Cognitive Domain: Reasoning**
**Description:** Analyzes a complex circuit diagram to determine the power consumption of light bulbs

Nine identical bulbs 1–9 are connected to a constant voltage V as shown in the figure.

Which bulbs use the least power?

- **A** Bulbs 2 and 3
- **B** Bulbs 4 and 5
- **C** Bulbs 6 and 7
- **D** Bulbs 8 and 9

See Appendix PC.5 for sampling guidelines and sampling participation notes †, ‡, and ¶.

( ) Standard errors appear in parentheses. Because of rounding some results may appear inconsistent.
### Exhibit P2.6.2: Advanced International Benchmark – Example Item 2 (Continued)

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* No Response.

See Appendix PC.5 for sampling guidelines and sampling participation notes †, ‡, and ¶.

( ) Standard errors appear in parentheses. Because of rounding some results may appear inconsistent.

### Exhibit P2.6.3: Advanced International Benchmark – Example Item 3

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</table>

**Content Domain:** Electricity & Magnetism  
**Cognitive Domain:** Reasoning  
**Description:** Identifies the prediction for the change in the path of a horizontal electron beam as a result of the presence of a magnetic field

---

A beam of electrons inside an evacuated glass tube is directed from left to right.

A uniform magnetic field is applied to the tube directed down, as shown in the diagram. What will happen to the electrons in the beam?

- **A** The beam curves into the page.
- **B** The beam curves out of the page.
- **C** The beam curves down.
- **D** The beam curves up.

---

See Appendix PC.5 for sampling guidelines and sampling participation notes †, ‡, and ¶.  
(†) Standard errors appear in parentheses. Because of rounding some results may appear inconsistent.  
A dash (-) indicates comparable data not available.
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* No Response.

See Appendix PC.5 for sampling guidelines and sampling participation notes †, ‡, and ¶.

( ) Standard errors appear in parentheses. Because of rounding some results may appear inconsistent.
A dash (-) indicates comparable data not available.

SOURCE: IEA’s Trends in International Mathematics and Science Study – TIMSS Advanced 2015
Exhibit P2.6.4: Advanced International Benchmark – Example Item 4

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<tr>
<td>Russian Federation</td>
<td>51 (2.6)</td>
<td>✗</td>
</tr>
<tr>
<td>† Lebanon</td>
<td>40 (3.0)</td>
<td>✗</td>
</tr>
<tr>
<td>Sweden</td>
<td>34 (1.9)</td>
<td>✗</td>
</tr>
<tr>
<td>Slovenia</td>
<td>32 (2.9)</td>
<td>✗</td>
</tr>
<tr>
<td>International Avg.</td>
<td>28 (0.7)</td>
<td>✗</td>
</tr>
<tr>
<td>Portugal</td>
<td>17 (2.1)</td>
<td></td>
</tr>
<tr>
<td>France</td>
<td>17 (1.1)</td>
<td></td>
</tr>
<tr>
<td>† United States</td>
<td>9 (1.1)</td>
<td></td>
</tr>
<tr>
<td>Italy</td>
<td>4 (0.9)</td>
<td></td>
</tr>
</tbody>
</table>

Content Domain: Wave Phenomena & Atomic/Nuclear Physics
Cognitive Domain: Applying
Description: Completes the equation for a nuclear fission reaction

In a fission reactor in a nuclear power plant, the following reaction may happen:

\[ _{92}^{235}U + _{0}^{1}n \rightarrow _{56}^{144}Ba + _{36}^{90}Kr + ? \]

Complete the equation of the above reaction.

\[ _{92}^{235}U + _{0}^{1}n \rightarrow _{56}^{144}Ba + _{36}^{90}Kr + \boxed{3 _{0}^{1}n} \]

The answer shown illustrates the type of response that would receive full credit (1 point). To receive 1 point, students answered 3 neutrons: \(3 _{0}^{1}n\)

- Percent significantly higher than international average
- Percent significantly lower than international average

See Appendix P2.6.5 for sampling guidelines and sampling participation notes †, ‡, and †.
### Scoring Guide

<table>
<thead>
<tr>
<th>Code</th>
<th>Response</th>
<th>Item: PA23066</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>Correct Response</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>3 neutrons (standard notation): $3\frac{1}{2}n$</td>
<td></td>
</tr>
<tr>
<td>70</td>
<td>Incorrect Response</td>
<td></td>
</tr>
<tr>
<td>79</td>
<td>2 neutrons (regardless of notation)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Other incorrect (including crossed out, erased, stray marks, illegible, or off task)</td>
<td></td>
</tr>
<tr>
<td>NR</td>
<td>Nonresponse</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Blank</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Country</th>
<th>Correct Student Responses</th>
<th>Incorrect Student Responses</th>
</tr>
</thead>
<tbody>
<tr>
<td>Norway</td>
<td>35 (1.8)</td>
<td>17 (1.3)</td>
</tr>
<tr>
<td>Russian Federation</td>
<td>50 (2.7)</td>
<td>2 (0.4)</td>
</tr>
<tr>
<td>Lebanon</td>
<td>40 (3.1)</td>
<td>1 (0.4)</td>
</tr>
<tr>
<td>Sweden</td>
<td>17 (1.4)</td>
<td>17 (1.3)</td>
</tr>
<tr>
<td>Slovenia</td>
<td>22 (2.3)</td>
<td>11 (1.8)</td>
</tr>
<tr>
<td>Portugal</td>
<td>15 (2.5)</td>
<td>2 (0.8)</td>
</tr>
<tr>
<td>France</td>
<td>16 (1.1)</td>
<td>1 (0.3)</td>
</tr>
<tr>
<td>United States</td>
<td>7 (1.1)</td>
<td>2 (0.4)</td>
</tr>
<tr>
<td>Italy</td>
<td>3 (0.9)</td>
<td>1 (0.3)</td>
</tr>
</tbody>
</table>

* No Response.

See Appendix PC.5 for sampling guidelines and sampling participation notes †, ‡, and ¶.

( ) Standard errors appear in parentheses. Because of rounding some results may appear inconsistent.
CHAPTER P3: ACHIEVEMENT IN CONTENT AND COGNITIVE DOMAINS

TIMSS ADVANCED 2015 INTERNATIONAL RESULTS IN ADVANCED MATHEMATICS AND PHYSICS
Differences reflected in Achievement by Gender

Achievement differences in content domains by gender reflect males’ higher achievement in 8 countries in physics overall.

<table>
<thead>
<tr>
<th>Content Domain</th>
<th>Number of Countries</th>
<th>Countries with Males Higher</th>
<th>Countries with Females Higher</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mechanics and Thermodynamics</td>
<td>4</td>
<td>Slovenia, Russian Federation, Portugal, and the United States</td>
<td>3 Countries</td>
</tr>
<tr>
<td>Electricity and Magnetism</td>
<td>2</td>
<td>Russian Federation and Italy</td>
<td>3 Countries</td>
</tr>
<tr>
<td>Wave Phenomena and Atomic/Nuclear Physics</td>
<td>2</td>
<td>Lebanon and France</td>
<td>5 Countries</td>
</tr>
</tbody>
</table>

Within physics, TIMSS Advanced provided results for three content domains—Mechanics and Thermodynamics, Electricity and Magnetism, and Wave Phenomena and Atomic/Nuclear Physics. Most countries demonstrated strengths in one or two content domains compared to physics achievement overall, and weaknesses in one or two content domains.

Achievement by Cognitive Domains

TIMSS Advanced provided results for three cognitive domains—Knowing, Applying, and Reasoning. Although there was some balance in achievement across cognitive domains, most countries had at least one strength and one weakness compared to physics achievement overall.

<table>
<thead>
<tr>
<th>Cognitive Domain</th>
<th>Number of Countries</th>
<th>Countries with Males Higher</th>
<th>Countries with Females Higher</th>
</tr>
</thead>
<tbody>
<tr>
<td>Knowing</td>
<td>3</td>
<td>Russian Federation, Norway, and Portugal</td>
<td>2 Countries</td>
</tr>
<tr>
<td>Applying</td>
<td>2</td>
<td>Slovenia and Lebanon</td>
<td>4 Countries</td>
</tr>
<tr>
<td>Reasoning</td>
<td>4</td>
<td>Norway, Portugal, the United States, and France</td>
<td>3 Countries</td>
</tr>
</tbody>
</table>

Differences reflected in Achievement by Gender

Besides reflecting males’ higher achievement in 8 countries in physics overall, achievement differences in the cognitive domains by gender show a male advantage, especially in Knowing and Reasoning.

<table>
<thead>
<tr>
<th>Cognitive Domain</th>
<th>Number of Countries where Males had higher achievement than Females</th>
<th>Number of Countries where Females had higher achievement than Males</th>
</tr>
</thead>
<tbody>
<tr>
<td>Knowing</td>
<td>7</td>
<td>0</td>
</tr>
<tr>
<td>Applying</td>
<td>4</td>
<td>0</td>
</tr>
<tr>
<td>Reasoning</td>
<td>8</td>
<td>0</td>
</tr>
</tbody>
</table>
### Exhibit P3.1: Achievement in Physics Content Domains

<table>
<thead>
<tr>
<th>Country</th>
<th>Overall Physics Average Scale Score</th>
<th>Mechanics and Thermodynamics (39 items)</th>
<th>Electricity and Magnetism (27 items)</th>
<th>Wave Phenomena and Atomic/Nuclear Physics (35 items)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Average Scale Score</td>
<td>Difference from Overall Physics Score</td>
<td>Average Scale Score</td>
<td>Difference from Overall Physics Score</td>
</tr>
<tr>
<td>Slovenia</td>
<td>531 (2.5)</td>
<td>541 (2.7)</td>
<td>530 (4.3)</td>
<td>-1 (4.5)</td>
</tr>
<tr>
<td>Russian Federation</td>
<td>508 (7.1)</td>
<td>514 (6.7)</td>
<td>515 (8.0)</td>
<td>8 (2.8)</td>
</tr>
<tr>
<td>Norway</td>
<td>507 (4.6)</td>
<td>503 (4.1)</td>
<td>514 (5.5)</td>
<td>7 (3.8)</td>
</tr>
<tr>
<td>Portugal</td>
<td>467 (4.6)</td>
<td>489 (4.8)</td>
<td>431 (5.8)</td>
<td>-35 (4.5)</td>
</tr>
<tr>
<td>Sweden</td>
<td>455 (5.9)</td>
<td>455 (6.1)</td>
<td>455 (6.0)</td>
<td>1 (2.6)</td>
</tr>
<tr>
<td>US</td>
<td>437 (9.7)</td>
<td>462 (9.6)</td>
<td>380 (12.2)</td>
<td>-58 (3.9)</td>
</tr>
<tr>
<td>Lebanon</td>
<td>410 (4.5)</td>
<td>395 (4.4)</td>
<td>399 (5.2)</td>
<td>-11 (5.9)</td>
</tr>
<tr>
<td>Italy</td>
<td>374 (6.9)</td>
<td>376 (6.4)</td>
<td>425 (6.6)</td>
<td>51 (3.7)</td>
</tr>
<tr>
<td>France</td>
<td>373 (4.0)</td>
<td>327 (5.7)</td>
<td>339 (4.7)</td>
<td>-34 (3.8)</td>
</tr>
</tbody>
</table>

- Subscale score significantly higher than overall physics score
- Subscale score significantly lower than overall physics score

See Appendix PC.5 for sampling guidelines and sampling participation notes †, ‡, and ¶.

(1) Standard errors appear in parentheses. Because of rounding some results may appear inconsistent.
### Exhibit P3.2: Achievement in Physics Content Domains by Gender

<table>
<thead>
<tr>
<th>Country</th>
<th>Mechanics and Thermodynamics</th>
<th>Electricity and Magnetism</th>
<th>Wave Phenomena and Atomic/Nuclear Physics</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Females</td>
<td>Males</td>
<td>Females</td>
</tr>
<tr>
<td>Slovenia</td>
<td>515 (6.1)</td>
<td>553 (3.6)</td>
<td>515 (7.2)</td>
</tr>
<tr>
<td>Russian Federation</td>
<td>502 (7.9)</td>
<td>523 (6.8)</td>
<td>510 (9.2)</td>
</tr>
<tr>
<td>Norway</td>
<td>481 (5.0)</td>
<td>511 (4.7)</td>
<td>507 (6.6)</td>
</tr>
<tr>
<td>Portugal</td>
<td>476 (7.0)</td>
<td>493 (5.2)</td>
<td>420 (9.0)</td>
</tr>
<tr>
<td>Sweden</td>
<td>441 (6.4)</td>
<td>465 (6.7)</td>
<td>457 (6.3)</td>
</tr>
<tr>
<td>United States</td>
<td>434 (11.7)</td>
<td>480 (9.4)</td>
<td>346 (15.2)</td>
</tr>
<tr>
<td>Lebanon</td>
<td>396 (9.8)</td>
<td>395 (4.6)</td>
<td>411 (13.0)</td>
</tr>
<tr>
<td>Italy</td>
<td>354 (6.7)</td>
<td>394 (7.4)</td>
<td>414 (6.9)</td>
</tr>
<tr>
<td>France</td>
<td>303 (6.4)</td>
<td>349 (6.5)</td>
<td>321 (7.4)</td>
</tr>
<tr>
<td>International Avg.</td>
<td>434 (2.6)</td>
<td>463 (2.1)</td>
<td>434 (3.1)</td>
</tr>
</tbody>
</table>

- Average significantly higher than other gender

See Appendix PC.5 for sampling guidelines and sampling participation notes †, ‡, and ¶.

(1) Standard errors appear in parentheses. Because of rounding some results may appear inconsistent.
## Exhibit P3.3: Achievement in Physics Cognitive Domains

<table>
<thead>
<tr>
<th>Country</th>
<th>Overall Physics Average Scale Score</th>
<th>Knowing (30 items)</th>
<th>Applying (41 items)</th>
<th>Reasoning (30 items)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Average Scale Score</td>
<td>Difference from Overall Physics Score</td>
<td>Average Scale Score</td>
<td>Difference from Overall Physics Score</td>
</tr>
<tr>
<td>Slovenia</td>
<td>531 (2.5)</td>
<td>521 (4.2)</td>
<td>-10 (3.3)</td>
<td>543 (3.8)</td>
</tr>
<tr>
<td>Russian Federation</td>
<td>508 (7.1)</td>
<td>517 (7.5)</td>
<td>9 (2.4)</td>
<td>508 (7.6)</td>
</tr>
<tr>
<td>Norway</td>
<td>507 (4.6)</td>
<td>529 (4.2)</td>
<td>22 (2.9)</td>
<td>484 (5.3)</td>
</tr>
<tr>
<td>Portugal</td>
<td>467 (4.6)</td>
<td>474 (4.7)</td>
<td>7 (3.0)</td>
<td>452 (5.7)</td>
</tr>
<tr>
<td>Sweden</td>
<td>455 (5.9)</td>
<td>452 (6.0)</td>
<td>-3 (2.1)</td>
<td>454 (6.4)</td>
</tr>
<tr>
<td>United States</td>
<td>437 (9.7)</td>
<td>444 (9.8)</td>
<td>7 (3.5)</td>
<td>420 (10.2)</td>
</tr>
<tr>
<td>Lebanon</td>
<td>410 (4.5)</td>
<td>378 (4.7)</td>
<td>-32 (3.6)</td>
<td>433 (5.4)</td>
</tr>
<tr>
<td>Italy</td>
<td>374 (6.9)</td>
<td>367 (6.6)</td>
<td>-7 (4.4)</td>
<td>371 (7.3)</td>
</tr>
<tr>
<td>France</td>
<td>373 (4.0)</td>
<td>375 (3.9)</td>
<td>2 (1.6)</td>
<td>358 (5.6)</td>
</tr>
</tbody>
</table>

- Subscale score significantly higher than overall physics score
- Subscale score significantly lower than overall physics score

See Appendix P.C.5 for sampling guidelines and sampling participation notes †, ‡, and ¶.

( ) Standard errors appear in parentheses. Because of rounding some results may appear inconsistent.
### Exhibit P3.4: Achievement in Physics Cognitive Domains by Gender

<table>
<thead>
<tr>
<th>Country</th>
<th>Knowing Females</th>
<th>Knowing Males</th>
<th>Applying Females</th>
<th>Applying Males</th>
<th>Reasoning Females</th>
<th>Reasoning Males</th>
</tr>
</thead>
<tbody>
<tr>
<td>Slovenia</td>
<td>492 (8.1)</td>
<td>533 (4.9)</td>
<td>537 (6.7)</td>
<td>546 (4.7)</td>
<td>477 (7.6)</td>
<td>529 (7.1)</td>
</tr>
<tr>
<td>Russian Federation</td>
<td>512 (8.8)</td>
<td>520 (7.6)</td>
<td>502 (9.3)</td>
<td>513 (7.7)</td>
<td>476 (8.2)</td>
<td>505 (7.0)</td>
</tr>
<tr>
<td>Norway</td>
<td>500 (7.0)</td>
<td>541 (4.5)</td>
<td>475 (7.0)</td>
<td>488 (5.5)</td>
<td>497 (9.4)</td>
<td>528 (5.9)</td>
</tr>
<tr>
<td>Portugal</td>
<td>460 (7.6)</td>
<td>479 (5.3)</td>
<td>443 (8.3)</td>
<td>455 (5.8)</td>
<td>467 (6.8)</td>
<td>485 (4.8)</td>
</tr>
<tr>
<td>Sweden</td>
<td>438 (6.4)</td>
<td>461 (6.5)</td>
<td>453 (6.6)</td>
<td>455 (7.1)</td>
<td>440 (6.7)</td>
<td>458 (6.5)</td>
</tr>
<tr>
<td>United States</td>
<td>401 (13.3)</td>
<td>471 (9.3)</td>
<td>401 (13.0)</td>
<td>433 (9.8)</td>
<td>425 (10.5)</td>
<td>474 (8.9)</td>
</tr>
<tr>
<td>Lebanon</td>
<td>385 (7.3)</td>
<td>374 (6.0)</td>
<td>441 (5.5)</td>
<td>427 (7.0)</td>
<td>386 (7.7)</td>
<td>368 (7.6)</td>
</tr>
<tr>
<td>Italy</td>
<td>343 (7.2)</td>
<td>388 (7.7)</td>
<td>359 (7.4)</td>
<td>382 (8.8)</td>
<td>353 (7.4)</td>
<td>394 (8.5)</td>
</tr>
<tr>
<td>France</td>
<td>347 (4.8)</td>
<td>399 (4.5)</td>
<td>345 (7.1)</td>
<td>369 (5.9)</td>
<td>377 (5.5)</td>
<td>414 (6.0)</td>
</tr>
<tr>
<td>International Avg.</td>
<td>431 (2.7)</td>
<td>463 (2.2)</td>
<td>440 (2.7)</td>
<td>452 (2.4)</td>
<td>433 (2.6)</td>
<td>462 (2.3)</td>
</tr>
</tbody>
</table>

- Average significantly higher than other gender

See Appendix PC.5 for sampling guidelines and sampling participation notes †, ‡, and ¶.

() Standard errors appear in parentheses. Because of rounding some results may appear inconsistent.
CHAPTER P4: HOME ENVIRONMENT AND FUTURE PLANS

TIMSS ADVANCED 2015 INTERNATIONAL RESULTS IN ADVANCED MATHEMATICS AND PHYSICS
Students’ Plans for Future Study

Nearly all the Physics students planned to continue their education after finishing secondary school and the vast majority intend to obtain advanced degrees.

Higher percentages of the Females taking physics than of the Males expect to obtain an advanced degree.

76% 70%

of students expect to obtain an advanced degree

The most popular areas of future study included:

- Engineering/Technology: 48%
- Biological/Biomedical: 24%
- Physics: 22%
- Mathematics: 22%

Education trailed behind (7%) as a future area of study.

Students’ Plans for Future Professions

Students who studied physics in secondary school reported considering a number of professions.

A career in Engineering/Technology was the most popular choice, being considered by 72% on average. More than 40% on average also considered Computer Science, Biological/Biomedical, Education, and Finance.

In every country, more Males were considering the professions of Engineering/Technology and Computer Science.

More Females were considering Biological/Biomedical (8 countries), Environmental Science (6 countries), and Education (5 countries).

Exhibit P4.1: Home Educational Resources

Reported by Physics Students

Students were scored according to their responses concerning the availability of four home resources on the Home Educational Resources scale. Students with Many Resources had a score of at least 11.4, which is the point on the scale corresponding to students reporting that they had more than 100 books in the home, both of the home study supports, and that at least one parent had finished university and that at least one parent was a professional, on average. Students with Few Resources had a score no higher than 5.8, which is the scale point corresponding to students reporting that they had 25 or fewer books in the home, neither of the home study supports, and that neither parent had gone beyond upper-secondary education and that neither parent was a small business owner or had a clerical or professional occupation, on average. All other students were assigned to the Some Resources category.

<table>
<thead>
<tr>
<th>Country</th>
<th>Many Resources</th>
<th>Some Resources</th>
<th>Few Resources</th>
<th>Average Scale Score</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Percent of Students</td>
<td>Average Achievement</td>
<td>Percent of Students</td>
<td>Average Achievement</td>
</tr>
<tr>
<td>Norway</td>
<td>51 (1.4)</td>
<td>529 (4.5)</td>
<td>48 (1.4)</td>
<td>485 (5.1)</td>
</tr>
<tr>
<td>Sweden</td>
<td>41 (1.1)</td>
<td>498 (6.0)</td>
<td>58 (1.1)</td>
<td>427 (5.9)</td>
</tr>
<tr>
<td>United States</td>
<td>36 (3.0)</td>
<td>481 (9.7)</td>
<td>62 (2.7)</td>
<td>415 (9.9)</td>
</tr>
<tr>
<td>Slovenia</td>
<td>29 (1.8)</td>
<td>559 (7.9)</td>
<td>70 (1.9)</td>
<td>521 (3.6)</td>
</tr>
<tr>
<td>France</td>
<td>28 (1.0)</td>
<td>410 (4.9)</td>
<td>71 (1.0)</td>
<td>360 (4.1)</td>
</tr>
<tr>
<td>Portugal</td>
<td>26 (1.9)</td>
<td>500 (5.5)</td>
<td>70 (1.9)</td>
<td>457 (5.0)</td>
</tr>
<tr>
<td>Russian Federation</td>
<td>22 (1.4)</td>
<td>533 (7.6)</td>
<td>78 (1.4)</td>
<td>501 (7.7)</td>
</tr>
<tr>
<td>Italy</td>
<td>20 (1.1)</td>
<td>397 (9.7)</td>
<td>78 (1.2)</td>
<td>369 (7.4)</td>
</tr>
<tr>
<td>Lebanon</td>
<td>8 (1.2)</td>
<td>434 (21.2)</td>
<td>84 (1.1)</td>
<td>412 (5.2)</td>
</tr>
<tr>
<td>International Avg.</td>
<td>29 (0.6)</td>
<td>482 (3.3)</td>
<td>69 (0.5)</td>
<td>439 (2.1)</td>
</tr>
</tbody>
</table>

This TIMSS Advanced questionnaire scale was established in 2015 based on the combined response distribution of all countries that participated in TIMSS Advanced 2015. To provide a point of reference for country comparisons, the scale centerpoint of 10 was located at the mean of the combined distribution. The units of the scale were chosen so that 2 scale score points corresponded to the standard deviation of the distribution. A tilde (~) indicates insufficient data to report achievement.

### Exhibit P4.2: Students Working at a Paid Job on a Regular Basis During the School Year

*Reported by Physics Students*

<table>
<thead>
<tr>
<th>Country</th>
<th>Time Spent Working at a Paid Job per Week</th>
<th>Percent of Students</th>
<th>Average Achievement</th>
<th>Percent of Students</th>
<th>Average Achievement</th>
<th>Percent of Students</th>
<th>Average Achievement</th>
<th>Percent of Students</th>
<th>Average Achievement</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No Time</td>
<td>Less than 5 Hours</td>
<td>5 to 10 Hours</td>
<td>More than 10 Hours</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Percent of Students</td>
<td>Average Achievement</td>
<td>Percent of Students</td>
<td>Average Achievement</td>
<td>Percent of Students</td>
<td>Average Achievement</td>
<td>Percent of Students</td>
<td>Average Achievement</td>
<td></td>
</tr>
<tr>
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() Standard errors appear in parentheses. Because of rounding some results may appear inconsistent.
A tilde (~) indicates insufficient data to report achievement.

*SOURCE: IEA’s Trends in International Mathematics and Science Study – TIMSS Advanced 2015*
## Exhibit P4.3: Students Speak the Language of the Test at Home

*Reported by Physics Students*

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(1) Standard errors appear in parentheses. Because of rounding some results may appear inconsistent. A tilde (~) indicates insufficient data to report achievement.
### Exhibit P4.4: Students' Expectations for Further Education

**Reported by Physics Students**

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<th>Bachelor's Degree</th>
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<th>Upper-Secondary Education</th>
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<td>% of Students</td>
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<td>% of Students</td>
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**International Avg.**

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**Students' Expectations for Further Education by Gender**

**Reported by Physics Students**

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*Percent significantly higher than other gender*

Standard errors appear in parentheses. Because of rounding some results may appear inconsistent.

A tilde (~) indicates insufficient data to report achievement.
### Exhibit P4.5: Intended Areas of Study for Students Planning to Continue Their Education

Reported by Physics Students

Students could indicate more than one area of study.

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<th>Engineering and Engineering Technologies</th>
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<td>Percent of Students</td>
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<td>54 (1.2)</td>
</tr>
<tr>
<td>United States</td>
<td>23 (1.7)</td>
<td>496 (9.4)</td>
<td>31 (2.1)</td>
<td>469 (9.6)</td>
<td>42 (1.9)</td>
</tr>
<tr>
<td>International Avg.</td>
<td>22 (0.4)</td>
<td>506 (2.7)</td>
<td>22 (0.4)</td>
<td>478 (2.9)</td>
<td>48 (0.5)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Country</th>
<th>Biological and Biomedical Sciences</th>
<th>Education</th>
<th>Business</th>
<th>Other</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Percent of Students</td>
<td>Average Achievement</td>
<td>Percent of Students</td>
<td>Average Achievement</td>
</tr>
<tr>
<td>France</td>
<td>40 (0.9)</td>
<td>360 (3.9)</td>
<td>6 (0.5)</td>
<td>350 (10.2)</td>
</tr>
<tr>
<td>Italy</td>
<td>37 (1.1)</td>
<td>380 (8.1)</td>
<td>10 (0.6)</td>
<td>357 (12.5)</td>
</tr>
<tr>
<td>Lebanon</td>
<td>7 (0.9)</td>
<td>413 (14.6)</td>
<td>3 (0.5)</td>
<td>375 (23.0)</td>
</tr>
<tr>
<td>Norway</td>
<td>17 (1.0)</td>
<td>504 (7.3)</td>
<td>11 (0.7)</td>
<td>490 (9.3)</td>
</tr>
<tr>
<td>Portugal</td>
<td>14 (1.5)</td>
<td>478 (8.1)</td>
<td>1 (0.2)</td>
<td>~</td>
</tr>
<tr>
<td>Russian Federation</td>
<td>12 (0.9)</td>
<td>491 (10.6)</td>
<td>8 (0.6)</td>
<td>482 (13.5)</td>
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<tr>
<td>Slovenia</td>
<td>21 (1.2)</td>
<td>552 (6.9)</td>
<td>5 (0.6)</td>
<td>498 (11.9)</td>
</tr>
<tr>
<td>Sweden</td>
<td>36 (1.1)</td>
<td>456 (6.3)</td>
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<td>447 (7.9)</td>
</tr>
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<td>United States</td>
<td>29 (1.7)</td>
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<td>407 (19.4)</td>
</tr>
<tr>
<td>International Avg.</td>
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<td>450 (3.1)</td>
<td>7 (0.2)</td>
<td>426 (5.1)</td>
</tr>
</tbody>
</table>

2. A tilde (~) indicates insufficient data to report achievement.
### Exhibit P4.6: Students’ Intended Future Profession

**Reported by Physics Students**

Students indicated either "yes" or "maybe" when asked if they wanted to work in the professional fields shown below.

<table>
<thead>
<tr>
<th>Country</th>
<th>Engineering and Engineering Technologies</th>
<th>Computer and Information Sciences</th>
<th>Biological and Biomedical Sciences</th>
<th>Environmental Sciences</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Percent of Students</td>
<td>Average Achievement</td>
<td>Percent of Students</td>
<td>Average Achievement</td>
</tr>
<tr>
<td>France</td>
<td>49 (1.0)</td>
<td>403 (4.4)</td>
<td>29 (0.9)</td>
<td>395 (5.9)</td>
</tr>
<tr>
<td>Italy</td>
<td>42 (0.9)</td>
<td>419 (6.9)</td>
<td>30 (1.0)</td>
<td>394 (6.9)</td>
</tr>
<tr>
<td>Lebanon</td>
<td>92 (1.1)</td>
<td>415 (4.9)</td>
<td>60 (1.6)</td>
<td>414 (7.5)</td>
</tr>
<tr>
<td>Norway</td>
<td>92 (0.5)</td>
<td>513 (4.5)</td>
<td>61 (1.2)</td>
<td>517 (4.6)</td>
</tr>
<tr>
<td>Portugal</td>
<td>85 (1.5)</td>
<td>475 (4.6)</td>
<td>63 (2.1)</td>
<td>467 (5.5)</td>
</tr>
<tr>
<td>Russian Federation</td>
<td>69 (1.4)</td>
<td>526 (6.5)</td>
<td>60 (1.2)</td>
<td>522 (6.4)</td>
</tr>
<tr>
<td>Slovenia</td>
<td>73 (1.4)</td>
<td>540 (3.0)</td>
<td>52 (1.5)</td>
<td>540 (4.2)</td>
</tr>
<tr>
<td>Sweden</td>
<td>83 (0.9)</td>
<td>469 (5.9)</td>
<td>58 (1.0)</td>
<td>457 (6.5)</td>
</tr>
<tr>
<td>United States</td>
<td>67 (1.8)</td>
<td>461 (8.6)</td>
<td>50 (2.3)</td>
<td>446 (9.0)</td>
</tr>
<tr>
<td>International Avg.</td>
<td>72 (0.4)</td>
<td>469 (1.9)</td>
<td>51 (0.5)</td>
<td>461 (2.1)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Country</th>
<th>Agriculture and Agricultural Sciences</th>
<th>Education</th>
<th>Finance/Banking</th>
<th>Actuarial Sciences</th>
</tr>
</thead>
<tbody>
<tr>
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<td>Percent of Students</td>
<td>Average Achievement</td>
<td>Percent of Students</td>
<td>Average Achievement</td>
</tr>
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<td>France</td>
<td>10 (0.6)</td>
<td>369 (6.4)</td>
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<tr>
<td>Lebanon</td>
<td>s 20 (1.6)</td>
<td>400 (10.7)</td>
<td>58 (1.9)</td>
<td>418 (5.8)</td>
</tr>
<tr>
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<td>512 (6.2)</td>
<td>58 (1.1)</td>
<td>519 (5.0)</td>
</tr>
<tr>
<td>Portugal</td>
<td>16 (1.2)</td>
<td>441 (7.4)</td>
<td>27 (1.7)</td>
<td>497 (6.9)</td>
</tr>
<tr>
<td>Russian Federation</td>
<td>20 (1.0)</td>
<td>491 (8.8)</td>
<td>35 (1.1)</td>
<td>514 (7.7)</td>
</tr>
<tr>
<td>Slovenia</td>
<td>29 (1.3)</td>
<td>535 (4.8)</td>
<td>50 (1.8)</td>
<td>543 (3.8)</td>
</tr>
<tr>
<td>Sweden</td>
<td>21 (1.1)</td>
<td>458 (7.0)</td>
<td>46 (1.1)</td>
<td>471 (5.8)</td>
</tr>
<tr>
<td>United States</td>
<td>15 (0.9)</td>
<td>424 (11.7)</td>
<td>45 (1.7)</td>
<td>453 (11.8)</td>
</tr>
<tr>
<td>International Avg.</td>
<td>18 (0.4)</td>
<td>445 (2.8)</td>
<td>45 (0.5)</td>
<td>465 (2.3)</td>
</tr>
</tbody>
</table>

( ) Standard errors appear in parentheses. Because of rounding some results may appear inconsistent. An "r" indicates data are available for at least 70% but less than 85% of the students. An "s" indicates data are available for at least 50% but less than 70% of the students.
### Exhibit P4.7: Students’ Intended Future Profession by Gender

**Reported by Physics Students**

Students indicated either “yes” or “maybe” when asked if they wanted to work in the professional fields shown below. The Percent of Females column shows the percent of female physics students choosing that professional field and the Percent of Males column shows the percent of male physics students choosing that professional field.

#### Engineering and Engineering Technologies

<table>
<thead>
<tr>
<th>Country</th>
<th>Percent of Females</th>
<th>Percent of Males</th>
<th>Percent of Females</th>
<th>Percent of Males</th>
<th>Percent of Females</th>
<th>Percent of Males</th>
<th>Percent of Females</th>
<th>Percent of Males</th>
<th>Percent of Females</th>
<th>Percent of Males</th>
</tr>
</thead>
<tbody>
<tr>
<td>France</td>
<td>34 (1.4)</td>
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<td>72 (1.2)</td>
<td>44 (1.3)</td>
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<td></td>
</tr>
<tr>
<td>Italy</td>
<td>28 (1.2)</td>
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<td>15 (1.0)</td>
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<td>35 (1.3)</td>
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<tr>
<td>Lebanon</td>
<td>89 (1.6)</td>
<td>94 (1.3)</td>
<td>s 50 (3.0)</td>
<td>r 65 (2.3)</td>
<td>s 25 (3.2)</td>
<td>s 24 (2.4)</td>
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<td>s 22 (1.8)</td>
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<td></td>
</tr>
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<td>Norway</td>
<td>87 (1.4)</td>
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<td>63 (1.9)</td>
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<td>65 (1.8)</td>
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<tr>
<td>Portugal</td>
<td>64 (3.9)</td>
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<td>34 (3.0)</td>
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<td>16 (1.3)</td>
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<td></td>
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<tr>
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<td>50 (1.8)</td>
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<td>72 (0.9)</td>
<td>41 (2.0)</td>
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<td>37 (1.5)</td>
<td>20 (1.2)</td>
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</tr>
<tr>
<td>Slovenia</td>
<td>50 (2.9)</td>
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<td>29 (2.4)</td>
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<td>72 (3.0)</td>
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#### Computer and Information Sciences

<table>
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<th>Percent of Females</th>
<th>Percent of Males</th>
<th>Percent of Females</th>
<th>Percent of Males</th>
<th>Percent of Females</th>
<th>Percent of Males</th>
<th>Percent of Females</th>
<th>Percent of Males</th>
<th>Percent of Females</th>
<th>Percent of Males</th>
</tr>
</thead>
<tbody>
<tr>
<td>France</td>
<td>17 (0.8)</td>
<td>20 (1.1)</td>
<td>45 (1.4)</td>
<td>41 (1.2)</td>
<td>22 (1.3)</td>
<td>35 (1.4)</td>
<td>14 (0.9)</td>
<td>16 (1.0)</td>
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<td></td>
</tr>
<tr>
<td>Italy</td>
<td>14 (1.3)</td>
<td>21 (1.1)</td>
<td>46 (1.6)</td>
<td>40 (1.7)</td>
<td>31 (1.3)</td>
<td>48 (1.4)</td>
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<td>17 (1.1)</td>
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<tr>
<td>Lebanon</td>
<td>s 16 (2.2)</td>
<td>s 22 (2.3)</td>
<td>r 72 (2.4)</td>
<td>r 49 (2.5)</td>
<td>s 40 (3.6)</td>
<td>s 35 (2.5)</td>
<td>s 17 (2.7)</td>
<td>s 19 (2.0)</td>
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<td></td>
</tr>
<tr>
<td>Norway</td>
<td>17 (1.5)</td>
<td>16 (1.1)</td>
<td>59 (1.7)</td>
<td>57 (1.3)</td>
<td>34 (1.8)</td>
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<td>36 (1.9)</td>
<td>32 (1.1)</td>
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<td>16 (1.3)</td>
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<td>9 (2.2)</td>
<td>6 (0.8)</td>
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</tr>
<tr>
<td>Russian Federation</td>
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<td>50 (1.4)</td>
<td>24 (1.3)</td>
<td>62 (1.6)</td>
<td>62 (1.5)</td>
<td>31 (1.5)</td>
<td>25 (1.5)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Slovenia</td>
<td>24 (2.3)</td>
<td>30 (1.8)</td>
<td>60 (2.4)</td>
<td>46 (1.9)</td>
<td>35 (2.4)</td>
<td>40 (1.7)</td>
<td>18 (2.3)</td>
<td>14 (1.3)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sweden</td>
<td>21 (1.6)</td>
<td>20 (1.1)</td>
<td>47 (1.6)</td>
<td>46 (1.4)</td>
<td>42 (1.7)</td>
<td>54 (1.5)</td>
<td>21 (1.3)</td>
<td>30 (1.1)</td>
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<td></td>
</tr>
<tr>
<td>United States</td>
<td>17 (2.0)</td>
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<td>45 (2.0)</td>
<td>45 (2.1)</td>
<td>38 (4.6)</td>
<td>38 (1.6)</td>
<td>27 (3.1)</td>
<td>30 (1.2)</td>
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<td></td>
</tr>
<tr>
<td><strong>International Avg.</strong></td>
<td>17 (0.6)</td>
<td>19 (0.5)</td>
<td>50 (0.7)</td>
<td>42 (0.6)</td>
<td>37 (0.8)</td>
<td>43 (0.6)</td>
<td>21 (0.7)</td>
<td>21 (0.4)</td>
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<td></td>
</tr>
</tbody>
</table>

- o Percent significantly higher than other gender

( ) Standard errors appear in parentheses. Because of rounding some results may appear inconsistent.

An “r” indicates data are available for at least 70% but less than 85% of the students. An “s” indicates data are available for at least 50% but less than 70% of the students.

**Source:** IEA’s Trends in International Mathematics and Science Study – TIMSS Advanced 2015
CHAPTER P5: SCHOOL COMPOSITION

TIMSS ADVANCED 2015 INTERNATIONAL RESULTS IN ADVANCED MATHEMATICS AND PHYSICS
In nearly all the TIMSS Advanced countries, students attending schools with more affluent than disadvantaged students had higher average physics achievement.

**Exhibit P5.1: School Composition by Economic Background of the Student Body**

Reported by Principals

<table>
<thead>
<tr>
<th>Country</th>
<th>More Affluent - Schools where more than 25% of the student body comes from economically affluent homes and not more than 25% from economically disadvantaged homes</th>
<th>Neither More Affluent nor More Disadvantaged</th>
<th>More Disadvantaged - Schools where more than 25% of the student body comes from economically disadvantaged homes and not more than 25% from economically affluent homes</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Percent of Students</td>
<td>Average Achievement</td>
<td>Percent of Students</td>
</tr>
<tr>
<td>France</td>
<td>50 (4.1)</td>
<td>384 (5.6)</td>
<td>28 (3.9)</td>
</tr>
<tr>
<td>Italy</td>
<td>62 (4.4)</td>
<td>378 (8.9)</td>
<td>35 (4.5)</td>
</tr>
<tr>
<td>Lebanon</td>
<td>34 (5.1)</td>
<td>442 (11.0)</td>
<td>29 (4.6)</td>
</tr>
<tr>
<td>Norway</td>
<td>r 71 (5.1)</td>
<td>510 (6.1)</td>
<td>27 (5.0)</td>
</tr>
<tr>
<td>Portugal</td>
<td>19 (3.4)</td>
<td>502 (7.9)</td>
<td>42 (5.9)</td>
</tr>
<tr>
<td>Russian Federation</td>
<td>84 (3.4)</td>
<td>519 (6.9)</td>
<td>13 (2.9)</td>
</tr>
<tr>
<td>Slovenia</td>
<td>75 (3.9)</td>
<td>540 (4.0)</td>
<td>18 (3.6)</td>
</tr>
<tr>
<td>Sweden</td>
<td>r 75 (3.1)</td>
<td>468 (7.9)</td>
<td>19 (3.3)</td>
</tr>
<tr>
<td>United States</td>
<td>r 42 (5.9)</td>
<td>473 (15.5)</td>
<td>24 (4.2)</td>
</tr>
<tr>
<td>International Avg.</td>
<td>57 (1.5)</td>
<td>468 (2.9)</td>
<td>26 (1.4)</td>
</tr>
</tbody>
</table>

(1) Standard errors appear in parentheses. Because of rounding some results may appear inconsistent. A tilde (~) indicates insufficient data to report achievement. An "r" indicates data are available for at least 70% but less than 85% of the students.

**Approximately what percentage of students in your school have the following backgrounds?**

- 0 to 10%
- 11 to 25%
- 26 to 50%
- More than 50%

1) Come from economically disadvantaged homes
2) Come from economically affluent homes

**More Affluent** - Schools where more than 25% of the student body comes from economically affluent homes and not more than 25% from economically disadvantaged homes

**More Disadvantaged** - Schools where more than 25% of the student body comes from economically disadvantaged homes and not more than 25% from economically affluent homes

**Neither More Affluent nor More Disadvantaged** - All other possible response combinations

SOURCE: IEA’s Trends in International Mathematics and Science Study – TIMSS Advanced 2015
**Exhibit P5.2: Schools with Students Having the Language of the Test as Their Native Language**

*Reported by Principals*

<table>
<thead>
<tr>
<th>Country</th>
<th>School Has More than 90% of Students with Language of Test as Their Native Language</th>
<th>School Has 51-90% of Students with Language of Test as Their Native Language</th>
<th>School Has 50% or Less of Students with Language of Test as Their Native Language</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Percent of Students</td>
<td>Average Achievement</td>
<td>Percent of Students</td>
</tr>
<tr>
<td>France</td>
<td>88 (3.1)</td>
<td>375 (4.3)</td>
<td>11 (3.1)</td>
</tr>
<tr>
<td>Italy</td>
<td>89 (2.9)</td>
<td>375 (7.7)</td>
<td>11 (2.9)</td>
</tr>
<tr>
<td>Lebanon</td>
<td>11 (3.6)</td>
<td>415 (12.9)</td>
<td>12 (2.8)</td>
</tr>
<tr>
<td>Norway</td>
<td>68 (3.3)</td>
<td>504 (5.7)</td>
<td>30 (5.3)</td>
</tr>
<tr>
<td>Portugal</td>
<td>93 (2.2)</td>
<td>466 (4.9)</td>
<td>3 (0.7)</td>
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<td>Russian Federation</td>
<td>84 (2.5)</td>
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<tr>
<td>Slovenia</td>
<td>91 (3.2)</td>
<td>536 (3.1)</td>
<td>8 (3.2)</td>
</tr>
<tr>
<td>Sweden</td>
<td>38 (3.6)</td>
<td>465 (7.0)</td>
<td>53 (5.3)</td>
</tr>
<tr>
<td>United States</td>
<td>63 (5.9)</td>
<td>458 (12.7)</td>
<td>25 (5.1)</td>
</tr>
<tr>
<td>International Avg.</td>
<td>69 (1.3)</td>
<td>457 (2.7)</td>
<td>18 (1.2)</td>
</tr>
</tbody>
</table>

(1) Standard errors appear in parentheses. Because of rounding some results may appear inconsistent. A tilde (~) indicates insufficient data to report achievement. An “r” indicates data are available for at least 70% but less than 85% of the students.
CHAPTER M6:
SCHOOL CLIMATE

TIMSS ADVANCED 2015 INTERNATIONAL RESULTS IN
ADVANCED MATHEMATICS AND PHYSICS
Schools Have Positive Environments

Generally, students taking physics courses are in positive school environments, and the more positive the school environment the higher the average achievement.

Principals and teachers agree that high percentages of TIMSS Advanced students attend schools that support physics education, although the principals have more positive attitudes than the teachers.

TEACHERS of physics reported a high degree of job satisfaction. Almost all students (89%) had teachers who were very satisfied or satisfied with their careers.

STUDENTS of physics reported a positive sense of school belonging.
### Exhibit P6.1: Programs to Encourage Students to Study Physics

**Reported by National Research Coordinators**

<table>
<thead>
<tr>
<th>Country</th>
<th>School Partnerships with Industry</th>
<th>School Collaborations with Universities</th>
<th>Contests/Competitions in Physics</th>
</tr>
</thead>
<tbody>
<tr>
<td>France</td>
<td>●</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>Italy</td>
<td>●</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>Lebanon</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>Norway</td>
<td>○</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>Portugal</td>
<td>○</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>Russian Federation</td>
<td>○</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>Slovenia</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>Sweden</td>
<td>●</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>United States</td>
<td>●</td>
<td>●</td>
<td>●</td>
</tr>
</tbody>
</table>

● Yes
○ No

**SOURCE:** IEA’s Trends in International Mathematics and Science Study – TIMSS Advanced 2015
**Exhibit P6.2: School Supports Advanced Mathematics and Physics Education – Principal Version**

Students were scored according to their principals’ degree of agreement with seven statements on the School Supports Advanced Mathematics and Physics Education scale. Students in schools where their principals reported that the school is **Strongly Supportive** of advanced mathematics and physics education had a score on the scale of at least 10.8, which corresponds to their principals “agreeing a lot” with four of the seven statements and “agreeing a little” with the other three, on average. Students in schools that are **Less than Supportive** of advanced mathematics and physics education had a score no higher than 6.5, which corresponds to their principals “disagreeing a little” with four of the seven statements and “agreeing a little” with the other three, on average. All other students attended schools that are **Supportive** of advanced mathematics and physics education.

<table>
<thead>
<tr>
<th>Country</th>
<th>Strongly Supportive</th>
<th>Supportive</th>
<th>Less than Supportive</th>
<th>Average Scale Score</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Percent of Students</td>
<td>Average Achievement</td>
<td>Percent of Students</td>
<td>Average Achievement</td>
</tr>
<tr>
<td>Russian Federation</td>
<td>79 (2.6)</td>
<td>521 (8.3)</td>
<td>21 (2.6)</td>
<td>456 (15.1)</td>
</tr>
<tr>
<td>United States</td>
<td>r 58 (6.0)</td>
<td>443 (16.4)</td>
<td>40 (6.0)</td>
<td>455 (12.1)</td>
</tr>
<tr>
<td>Norway</td>
<td>r 54 (5.7)</td>
<td>511 (6.2)</td>
<td>46 (5.7)</td>
<td>501 (6.5)</td>
</tr>
<tr>
<td>Lebanon</td>
<td>39 (2.5)</td>
<td>410 (8.0)</td>
<td>59 (2.5)</td>
<td>411 (5.3)</td>
</tr>
<tr>
<td>Portugal</td>
<td>34 (2.9)</td>
<td>468 (8.1)</td>
<td>61 (4.5)</td>
<td>467 (6.1)</td>
</tr>
<tr>
<td>Italy</td>
<td>29 (4.3)</td>
<td>385 (12.6)</td>
<td>67 (4.4)</td>
<td>369 (10.5)</td>
</tr>
<tr>
<td>Slovenia</td>
<td>10 (2.1)</td>
<td>591 (14.7)</td>
<td>90 (2.1)</td>
<td>525 (2.9)</td>
</tr>
<tr>
<td>Sweden</td>
<td>8 (2.4)</td>
<td>449 (14.4)</td>
<td>77 (3.8)</td>
<td>461 (7.7)</td>
</tr>
<tr>
<td>France</td>
<td>8 (2.3)</td>
<td>400 (12.0)</td>
<td>84 (3.4)</td>
<td>369 (4.4)</td>
</tr>
<tr>
<td>International Avg.</td>
<td>35 (1.3)</td>
<td>464 (3.9)</td>
<td>61 (1.4)</td>
<td>446 (2.9)</td>
</tr>
</tbody>
</table>

This TIMSS Advanced questionnaire scale was established in 2015 based on the combined response distribution of all countries that participated in TIMSS Advanced 2015. To provide a point of reference for country comparisons, the scale centerpoint of 10 was located at the mean of the combined distribution. The units of the scale were chosen so that 2 scale score points corresponded to the standard deviation of the distribution.

( ) Standard errors appear in parentheses. Because of rounding some results may appear inconsistent.

A tilde (~) indicates insufficient data to report achievement.

An “r” indicates data are available for at least 70% but less than 85% of the students.
**Exhibit P6.3: School Supports Advanced Mathematics and Physics Education – Teacher Version**

**Reported by Physics Teachers**

Students were scored according to their teachers' degree of agreement with seven statements on the School Supports Advanced Mathematics and Physics Education scale. Students in schools where their teachers reported that the school is **Strongly Supportive** of advanced mathematics and physics education had a score on the scale of at least 11.6, which corresponds to their teachers “agreeing a lot” with four of the seven statements and “agreeing a little” with the other three, on average. Students in schools that are **Less than Supportive** of advanced mathematics and physics education had a score no higher than 7.5, which corresponds to their teachers “disagreeing a little” with four of the seven statements and “agreeing a little” with the other three, on average. All other students attended schools that are **Supportive** of advanced mathematics and physics education.

<table>
<thead>
<tr>
<th>Country</th>
<th>Strongly Supportive</th>
<th>Supportive</th>
<th>Less than Supportive</th>
<th>Average Scale Score</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Percent of Students</td>
<td>Average Achievement</td>
<td>Percent of Students</td>
<td>Average Achievement</td>
</tr>
<tr>
<td>Russian Federation</td>
<td>58 (4.0)</td>
<td>508 (8.9)</td>
<td>42 (4.0)</td>
<td>510 (14.1)</td>
</tr>
<tr>
<td>Lebanon</td>
<td>48 (3.4)</td>
<td>412 (7.2)</td>
<td>50 (3.5)</td>
<td>410 (5.9)</td>
</tr>
<tr>
<td>United States</td>
<td>37 (5.2)</td>
<td>456 (15.1)</td>
<td>58 (5.1)</td>
<td>434 (14.5)</td>
</tr>
<tr>
<td>Norway</td>
<td>23 (3.6)</td>
<td>512 (9.0)</td>
<td>75 (3.8)</td>
<td>503 (5.9)</td>
</tr>
<tr>
<td>Portugal</td>
<td>18 (3.3)</td>
<td>483 (10.9)</td>
<td>75 (4.0)</td>
<td>464 (5.4)</td>
</tr>
<tr>
<td>Italy</td>
<td>10 (2.1)</td>
<td>386 (22.1)</td>
<td>67 (2.8)</td>
<td>377 (8.9)</td>
</tr>
<tr>
<td>France</td>
<td>3 (1.1)</td>
<td>400 (14.5)</td>
<td>79 (2.2)</td>
<td>376 (4.1)</td>
</tr>
<tr>
<td>Sweden</td>
<td>3 (1.3)</td>
<td>480 (16.7)</td>
<td>79 (3.4)</td>
<td>456 (6.8)</td>
</tr>
<tr>
<td>Slovenia</td>
<td>2 (0.1)</td>
<td>~ ~</td>
<td>69 (1.9)</td>
<td>538 (3.5)</td>
</tr>
<tr>
<td>International Avg.</td>
<td>23 (1.0)</td>
<td>455 (4.9)</td>
<td>66 (1.2)</td>
<td>452 (2.9)</td>
</tr>
</tbody>
</table>

This TIMSS Advanced questionnaire scale was established in 2015 based on the combined response distribution of all countries that participated in TIMSS Advanced 2015. To provide a point of reference for country comparisons, the scale centerpoint of 10 was located at the mean of the combined distribution. The units of the scale were chosen so that 2 scale score points corresponded to the standard deviation of the distribution.

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---

**How much do you agree with these statements about advanced mathematics and physics education within your school?**

1. The school encourages students to study advanced mathematics and physics.
2. The school promotes professional development for teachers of advanced mathematics and physics.
3. The school provides students with information about career options in advanced mathematics and physics.
4. Advanced mathematics and physics teachers are admired by other teachers in the school.
5. Teachers have high expectations for student achievement in advanced mathematics and physics.
6. Students at this school respect students who excel in advanced mathematics and physics.
7. Parents expect their children to study advanced mathematics and physics.

**Scale Scores**

- **Strongly Supportive**: 11.6
- **Supportive**: 7.5
- **Less than Supportive**: ~

---

SOURCE: IEA’s Trends in International Mathematics and Science Study – TIMSS Advanced 2015
### Exhibit P6.4: Teacher Job Satisfaction

Reported by Physics Teachers

Students were scored according to how often their teachers responded positively to the seven statements on the Teacher Job Satisfaction scale. Students with **Very Satisfied** teachers had a score on the scale of at least 10.6, which corresponds to their teachers responding "very often" to four of the seven statements and responding "often" to the other three, on average. Students with **Less than Satisfied** teachers had a score no higher than 7.4, which corresponds to their teachers responding "sometimes" to four of the seven statements and responding "often" to the other three, on average. All other students had **Satisfied** teachers.

<table>
<thead>
<tr>
<th>Country</th>
<th>Very Satisfied</th>
<th>Satisfied</th>
<th>Less than Satisfied</th>
<th>Average Scale Score</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Percent of Students</td>
<td>Average Achievement</td>
<td>Percent of Students</td>
<td>Average Achievement</td>
</tr>
<tr>
<td>Lebanon</td>
<td>67 (4.2)</td>
<td>412 (5.1)</td>
<td>30 (4.1)</td>
<td>409 (10.5)</td>
</tr>
<tr>
<td>United States</td>
<td>52 (4.9)</td>
<td>458 (9.7)</td>
<td>37 (5.3)</td>
<td>432 (20.5)</td>
</tr>
<tr>
<td>Norway</td>
<td>51 (4.1)</td>
<td>504 (6.1)</td>
<td>45 (4.0)</td>
<td>505 (6.1)</td>
</tr>
<tr>
<td>Russian Federation</td>
<td>44 (4.4)</td>
<td>511 (11.3)</td>
<td>51 (4.0)</td>
<td>504 (10.8)</td>
</tr>
<tr>
<td>Sweden</td>
<td>34 (4.3)</td>
<td>462 (11.8)</td>
<td>56 (3.9)</td>
<td>449 (7.6)</td>
</tr>
<tr>
<td>Italy</td>
<td>31 (3.4)</td>
<td>355 (13.4)</td>
<td>53 (3.7)</td>
<td>392 (8.5)</td>
</tr>
<tr>
<td>Slovenia</td>
<td>29 (2.1)</td>
<td>557 (6.7)</td>
<td>58 (3.5)</td>
<td>531 (3.6)</td>
</tr>
<tr>
<td>Portugal</td>
<td>29 (4.0)</td>
<td>477 (8.0)</td>
<td>62 (4.8)</td>
<td>462 (5.8)</td>
</tr>
<tr>
<td>France</td>
<td>25 (2.5)</td>
<td>377 (7.0)</td>
<td>53 (3.3)</td>
<td>373 (4.5)</td>
</tr>
<tr>
<td>International Avg.</td>
<td>40 (1.3)</td>
<td>457 (3.1)</td>
<td>49 (1.4)</td>
<td>451 (3.3)</td>
</tr>
</tbody>
</table>

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An "r" indicates data are available for at least 70% but less than 85% of the students.
### Exhibit P6.5: Students’ Sense of School Belonging

Students were scored according to their agreement to nine statements about their Sense of School Belonging. Students with a High Sense of School Belonging had a score on the scale of at least 10.5, which corresponds to their “agreeing a lot” to five of the nine statements and “agreeing a little” to each of the other four statements, on average. Students with Little Sense of School Belonging had a score no higher than 7.6, which corresponds to their “disagreeing a little” to five of the nine statements and “agreeing a little” to each of the other four statements, on average. All other students had a Sense of School Belonging.

<table>
<thead>
<tr>
<th>Country</th>
<th>Average Scale Score</th>
<th>Percent of Students</th>
<th>Percent of Students</th>
<th>Average Achievement</th>
<th>Percent of Students</th>
<th>Average Achievement</th>
<th>Percent of Students</th>
<th>Average Achievement</th>
<th>Average Achievement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Norway</td>
<td>11.0 (0.06)</td>
<td>63 (1.4)</td>
<td>34 (1.2)</td>
<td>491 (6.0)</td>
<td>3 (0.4)</td>
<td>444 (13.8)</td>
<td>11.0 (0.06)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sweden</td>
<td>10.7 (0.07)</td>
<td>55 (1.6)</td>
<td>41 (1.5)</td>
<td>440 (7.4)</td>
<td>5 (0.4)</td>
<td>364 (13.4)</td>
<td>10.7 (0.07)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Russian Federation</td>
<td>10.7 (0.06)</td>
<td>52 (1.3)</td>
<td>41 (1.2)</td>
<td>503 (7.5)</td>
<td>6 (0.5)</td>
<td>491 (9.8)</td>
<td>10.7 (0.06)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>United States</td>
<td>10.2 (0.10)</td>
<td>45 (2.1)</td>
<td>48 (1.9)</td>
<td>433 (11.1)</td>
<td>7 (0.9)</td>
<td>401 (18.9)</td>
<td>10.2 (0.10)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lebanon</td>
<td>10.2 (0.10)</td>
<td>44 (1.9)</td>
<td>46 (2.0)</td>
<td>413 (5.5)</td>
<td>10 (1.5)</td>
<td>409 (10.5)</td>
<td>10.2 (0.10)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Portugal</td>
<td>10.2 (0.07)</td>
<td>43 (1.7)</td>
<td>51 (1.5)</td>
<td>465 (5.1)</td>
<td>5 (0.8)</td>
<td>421 (12.3)</td>
<td>10.2 (0.07)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>France</td>
<td>9.4 (0.05)</td>
<td>22 (1.2)</td>
<td>71 (1.0)</td>
<td>370 (4.1)</td>
<td>7 (0.6)</td>
<td>321 (7.4)</td>
<td>9.4 (0.05)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Italy</td>
<td>8.8 (0.05)</td>
<td>16 (1.0)</td>
<td>63 (1.0)</td>
<td>381 (7.4)</td>
<td>21 (1.1)</td>
<td>354 (8.6)</td>
<td>8.8 (0.05)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Slovenia</td>
<td>8.8 (0.04)</td>
<td>14 (0.9)</td>
<td>70 (1.4)</td>
<td>533 (3.5)</td>
<td>17 (1.1)</td>
<td>493 (9.4)</td>
<td>8.8 (0.04)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>International Avg.</td>
<td>8.8 (0.04)</td>
<td>39 (0.5)</td>
<td>52 (0.5)</td>
<td>448 (2.3)</td>
<td>9 (0.3)</td>
<td>411 (4.0)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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() Standard errors appear in parentheses. Because of rounding some results may appear inconsistent.
CHAPTER P7: SCHOOL SAFETY

TIMSS ADVANCED 2015 INTERNATIONAL RESULTS IN ADVANCED MATHEMATICS AND PHYSICS
Students Are in Safe Schools
Principals and teachers agreed that ALMOST ALL the TIMSS Advanced students were in safe school environments.

**Principals’ Reports**
- 57% of students were in schools where principals reported HARDLY ANY discipline problems.
- 36% of students were in schools where principals reported only MINOR discipline problems.
- 7% of students were in schools where principals reported MODERATE TO SEVERE discipline problems.

<table>
<thead>
<tr>
<th>Discipline Problems</th>
<th>Average Achievement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hardly any</td>
<td>463</td>
</tr>
<tr>
<td>Minor</td>
<td>441</td>
</tr>
<tr>
<td>Moderate to severe</td>
<td>391</td>
</tr>
</tbody>
</table>

**Teachers’ Reports**
- 55% of students were in schools teachers found VERY safe and orderly.
- 40% of students were in schools teachers found safe and orderly.
- 5% of students were in schools teachers found LESS THAN safe and orderly.

<table>
<thead>
<tr>
<th>Orderliness</th>
<th>Average Achievement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very</td>
<td>462</td>
</tr>
<tr>
<td>Safe and orderly</td>
<td>448</td>
</tr>
<tr>
<td>Less than safe and</td>
<td>386</td>
</tr>
<tr>
<td>orderly</td>
<td></td>
</tr>
</tbody>
</table>

Exhibit P7.1: School Discipline Problems – Principals’ Reports

Students were scored according to their principals’ responses concerning eleven potential school problems on the *School Discipline Problems* scale. Students in schools with **Hardly Any Problems** had a score on the scale of at least 10.0, which corresponds to their principals reporting “not a problem” for six of the eleven issues and “minor problem” for the other five, on average. Students in schools with **Moderate to Severe Problems** had a score no higher than 7.2, which corresponds to their principals reporting “moderate problem” for six of the eleven issues and “minor problem” for the other five, on average. All other students attended schools with **Minor Problems**.

<table>
<thead>
<tr>
<th>Country</th>
<th>Hardly Any Problems</th>
<th>Minor Problems</th>
<th>Moderate to Severe Problems</th>
<th>Average Scale Score</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Percent of Students</td>
<td>Average Achievement</td>
<td>Percent of Students</td>
<td>Average Achievement</td>
</tr>
<tr>
<td>Russian Federation</td>
<td>86 (2.3)</td>
<td>510 (8.6)</td>
<td>14 (2.3)</td>
<td>495 (20.2)</td>
</tr>
<tr>
<td>France</td>
<td>65 (4.7)</td>
<td>375 (5.2)</td>
<td>31 (4.5)</td>
<td>363 (8.4)</td>
</tr>
<tr>
<td>Norway</td>
<td>r</td>
<td>65 (5.1)</td>
<td>512 (5.4)</td>
<td>35 (5.0)</td>
</tr>
<tr>
<td>Slovenia</td>
<td>62 (4.1)</td>
<td>545 (4.2)</td>
<td>38 (4.1)</td>
<td>509 (5.8)</td>
</tr>
<tr>
<td>Portugal</td>
<td>56 (4.6)</td>
<td>467 (6.1)</td>
<td>36 (4.5)</td>
<td>470 (7.4)</td>
</tr>
<tr>
<td>Lebanon</td>
<td>49 (3.7)</td>
<td>417 (6.6)</td>
<td>25 (4.8)</td>
<td>406 (12.0)</td>
</tr>
<tr>
<td>United States</td>
<td>r</td>
<td>46 (6.1)</td>
<td>462 (16.0)</td>
<td>53 (6.1)</td>
</tr>
<tr>
<td>Italy</td>
<td>44 (4.4)</td>
<td>403 (11.5)</td>
<td>37 (4.8)</td>
<td>353 (12.5)</td>
</tr>
<tr>
<td>Sweden</td>
<td>42 (4.0)</td>
<td>473 (10.5)</td>
<td>56 (4.2)</td>
<td>441 (7.4)</td>
</tr>
<tr>
<td><strong>International Avg.</strong></td>
<td><strong>57 (1.5)</strong></td>
<td><strong>463 (3.0)</strong></td>
<td><strong>36 (1.5)</strong></td>
<td><strong>441 (3.8)</strong></td>
</tr>
</tbody>
</table>

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A tilde (~) indicates insufficient data to report achievement.

A “r” indicates data are available for at least 70% but less than 85% of the students.

---

**To what degree is each of the following a problem among twelfth grade students in your school?**

- **Not a problem**
- **Minor problem**
- **Moderate problem**
- **Serious problem**

1. Arriving late at school
2. Absenteeism (i.e., unjustified absences)
3. Classroom disturbance
4. Cheating
5. Profanity
6. Vandalism
7. Theft
8. Intimidation or verbal abuse among students (including texting, emailing, etc.)
9. Physical injury to other students
10. Intimidation or verbal abuse of teachers or staff (including texting, emailing, etc.)
11. Physical injury to teachers or staff

Hardly Any Problems:
- **10.0**
- **Minor Problems**:
- **7.2**
- **Moderate to Severe Problems**
Exhibit P7.2: Safe and Orderly School – Teachers’ Reports

Reported by Physics Teachers

Students were scored according to their teachers’ degree of agreement with eight statements on the Safe and Orderly School scale. Students in Very Safe and Orderly schools had a score on the scale of at least 9.8, which corresponds to their teachers “agreeing a lot” with four of the eight qualities of a safe and orderly school and “agreeing a little” with the other four, on average. Students in Less than Safe and Orderly schools had a score no higher than 6.4, which corresponds to their teachers “disagreeing a little” with four of the eight qualities and “agreeing a little” with the other four, on average. All other students attended Safe and Orderly schools.

<table>
<thead>
<tr>
<th>Country</th>
<th>Very Safe and Orderly</th>
<th>Safe and Orderly</th>
<th>Less than Safe and Orderly</th>
<th>Average Scale Score</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Percent of Students</td>
<td>Average Achievement</td>
<td>Percent of Students</td>
<td>Average Achievement</td>
</tr>
<tr>
<td>Russian Federation</td>
<td>83 (3.0)</td>
<td>512 (8.4)</td>
<td>17 (3.0)</td>
<td>489 (16.2)</td>
</tr>
<tr>
<td>Norway</td>
<td>77 (3.4)</td>
<td>509 (5.0)</td>
<td>22 (3.5)</td>
<td>497 (10.0)</td>
</tr>
<tr>
<td>Lebanon</td>
<td>67 (4.0)</td>
<td>413 (5.3)</td>
<td>32 (4.0)</td>
<td>405 (9.8)</td>
</tr>
<tr>
<td>Sweden</td>
<td>55 (4.5)</td>
<td>461 (8.4)</td>
<td>42 (4.6)</td>
<td>454 (9.7)</td>
</tr>
<tr>
<td>United States</td>
<td>52 (5.3)</td>
<td>458 (10.4)</td>
<td>34 (5.8)</td>
<td>458 (15.0)</td>
</tr>
<tr>
<td>Italy</td>
<td>50 (3.9)</td>
<td>384 (8.4)</td>
<td>45 (3.8)</td>
<td>379 (11.7)</td>
</tr>
<tr>
<td>Portugal</td>
<td>50 (4.3)</td>
<td>475 (6.1)</td>
<td>48 (4.1)</td>
<td>458 (6.8)</td>
</tr>
<tr>
<td>Slovenia</td>
<td>35 (2.6)</td>
<td>558 (5.9)</td>
<td>56 (1.8)</td>
<td>515 (4.0)</td>
</tr>
<tr>
<td>France</td>
<td>27 (2.8)</td>
<td>384 (7.1)</td>
<td>67 (3.1)</td>
<td>374 (4.0)</td>
</tr>
<tr>
<td>International Avg.</td>
<td>55 (1.3)</td>
<td>462 (2.5)</td>
<td>40 (1.3)</td>
<td>448 (3.5)</td>
</tr>
</tbody>
</table>

Average Scale Score

This TIMSS Advanced questionnaire scale was established in 2015 based on the combined response distribution of all countries that participated in TIMSS Advanced 2015. To provide a point of reference for country comparisons, the scale centerpoint of 10 was located at the mean of the combined distribution. The units of the scale were chosen so that 2 scale score points corresponded to the standard deviation of the distribution.

( ) Standard errors appear in parentheses. Because of rounding some results may appear inconsistent.
A tilde (~) indicates insufficient data to report achievement.
An “r” indicates data are available for at least 70% but less than 85% of the students.

Thinking about your current school, indicate the extent to which you agree or disagree with each of the following statements.

This TIMSS Advanced questionnaire scale was established in 2015 based on the combined response distribution of all countries that participated in TIMSS Advanced 2015. To provide a point of reference for country comparisons, the scale centerpoint of 10 was located at the mean of the combined distribution. The units of the scale were chosen so that 2 scale score points corresponded to the standard deviation of the distribution.

( ) Standard errors appear in parentheses. Because of rounding some results may appear inconsistent.
A tilde (~) indicates insufficient data to report achievement.
An “r” indicates data are available for at least 70% but less than 85% of the students.
CHAPTER P8: TEACHERS’ AND PRINCIPALS’ PREPARATION
TIMSS ADVANCED 2015 INTERNATIONAL RESULTS IN ADVANCED MATHEMATICS AND PHYSICS
Students Have Well Qualified Teachers and Principals

Physics teachers of TIMSS Advanced students reported high levels of education and considerable experience.

99% of students were taught by physics teachers with at least a Bachelor’s degree

67% of students were taught by physics teachers with a Master’s or Doctorate degree

On average, students were taught by physics teachers with 13 years of experience teaching physics at the advanced level.

The TIMSS Advanced countries have special requirements for teaching physics, so it may be a concern that:

76% of Physics students were taught by physics teachers 40 years old or older who may be thinking about retirement.

Principals of schools with TIMSS Advanced Physics students reported high levels of education and experience.

99% of students had principals with at least a Bachelor’s degree

70% of students had principals with a Master’s or Doctorate degree

On average, principals had 11 years of experience.

### Exhibit P8.1: National Requirements for Being a Physics Teacher in the Final Year of School

**Reported by National Research Coordinators**

<table>
<thead>
<tr>
<th>Country</th>
<th>Requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td>France</td>
<td>Being a physics and chemistry secondary school teacher is the only requirement to teach Grade 12 advanced physics. Secondary school teachers must hold a master’s degree and pass the competitive national examination.</td>
</tr>
<tr>
<td>Italy</td>
<td>Teachers must hold a degree in physics (5 years of university study), complete a 1-year teacher certification course, and win a public contest.</td>
</tr>
<tr>
<td>Lebanon</td>
<td>Teachers must hold a Bachelor of Science degree or teaching diploma in physics for Grades 9, 10, 11, and 12.</td>
</tr>
<tr>
<td>Norway</td>
<td>Teachers are required to have at least a university bachelor’s degree and have taken at least 1 full year (60 credit points) of physics courses. They also need 1 year of teacher education courses, consisting of general pedagogy, physics education, and teaching practice in schools. These courses may be taken separately after finishing subject studies, or as an integrated part. The current tendency is that a full master’s degree will be required.</td>
</tr>
<tr>
<td>Portugal</td>
<td>Fully qualified physics (and chemistry) teachers must have at least a Master of Science degree in physics and chemistry education, which includes a professional internship. They must pass both a general knowledge exam and a specific (physics and chemistry) teachers’ qualifying examination.</td>
</tr>
<tr>
<td>Russian Federation</td>
<td>In general, physics teachers should complete a university degree in physics education or have completed a university major in physics or engineering, etc., as well as a set of education courses. Usually, advanced physics teachers have completed additional specific courses in advanced physics in a university education program. As a rule, teachers of advanced physics courses have 3–5 years of experience teaching in upper-secondary school.</td>
</tr>
<tr>
<td>Slovenia</td>
<td>All teachers must have an appropriate university degree in education, pedagogical training, and have successfully completed the teaching certification examination. Teachers for the physics program should have a second-level university degree, which means 5 years of mathematics and physics university study or two university education science subjects with a set of physics pedagogical courses.</td>
</tr>
<tr>
<td>Sweden</td>
<td>Teachers must be licensed through a teacher education program. To become a physics teacher in upper-secondary school you need at least 1.5 years of physics courses at a university. You also need 1.5–2 years of tertiary level studies in one more subject, and 1.5 years of courses in specific and general education. In total, 300 credits for 5–5.5 years are required. After finishing a teacher education program, prospective teachers apply for a license at the Swedish National Agency for Education.</td>
</tr>
<tr>
<td>United States</td>
<td>All public school teachers must be licensed by their state’s department of education, and requirements for licensure vary by state. Secondary school physics teachers may have a bachelor’s degree in physics (and possibly a master’s degree in education), or a double major in physics and education. Additionally, all teachers must be highly qualified, which includes demonstrating expertise in their subject area by either passing a subject test or completing an undergraduate degree, completing a graduate degree, completing coursework equivalent to an undergraduate major, or completing advanced certification or credentialing.</td>
</tr>
</tbody>
</table>
### Exhibit P8.2: Physics Teachers’ Formal Education*

<table>
<thead>
<tr>
<th>Country</th>
<th>Completed Postgraduate University Degree**</th>
<th>Completed Bachelor’s Degree or Equivalent but Not a Postgraduate Degree</th>
<th>Did Not Complete Bachelor’s Degree</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Percent of Students</td>
<td>Average Achievement</td>
<td>Percent of Students</td>
</tr>
<tr>
<td>France</td>
<td>81 (2.5)</td>
<td>375 (4.4)</td>
<td>19 (2.5)</td>
</tr>
<tr>
<td>Italy</td>
<td>14 (2.3)</td>
<td>362 (17.4)</td>
<td>86 (2.3)</td>
</tr>
<tr>
<td>Lebanon</td>
<td>71 (2.9)</td>
<td>406 (4.9)</td>
<td>22 (2.3)</td>
</tr>
<tr>
<td>Norway</td>
<td>86 (2.8)</td>
<td>506 (4.8)</td>
<td>14 (2.8)</td>
</tr>
<tr>
<td>Portugal</td>
<td>27 (4.5)</td>
<td>466 (9.0)</td>
<td>72 (4.6)</td>
</tr>
<tr>
<td>Russian Federation</td>
<td>79 (3.5)</td>
<td>510 (8.0)</td>
<td>21 (3.5)</td>
</tr>
<tr>
<td>Slovenia</td>
<td>100 (0.0)</td>
<td>531 (2.5)</td>
<td>0 (0.0)</td>
</tr>
<tr>
<td>Sweden</td>
<td>73 (4.5)</td>
<td>459 (7.3)</td>
<td>25 (4.5)</td>
</tr>
<tr>
<td>United States</td>
<td>r 77 (6.0)</td>
<td>447 (7.7)</td>
<td>23 (6.0)</td>
</tr>
<tr>
<td>International Avg.</td>
<td>67 (1.2)</td>
<td>451 (2.8)</td>
<td>31 (1.2)</td>
</tr>
</tbody>
</table>

* Based on countries’ categorizations according to UNESCO’s International Standard Classification of Education (Operational Manual for ISCED-2011).

** For example, doctorate, master’s, or other postgraduate degree.

( ) Standard errors appear in parentheses. Because of rounding some results may appear inconsistent.

A tilde (~) indicates insufficient data to report achievement.

An "r" indicates data are available for at least 70% but less than 85% of the students.

---

**Source:** IEA’s Trend in International Mathematics and Science Study – TIMSS Advanced 2015
### Exhibit P8.3: Physics Teachers Majored in Physics and Education

<table>
<thead>
<tr>
<th>Country</th>
<th>Major in Physics and Physics Education</th>
<th>Major in Physics but No Major in Physics Education</th>
<th>Major in Physics Education but No Major in Physics</th>
<th>All Other Majors</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Percent of Students</td>
<td>Average Achievement</td>
<td>Percent of Students</td>
<td>Average Achievement</td>
</tr>
<tr>
<td>France</td>
<td>25 (2.8)</td>
<td>371 (7.2)</td>
<td>71 (2.8)</td>
<td>376 (4.6)</td>
</tr>
<tr>
<td>Italy</td>
<td>38 (2.9)</td>
<td>369 (12.4)</td>
<td>37 (3.0)</td>
<td>393 (9.2)</td>
</tr>
<tr>
<td>Lebanon</td>
<td>51 (4.8)</td>
<td>406 (7.2)</td>
<td>48 (4.8)</td>
<td>419 (8.0)</td>
</tr>
<tr>
<td>Norway</td>
<td>10 (2.9)</td>
<td>513 (11.6)</td>
<td>88 (3.3)</td>
<td>506 (5.1)</td>
</tr>
<tr>
<td>Portugal</td>
<td>42 (4.5)</td>
<td>470 (7.1)</td>
<td>55 (4.4)</td>
<td>466 (6.4)</td>
</tr>
<tr>
<td>Russian Federation</td>
<td>64 (3.7)</td>
<td>513 (9.3)</td>
<td>34 (3.9)</td>
<td>498 (9.1)</td>
</tr>
<tr>
<td>Slovenia</td>
<td>41 (3.1)</td>
<td>531 (4.2)</td>
<td>44 (3.3)</td>
<td>526 (4.8)</td>
</tr>
<tr>
<td>Sweden</td>
<td>71 (4.3)</td>
<td>463 (7.9)</td>
<td>21 (3.8)</td>
<td>446 (12.9)</td>
</tr>
<tr>
<td>United States</td>
<td>r 24 (4.1)</td>
<td>444 (14.7)</td>
<td>31 (4.7)</td>
<td>429 (22.4)</td>
</tr>
<tr>
<td>International Avg.</td>
<td>41 (1.2)</td>
<td>453 (1.2)</td>
<td>48 (1.3)</td>
<td>451 (3.5)</td>
</tr>
</tbody>
</table>

() Standard errors appear in parentheses. Because of rounding some results may appear inconsistent.  
A tilde (~) indicates insufficient data to report achievement.  
An *r* indicates data are available for at least 70% but less than 85% of the students.
<table>
<thead>
<tr>
<th>Country</th>
<th>Gender</th>
<th>Percent of Students by Teacher Characteristics</th>
<th>Average Number of Years Teaching</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Female</td>
<td>Male</td>
<td>29 Years or Under</td>
</tr>
<tr>
<td>France</td>
<td>38 (3.3)</td>
<td>62 (3.3)</td>
<td>2 (1.0)</td>
</tr>
<tr>
<td>Italy</td>
<td>57 (3.1)</td>
<td>43 (3.1)</td>
<td>2 (0.7)</td>
</tr>
<tr>
<td>Lebanon</td>
<td>20 (2.8)</td>
<td>80 (2.8)</td>
<td>3 (0.6)</td>
</tr>
<tr>
<td>Norway</td>
<td>24 (4.1)</td>
<td>76 (4.1)</td>
<td>7 (1.9)</td>
</tr>
<tr>
<td>Portugal</td>
<td>56 (4.8)</td>
<td>44 (4.8)</td>
<td>0 (0.0)</td>
</tr>
<tr>
<td>Russian Federation</td>
<td>77 (3.0)</td>
<td>23 (3.0)</td>
<td>3 (1.4)</td>
</tr>
<tr>
<td>Slovenia</td>
<td>31 (3.3)</td>
<td>69 (3.3)</td>
<td>1 (0.0)</td>
</tr>
<tr>
<td>Sweden</td>
<td>27 (4.8)</td>
<td>73 (4.8)</td>
<td>7 (1.7)</td>
</tr>
<tr>
<td>United States</td>
<td>r 31 (5.7)</td>
<td>69 (5.7)</td>
<td>r 19 (4.7)</td>
</tr>
<tr>
<td>International Avg.</td>
<td>40 (1.3)</td>
<td>60 (1.3)</td>
<td>5 (0.6)</td>
</tr>
</tbody>
</table>

( ) Standard errors appear in parentheses. Because of rounding, some results may appear inconsistent.

An "r" indicates data are available for at least 70% but less than 85% of the students. An "s" indicates data are available for at least 50% but less than 70% of the students.
### Exhibit P8.5: Physics Teachers’ Participation in Professional Development in Physics in the Past Two Years

**Reported by Physics Teachers**

Teachers could indicate participating in more than one area of professional development.

<table>
<thead>
<tr>
<th>Country</th>
<th>Physics Content</th>
<th>Physics Pedagogy/Instruction</th>
<th>Physics Curriculum</th>
<th>Integrating Information Technology into Physics</th>
<th>Improving Students’ Critical Thinking or Problem Solving Skills</th>
<th>Physics Assessment</th>
<th>Addressing Individual Students’ Needs</th>
</tr>
</thead>
<tbody>
<tr>
<td>France</td>
<td>32 (2.8)</td>
<td>51 (3.4)</td>
<td>37 (3.5)</td>
<td>20 (2.9)</td>
<td>21 (2.8)</td>
<td>32 (2.8)</td>
<td>9 (1.9)</td>
</tr>
<tr>
<td>Italy</td>
<td>42 (3.6)</td>
<td>35 (3.4)</td>
<td>21 (2.8)</td>
<td>21 (2.9)</td>
<td>9 (2.0)</td>
<td>8 (1.7)</td>
<td>13 (2.7)</td>
</tr>
<tr>
<td>Lebanon</td>
<td>53 (4.1)</td>
<td>58 (2.6)</td>
<td>50 (3.8)</td>
<td>69 (2.5)</td>
<td>50 (3.7)</td>
<td>60 (3.1)</td>
<td>46 (4.3)</td>
</tr>
<tr>
<td>Norway</td>
<td>35 (4.6)</td>
<td>18 (3.7)</td>
<td>15 (3.6)</td>
<td>20 (3.4)</td>
<td>5 (1.8)</td>
<td>17 (3.5)</td>
<td>6 (2.0)</td>
</tr>
<tr>
<td>Portugal</td>
<td>59 (5.1)</td>
<td>48 (4.6)</td>
<td>35 (5.1)</td>
<td>55 (5.0)</td>
<td>16 (3.1)</td>
<td>17 (3.9)</td>
<td>13 (3.7)</td>
</tr>
<tr>
<td>Russian Federation</td>
<td>62 (4.1)</td>
<td>79 (3.8)</td>
<td>82 (2.7)</td>
<td>76 (3.4)</td>
<td>58 (4.8)</td>
<td>53 (4.3)</td>
<td>50 (3.9)</td>
</tr>
<tr>
<td>Slovenia</td>
<td>82 (2.4)</td>
<td>76 (3.0)</td>
<td>49 (3.6)</td>
<td>61 (3.0)</td>
<td>48 (3.0)</td>
<td>40 (3.6)</td>
<td>24 (3.4)</td>
</tr>
<tr>
<td>Sweden</td>
<td>42 (4.2)</td>
<td>28 (4.8)</td>
<td>15 (3.1)</td>
<td>27 (4.4)</td>
<td>9 (2.6)</td>
<td>26 (4.2)</td>
<td>17 (4.1)</td>
</tr>
<tr>
<td>United States</td>
<td>s 64 (5.8)</td>
<td>s 67 (5.3)</td>
<td>s 76 (5.4)</td>
<td>s 38 (5.1)</td>
<td>s 53 (6.2)</td>
<td>s 48 (5.6)</td>
<td>s 37 (5.9)</td>
</tr>
<tr>
<td>International Avg.</td>
<td>52 (1.4)</td>
<td>51 (1.3)</td>
<td>42 (1.3)</td>
<td>43 (1.2)</td>
<td>30 (1.2)</td>
<td>33 (1.3)</td>
<td>24 (1.2)</td>
</tr>
</tbody>
</table>

( ) Standard errors appear in parentheses. Because of rounding some results may appear inconsistent. An "s" indicates data are available for at least 50% but less than 70% of the students.

SOURCE: IEA’s Trends in International Mathematics and Science Study – TIMSS Advanced 2015
### Exhibit P8.6: Principals’ Formal Education*

<table>
<thead>
<tr>
<th>Country</th>
<th>Did Not Complete Bachelor’s Degree or Equivalent but Not a Postgraduate Degree</th>
<th>Completed Bachelor’s Degree or Equivalent but Not a Postgraduate Degree</th>
<th>Completed Postgraduate University Degree**</th>
</tr>
</thead>
<tbody>
<tr>
<td>France</td>
<td>73 (4.0)</td>
<td>25 (4.0)</td>
<td>1 (1.1)</td>
</tr>
<tr>
<td>Italy</td>
<td>30 (4.7)</td>
<td>67 (4.8)</td>
<td>3 (1.8)</td>
</tr>
<tr>
<td>Lebanon</td>
<td>71 (4.3)</td>
<td>26 (4.3)</td>
<td>3 (0.5)</td>
</tr>
<tr>
<td>Norway</td>
<td>r</td>
<td>23 (4.7)</td>
<td>0 (0.0)</td>
</tr>
<tr>
<td>Portugal</td>
<td>38 (5.4)</td>
<td>62 (5.4)</td>
<td>0 (0.0)</td>
</tr>
<tr>
<td>Russian Federation</td>
<td>82 (2.8)</td>
<td>18 (2.8)</td>
<td>0 (0.0)</td>
</tr>
<tr>
<td>Slovenia</td>
<td>100 (0.0)</td>
<td>0 (0.0)</td>
<td>0 (0.0)</td>
</tr>
<tr>
<td>Sweden</td>
<td>61 (6.1)</td>
<td>35 (5.9)</td>
<td>4 (1.7)</td>
</tr>
<tr>
<td>United States</td>
<td>r</td>
<td>100 (0.3)</td>
<td>0 (0.0)</td>
</tr>
<tr>
<td><strong>International Avg.</strong></td>
<td>70 (1.4)</td>
<td>29 (1.4)</td>
<td>1 (0.3)</td>
</tr>
</tbody>
</table>

* Based on countries’ categorizations according to UNESCO’s International Standard Classification of Education (Operational Manual for ISCED-2011).
** For example, doctorate, master’s, or other postgraduate degree.
( ) Standard errors appear in parentheses. Because of rounding some results may appear inconsistent.
An “r” indicates data are available for at least 70% but less than 85% of the students.

SOURCE: IEA’s Trends in International Mathematics and Science Study – TIMSS Advanced 2015
### Exhibit P8.7: Principals’ Years of Experience

Reported by Principals

<table>
<thead>
<tr>
<th>Country</th>
<th>20 Years or More</th>
<th>At Least 10 but Less than 20 Years</th>
<th>At Least 5 but Less than 10 Years</th>
<th>Less than 5 Years</th>
<th>Average Years of Experience as a Principal</th>
</tr>
</thead>
<tbody>
<tr>
<td>France</td>
<td>14 (2.7)</td>
<td>31 (4.1)</td>
<td>27 (3.9)</td>
<td>28 (4.4)</td>
<td>10 (0.7)</td>
</tr>
<tr>
<td>Italy</td>
<td>18 (3.6)</td>
<td>27 (4.2)</td>
<td>41 (4.4)</td>
<td>13 (3.0)</td>
<td>11 (0.7)</td>
</tr>
<tr>
<td>Lebanon</td>
<td>33 (5.0)</td>
<td>20 (2.8)</td>
<td>26 (3.4)</td>
<td>21 (2.9)</td>
<td>14 (0.9)</td>
</tr>
<tr>
<td>Norway</td>
<td>r</td>
<td>24 (5.2)</td>
<td>40 (5.9)</td>
<td>8 (2.7)</td>
<td>14 (0.7)</td>
</tr>
<tr>
<td>Portugal</td>
<td>18 (3.1)</td>
<td>30 (3.6)</td>
<td>25 (4.7)</td>
<td>26 (4.8)</td>
<td>11 (0.8)</td>
</tr>
<tr>
<td>Russian Federation</td>
<td>24 (4.0)</td>
<td>35 (3.8)</td>
<td>20 (3.0)</td>
<td>21 (3.5)</td>
<td>13 (0.8)</td>
</tr>
<tr>
<td>Slovenia</td>
<td>12 (3.3)</td>
<td>39 (4.4)</td>
<td>30 (3.8)</td>
<td>20 (1.3)</td>
<td>12 (0.5)</td>
</tr>
<tr>
<td>Sweden</td>
<td>6 (2.6)</td>
<td>33 (5.1)</td>
<td>27 (4.0)</td>
<td>34 (4.5)</td>
<td>8 (0.6)</td>
</tr>
<tr>
<td>United States</td>
<td>r</td>
<td>5 (1.7)</td>
<td>30 (5.3)</td>
<td>27 (4.4)</td>
<td>8 (0.7)</td>
</tr>
<tr>
<td>International Avg.</td>
<td>17 (1.2)</td>
<td>32 (1.5)</td>
<td>28 (1.3)</td>
<td>23 (1.3)</td>
<td>11 (0.2)</td>
</tr>
</tbody>
</table>

( ) Standard errors appear in parentheses. Because of rounding some results may appear inconsistent. An “r” indicates data are available for at least 70% but less than 85% of the students.

SOURCE: IEA’s Trends in International Mathematics and Science Study – TIMSS Advanced 2015
CHAPTER P9: CLASSROOM INSTRUCTION

TIMSS ADVANCED 2015 INTERNATIONAL RESULTS IN ADVANCED MATHEMATICS AND PHYSICS
Curriculum

There was variation in topic coverage within content domains. However, according to their teachers, on average, most Physics students had been taught the TIMSS Advanced topics.

Eight of the nine countries participating in TIMSS Advanced had a national curriculum, with the United States being the exception. All but three (Italy, Sweden and the United States) had a "high stakes" test for students nearing the completion of secondary school.

There was variation in topic coverage within content domains. However, according to their teachers, on average, most Physics students had been taught the TIMSS Advanced topics.

Covering a rigorous curriculum is key in students' opportunity to learn. Across the TIMSS Advanced countries there was a wide range in access to digital devices to use in physics lessons, with 79% of students on average having digital devices available.

Students used the Internet for their TIMSS Advanced school work primarily to:

- Find information about physics concepts or solve problems (72-74%)
- Collaborate with classmates on physics assignments or projects (64%)

Across the TIMSS Advanced countries there was a wide range in access to digital devices to use in physics lessons, with 79% of students on average having digital devices available.

Technology

Students also studied outside of school:

- 100% of students in Norway
- 77% of students in Lebanon
- Almost all students were assigned homework except in Slovenia and Sweden:
  - Slovenia: 69%
  - Sweden: 71%
  - All other countries: 82-100%

Except in the Russian Federation, Portugal, and France, few Physics students reported attending extra tutoring outside of school to improve their achievement.

There was a considerable range in the yearly number of instructional hours in physics.

- 102 hours in Italy
- 133 hours in Lebanon
- International average: 200 hours

Instructional time remains a crucial resource in considering students' opportunity to learn in their final year, even though there are many factors that influence the effectiveness of an educational system.

There was a considerable range in the yearly number of instructional hours in physics.

Instructional Time

Technology

Mechanics and Thermodynamics Topics
Electricity and Magnetism Topics
Wave Phenomena and Atomic/Nuclear Physics Topics

90%
83%
81%

<table>
<thead>
<tr>
<th>Country</th>
<th>Total Instructional Hours per Year</th>
<th>Hours per Year for Physics Instruction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lebanon</td>
<td>932 (11.2)</td>
<td>200 (3.1)</td>
</tr>
<tr>
<td>United States</td>
<td>r 1132 (22.5)</td>
<td>s 162 (13.3)</td>
</tr>
<tr>
<td>Norway</td>
<td>r 991 (14.1)</td>
<td>r 139 (3.0)</td>
</tr>
<tr>
<td>Russian Federation</td>
<td>920 (8.7)</td>
<td>133 (2.0)</td>
</tr>
<tr>
<td>Portugal</td>
<td>r 1046 (37.1)</td>
<td>120 (6.2)</td>
</tr>
<tr>
<td>France</td>
<td>1340 (22.5)</td>
<td>r 116 (4.2)</td>
</tr>
<tr>
<td>Slovenia</td>
<td>902 (5.9)</td>
<td>115 (1.0)</td>
</tr>
<tr>
<td>Sweden</td>
<td>920 (13.8)</td>
<td>106 (3.0)</td>
</tr>
<tr>
<td>Italy</td>
<td>r 1018 (8.2)</td>
<td>r 102 (1.7)</td>
</tr>
<tr>
<td>International Avg.</td>
<td>1023 (6.2)</td>
<td>123 (1.8)</td>
</tr>
</tbody>
</table>

An "r" indicates data are available for at least 70% but less than 85% of the students. An "s" indicates data are available for at least 50% but less than 70% of the students.

Standard errors appear in parentheses. Because of rounding some results may appear inconsistent.

### Exhibit P9.2: Types of Homework Assignments

**Reported by Physics Teachers**

<table>
<thead>
<tr>
<th>Country</th>
<th>Physics Homework Assigned to Class</th>
<th>Percent of Students Whose Teachers &quot;Sometimes&quot; or &quot;Always or Almost Always&quot; Assign Each Type of Homework</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Yes (std. dev.)</td>
<td>No (std. dev.)</td>
</tr>
<tr>
<td><strong>France</strong></td>
<td>98 (0.4)</td>
<td>375 (4.0)</td>
</tr>
<tr>
<td><strong>Italy</strong></td>
<td>97 (1.2)</td>
<td>377 (7.2)</td>
</tr>
<tr>
<td><strong>Lebanon</strong></td>
<td>97 (1.1)</td>
<td>409 (4.6)</td>
</tr>
<tr>
<td><strong>Norway</strong></td>
<td>95 (2.1)</td>
<td>504 (4.5)</td>
</tr>
<tr>
<td><strong>Portugal</strong></td>
<td>82 (3.9)</td>
<td>465 (4.6)</td>
</tr>
<tr>
<td><strong>Russian Federation</strong></td>
<td>100 (0.0)</td>
<td>508 (7.1)</td>
</tr>
<tr>
<td><strong>Slovenia</strong></td>
<td>69 (2.2)</td>
<td>531 (3.3)</td>
</tr>
<tr>
<td><strong>Sweden</strong></td>
<td>71 (3.8)</td>
<td>454 (7.8)</td>
</tr>
<tr>
<td><strong>United States</strong></td>
<td>s 93 (4.4)</td>
<td>443 (11.0)</td>
</tr>
<tr>
<td><strong>International Avg.</strong></td>
<td>89 (0.9)</td>
<td>452 (2.1)</td>
</tr>
</tbody>
</table>

( ) Standard errors appear in parentheses. Because of rounding some results may appear inconsistent.
A tilde (~) indicates insufficient data to report achievement.
An "s" indicates data are available for at least 50% but less than 70% of the students.
### Exhibit P9.3: Students Attended Extra Tutoring in Physics Not Provided by the School

**Reported by Physics Students**

<table>
<thead>
<tr>
<th>Country</th>
<th>Students Did Not Attend Extra Tutoring</th>
<th>Students Attended Extra Tutoring</th>
<th>Reasons for Attending Extra Tutoring (Students Could Indicate More than One)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Percent of Students</td>
<td>Average Achievement</td>
<td>Percent of Students</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>France</td>
<td>80 (0.9)</td>
<td>384 (4.2)</td>
<td>20 (0.9)</td>
</tr>
<tr>
<td>Italy</td>
<td>83 (0.9)</td>
<td>377 (7.3)</td>
<td>17 (0.9)</td>
</tr>
<tr>
<td>Lebanon</td>
<td>85 (1.3)</td>
<td>418 (4.9)</td>
<td>15 (1.3)</td>
</tr>
<tr>
<td>Norway</td>
<td>97 (0.4)</td>
<td>509 (4.5)</td>
<td>3 (0.4)</td>
</tr>
<tr>
<td>Portugal</td>
<td>73 (1.6)</td>
<td>467 (4.9)</td>
<td>27 (1.6)</td>
</tr>
<tr>
<td>Russian Federation</td>
<td>48 (1.5)</td>
<td>481 (8.7)</td>
<td>52 (1.5)</td>
</tr>
<tr>
<td>Slovenia</td>
<td>92 (0.8)</td>
<td>536 (2.8)</td>
<td>8 (0.8)</td>
</tr>
<tr>
<td>Sweden</td>
<td>91 (0.7)</td>
<td>460 (5.9)</td>
<td>9 (0.7)</td>
</tr>
<tr>
<td>United States</td>
<td>89 (0.8)</td>
<td>443 (9.9)</td>
<td>11 (0.8)</td>
</tr>
<tr>
<td>International Avg.</td>
<td>82 (0.4)</td>
<td>453 (2.3)</td>
<td>18 (0.4)</td>
</tr>
</tbody>
</table>

(Standard errors appear in parentheses. Because of rounding some results may appear inconsistent. A tilde (~) indicates insufficient data to report achievement.)
<table>
<thead>
<tr>
<th>Country</th>
<th>Examinations with Consequences for Individual Students</th>
<th>Grades at Which Examinations with Consequences for Individual Students are Given</th>
<th>Format of Examinations with Consequences for Individual Students</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>France</td>
<td>Yes</td>
<td>Grade 12</td>
<td>Written and oral examinations</td>
<td>Each subject examination grade is weighted differently according to the track students are attending. In the scientific track, mathematics and other science grades altogether are weighted as much as half the student’s total grade average.</td>
</tr>
<tr>
<td>Italy</td>
<td>No</td>
<td>n/a</td>
<td>n/a</td>
<td>Students take a final examination at the end of each cycle (K8 and K13). For the transition from one school year to the next, the final evaluation is done through student achievement tests (written and oral), which take place throughout the school year. The school leaving examination (taken after five years of Liceo) consists of two national written examinations, one school written examination, and one school oral examination.</td>
</tr>
<tr>
<td>Lebanon</td>
<td>Yes</td>
<td>Grade 12</td>
<td>Written examinations</td>
<td>At the end of the third year of the secondary cycle or Grade 12, students have to pass the Official Baccalaureate exams for the four sections—life sciences, general sciences, economics, and humanities. The purpose of these exams is for the students to be able to continue with their university studies.</td>
</tr>
<tr>
<td>Norway</td>
<td>Yes</td>
<td>Grades 12 and 13</td>
<td>Written and oral examinations</td>
<td>Nationwide final examinations are produced by an independent educational assessment public institute (IAVE, I. P.). The application and scoring of the examinations is coordinated by a National Exam Jury Board under the supervision of the General Education Directorate of the Ministry of Education.</td>
</tr>
<tr>
<td>Portugal</td>
<td>Yes</td>
<td>Grade 11</td>
<td>Written examinations</td>
<td>All high school graduates have to pass two mandatory Unified State Examinations (USE): mathematics and Russian language. Graduates of the Profile physics program (Grade 11) do not have to pass any mandatory examination in physics. Students take the USE in physics if they are seeking admission to university courses in physics, mathematics, chemistry, etc. The USE in physics is usually taken by about 25% of all high school graduates each year. Students’ high school grades are not considered for university admission.</td>
</tr>
<tr>
<td>Russian Federation</td>
<td>Yes</td>
<td>Grades 9 and 11</td>
<td>Written examinations</td>
<td>Achievement on the Matura examination and achievement in the last two years of schooling are used to select students where there is a limit to the number of candidates for a university program. The Matura is prepared and administered by the National Examination Center.</td>
</tr>
<tr>
<td>Slovenia</td>
<td>Yes</td>
<td>Grades 9 and 13</td>
<td>Written and oral examinations</td>
<td>Although there are no national exams with consequences for individual students, many high school students take Advanced Placement (AP) or International Baccalaureate (IB) courses that culminate with an end-of-course exam. Students can take these AP or IB written exams at a price and, if they score well, can earn course credit at many colleges and universities. In addition, to apply for admission to most colleges and universities in the United States, students in Grades 11 and 12 take written exams to demonstrate their readiness for college-level work. Private companies (e.g., ACT, College Board) offer these exams in different subjects to students for a price.</td>
</tr>
<tr>
<td>Sweden</td>
<td>No</td>
<td>n/a</td>
<td>n/a</td>
<td>No</td>
</tr>
<tr>
<td>United States</td>
<td>No</td>
<td>n/a</td>
<td>n/a</td>
<td>No</td>
</tr>
</tbody>
</table>

Reported by National Research Coordinators

**Exhibit P9.5: Characteristics and Methods Used to Evaluate the Physics Curriculum**

*Reported by National Research Coordinators*

<table>
<thead>
<tr>
<th>Country</th>
<th>National Curriculum</th>
<th>Year Introduced</th>
<th>Being Revised</th>
<th>Visits by Inspectors</th>
<th>Research Programs</th>
<th>School Self-Evaluation</th>
<th>National or Regional Assessments</th>
</tr>
</thead>
<tbody>
<tr>
<td>France</td>
<td>● 2011</td>
<td>○</td>
<td>● ● ● ○ ○ ○ ●</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Italy</td>
<td>● 2010</td>
<td>○</td>
<td>○ ● ● ○ ○ ○ ●</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lebanon</td>
<td>● 2001</td>
<td>○</td>
<td>○ ● ● ○ ● ● ●</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Norway</td>
<td>● 2006</td>
<td>○</td>
<td>○ ● ● ○ ● ● ●</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Portugal</td>
<td>● 2005</td>
<td>●</td>
<td>○ ○ ● ○ ● ● ●</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Russian Federation</td>
<td>● 2004</td>
<td>●</td>
<td>○ ● ● ● ● ● ●</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Slovenia</td>
<td>● 2008</td>
<td>○</td>
<td>○ ● ● ● ● ● ●</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sweden</td>
<td>● 2011</td>
<td>○</td>
<td>● ● ● ● ● ● ●</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>United States</td>
<td>○ Varies by school</td>
<td>○</td>
<td>● Varies by course</td>
<td>● ● ● ○ ○ ○ ●</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

● Yes  ○ No

*SOURCE: IEA’s Trends in International Mathematics and Science Study – TIMSS Advanced 2015*
### Exhibit P9.6: Number of TIMSS Advanced Physics Topics in the Intended Curriculum

<table>
<thead>
<tr>
<th>Country</th>
<th>All Physics (22 topics)</th>
<th>Mechanics and Thermodynamics (9 topics)</th>
<th>Electricity and Magnetism (6 topics)</th>
<th>Wave Phenomena and Atomic/Nuclear Physics (7 topics)</th>
</tr>
</thead>
<tbody>
<tr>
<td>France</td>
<td>15</td>
<td>5</td>
<td>3</td>
<td>7</td>
</tr>
<tr>
<td>Italy</td>
<td>17</td>
<td>4</td>
<td>6</td>
<td>7</td>
</tr>
<tr>
<td>Lebanon</td>
<td>22</td>
<td>9</td>
<td>6</td>
<td>7</td>
</tr>
<tr>
<td>Norway</td>
<td>21</td>
<td>9</td>
<td>6</td>
<td>6</td>
</tr>
<tr>
<td>Portugal</td>
<td>19</td>
<td>8</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>Russian Federation</td>
<td>20</td>
<td>9</td>
<td>6</td>
<td>5</td>
</tr>
<tr>
<td>Slovenia</td>
<td>22</td>
<td>9</td>
<td>6</td>
<td>7</td>
</tr>
<tr>
<td>Sweden</td>
<td>22</td>
<td>9</td>
<td>6</td>
<td>7</td>
</tr>
<tr>
<td>United States</td>
<td>21</td>
<td>9</td>
<td>6</td>
<td>6</td>
</tr>
</tbody>
</table>

In the United States, the number of TIMSS Advanced physics topics covered varies by state and course type. The data shown in this table reflect the maximum number of topics that may be covered in each content domain.

### TIMSS Advanced 2015 Physics Topics

**A. Mechanics and Thermodynamics**

1) Applying Newton’s laws and laws of motion  
2) Forces, including frictional force, acting on a body  
3) Forces acting on a body moving in a circular path; the body’s centripetal acceleration, speed, and circling time  
4) The law of gravitation in relation to the movement of celestial objects  
5) Kinetic and potential energy; conversation of mechanical energy  
6) The law of conservation of momentum; elastic and inelastic collisions  
7) The first law of thermodynamics  
8) Heat transfer and specific heat capacities  
9) The law of ideal gases; expansion of solids and liquids in relation to temperature change

**B. Electricity and Magnetism**

1) Electrostatic attraction or repulsion between isolated charged particles — Coulomb’s law  
2) Charged particles in an electric field  
3) Electrical circuits; using Ohm’s law and Joule’s law  
4) Charged particles in a magnetic field  
5) Relationship between magnetism and electricity; magnetic fields around electric conductors; electromagnetic induction  
6) Faraday’s and Lenz’s laws of induction

**C. Wave Phenomena and Atomic/Nuclear Physics**

1) Mechanical waves; the relationship between speed, frequency, and wavelength  
2) Electromagnetic radiation; wavelength and frequency of various types of waves (radio, infrared, visible light, x-rays, gamma rays)  
3) Thermal radiation, temperature, and wavelength  
4) Reflection, refraction, interference, and diffraction  
5) The structure of the atom and its nucleus; atomic number and atomic mass; electromagnetic emission and absorption and the behavior of electrons  
6) Wave–particle duality and the photoelectric effect; types of nuclear reactions and their role in nature and society; radioactive isotopes  
7) Mass-energy equivalence in nuclear reactions and particle transformations
### Exhibit P9.7: Percentages of Students Taught* the TIMSS Advanced Topics in Physics

#### Mechanics and Thermodynamics Topics

*Reported by Physics Teachers*

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>France</td>
<td>98 (0.6)</td>
<td>94 (1.2)</td>
<td>96 (1.1)</td>
<td>98 (0.6)</td>
<td>97 (1.0)</td>
<td>78 (2.5)</td>
<td>37 (3.0)</td>
<td>87 (2.1)</td>
<td>37 (2.6)</td>
</tr>
<tr>
<td>Italy</td>
<td>99 (0.6)</td>
<td>99 (0.6)</td>
<td>99 (0.6)</td>
<td>98 (1.0)</td>
<td>99 (0.6)</td>
<td>98 (0.7)</td>
<td>98 (1.4)</td>
<td>98 (1.4)</td>
<td>98 (1.4)</td>
</tr>
<tr>
<td>Lebanon</td>
<td>100 (0.0)</td>
<td>100 (0.0)</td>
<td>100 (0.0)</td>
<td>95 (0.9)</td>
<td>100 (0.0)</td>
<td>97 (0.5)</td>
<td>31 (3.5)</td>
<td>40 (4.1)</td>
<td>34 (4.1)</td>
</tr>
<tr>
<td>Norway</td>
<td>99 (0.6)</td>
<td>99 (0.6)</td>
<td>99 (0.6)</td>
<td>99 (0.8)</td>
<td>99 (0.6)</td>
<td>99 (0.8)</td>
<td>71 (3.8)</td>
<td>42 (3.5)</td>
<td>37 (4.8)</td>
</tr>
<tr>
<td>Portugal</td>
<td>100 (0.0)</td>
<td>100 (0.0)</td>
<td>100 (0.0)</td>
<td>96 (2.4)</td>
<td>100 (0.0)</td>
<td>92 (2.9)</td>
<td>99 (1.1)</td>
<td>100 (0.0)</td>
<td>37 (4.8)</td>
</tr>
<tr>
<td>Russian Federation</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Slovenia</td>
<td>100 (0.0)</td>
<td>100 (0.0)</td>
<td>100 (0.0)</td>
<td>100 (0.0)</td>
<td>100 (0.0)</td>
<td>100 (0.0)</td>
<td>100 (0.0)</td>
<td>100 (0.0)</td>
<td>100 (0.0)</td>
</tr>
<tr>
<td>Sweden</td>
<td>99 (0.9)</td>
<td>99 (0.9)</td>
<td>99 (0.9)</td>
<td>94 (2.3)</td>
<td>99 (1.1)</td>
<td>96 (1.5)</td>
<td>98 (1.2)</td>
<td>98 (1.2)</td>
<td>90 (2.6)</td>
</tr>
<tr>
<td>United States</td>
<td>s 100 (0.2)</td>
<td>s 100 (0.0)</td>
<td>s 97 (2.1)</td>
<td>s 95 (2.6)</td>
<td>s 99 (0.7)</td>
<td>s 99 (0.4)</td>
<td>s 52 (5.2)</td>
<td>s 52 (5.3)</td>
<td>s 56 (6.0)</td>
</tr>
<tr>
<td>International Avg.</td>
<td>99 (0.2)</td>
<td>99 (0.2)</td>
<td>99 (0.3)</td>
<td>97 (0.6)</td>
<td>99 (0.2)</td>
<td>95 (0.5)</td>
<td>77 (0.9)</td>
<td>81 (1.0)</td>
<td>62 (1.3)</td>
</tr>
</tbody>
</table>

* Percentage mostly taught before or in the assessment year.

( ) Standard errors appear in parentheses. Because of rounding some results may appear inconsistent.

A dash (-) indicates comparable data not available.

An "s" indicates data are available for at least 50% but less than 70% of the students.

---

### TIMSS Advanced 2015 Mechanics and Thermodynamics Topics

1. **Newton’s Laws**: Applying Newton’s laws and laws of motion
2. **Forces**: Forces, including frictional force, acting on a body
3. **Body Moving in a Circular Path**: Forces acting on a body moving in a circular path; the body’s centripetal acceleration, speed, and circling time
4. **The Law of Gravitation**: The law of gravitation in relation to the movement of celestial objects
5. **Kinetic and Potential Energy**: Kinetic and potential energy; conservation of mechanical energy
6. **Conservation of Momentum**: The law of conservation of momentum; elastic and inelastic collisions
7. **The First Law of Thermodynamics**
8. **Heat Transfer**: Heat transfer and specific heat capacities
9. **Ideal Gases**: The law of ideal gases; expansion of solids in relation to temperature change

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*Downloaded from timss2015.org/advanced/download-center/*
### Exhibit P9.7: Percentages of Students Taught* the TIMSS Advanced Topics in Physics (Continued)

**Electricity and Magnetism Topics**
*Reported by Physics Teachers*

<table>
<thead>
<tr>
<th>Country</th>
<th>Coulomb's Law</th>
<th>Charged Particles in an Electric Field</th>
<th>Electrical Circuits</th>
<th>Charged Particles in a Magnetic Field</th>
<th>Magnetism</th>
<th>Faraday’s and Lenz’s Laws</th>
</tr>
</thead>
<tbody>
<tr>
<td>France</td>
<td>93 (1.5)</td>
<td>96 (0.9)</td>
<td>72 (2.8)</td>
<td>28 (3.1)</td>
<td>18 (2.3)</td>
<td>3 (1.0)</td>
</tr>
<tr>
<td>Italy</td>
<td>100 (0.0)</td>
<td>100 (0.0)</td>
<td>100 (0.0)</td>
<td>97 (1.2)</td>
<td>94 (1.4)</td>
<td>90 (1.9)</td>
</tr>
<tr>
<td>Lebanon</td>
<td>99 (1.0)</td>
<td>95 (1.0)</td>
<td>100 (0.0)</td>
<td>74 (4.2)</td>
<td>98 (0.3)</td>
<td>98 (0.3)</td>
</tr>
<tr>
<td>Norway</td>
<td>98 (1.0)</td>
<td>98 (1.1)</td>
<td>100 (0.0)</td>
<td>95 (1.7)</td>
<td>90 (3.0)</td>
<td>84 (3.6)</td>
</tr>
<tr>
<td>Portugal</td>
<td>92 (3.2)</td>
<td>94 (3.2)</td>
<td>80 (4.1)</td>
<td>61 (4.1)</td>
<td>84 (4.0)</td>
<td>69 (4.3)</td>
</tr>
<tr>
<td>Russian Federation</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Slovenia</td>
<td>99 (1.4)</td>
<td>99 (1.4)</td>
<td>99 (1.4)</td>
<td>99 (0.1)</td>
<td>99 (0.1)</td>
<td>95 (2.4)</td>
</tr>
<tr>
<td>Sweden</td>
<td>99 (0.9)</td>
<td>98 (1.2)</td>
<td>98 (1.1)</td>
<td>91 (2.6)</td>
<td>88 (2.1)</td>
<td>84 (2.1)</td>
</tr>
<tr>
<td>United States</td>
<td>s 80 (3.9)</td>
<td>s 66 (4.7)</td>
<td>s 78 (3.7)</td>
<td>s 48 (4.9)</td>
<td>s 45 (5.2)</td>
<td>s 40 (5.2)</td>
</tr>
<tr>
<td>International Avg.</td>
<td>95 (0.7)</td>
<td>93 (0.8)</td>
<td>91 (0.8)</td>
<td>74 (1.1)</td>
<td>77 (1.0)</td>
<td>70 (1.1)</td>
</tr>
</tbody>
</table>

* Percentage mostly taught before or in the assessment year.

( ) Standard errors appear in parentheses. Because of rounding some results may appear inconsistent.

A dash (-) indicates comparable data not available.

An “s” indicates data are available for at least 50% but less than 70% of the students.

**TIMSS Advanced 2015 Electricity and Magnetism Topics**

1. **Coulomb’s Law:** Electrostatic attraction or repulsion between isolated charged particles—Coulomb’s law
2. **Charged Particles in an Electric Field**
3. **Electrical Circuits:** Electrical circuits; Ohm’s law and Joule’s law
4. **Charged Particles in a Magnetic Field**
5. **Magnetism:** Relationship between magnetism and electricity; magnetic fields around electric conductors; electromagnetic induction
6. **Faraday’s and Lenz’s Laws:** Faraday’s and Lenz’s laws of induction
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>France</td>
<td>98 (0.8)</td>
<td>98 (0.9)</td>
<td>92 (1.6)</td>
<td>97 (0.9)</td>
<td>98 (0.6)</td>
<td>89 (2.1)</td>
<td>89 (2.0)</td>
</tr>
<tr>
<td>Italy</td>
<td>91 (2.2)</td>
<td>72 (3.1)</td>
<td>62 (3.5)</td>
<td>85 (2.6)</td>
<td>35 (3.0)</td>
<td>19 (2.8)</td>
<td>20 (3.1)</td>
</tr>
<tr>
<td>Lebanon</td>
<td>99 (0.1)</td>
<td>99 (0.1)</td>
<td>54 (3.3)</td>
<td>100 (0.3)</td>
<td>98 (0.5)</td>
<td>97 (0.4)</td>
<td>96 (0.7)</td>
</tr>
<tr>
<td>Norway</td>
<td>100 (0.0)</td>
<td>99 (0.9)</td>
<td>99 (0.7)</td>
<td>89 (3.6)</td>
<td>99 (0.8)</td>
<td>67 (4.3)</td>
<td>93 (2.4)</td>
</tr>
<tr>
<td>Portugal</td>
<td>94 (2.5)</td>
<td>97 (1.5)</td>
<td>96 (2.1)</td>
<td>97 (1.5)</td>
<td>95 (2.0)</td>
<td>80 (3.3)</td>
<td>42 (5.2)</td>
</tr>
<tr>
<td>Russian Federation</td>
<td>- -</td>
<td>- -</td>
<td>- -</td>
<td>- -</td>
<td>- -</td>
<td>- -</td>
<td>- -</td>
</tr>
<tr>
<td>Slovenia</td>
<td>99 (1.4)</td>
<td>98 (1.9)</td>
<td>95 (0.8)</td>
<td>97 (1.9)</td>
<td>96 (1.8)</td>
<td>88 (1.8)</td>
<td>89 (1.8)</td>
</tr>
<tr>
<td>Sweden</td>
<td>92 (3.3)</td>
<td>77 (3.2)</td>
<td>68 (4.9)</td>
<td>83 (4.0)</td>
<td>72 (4.7)</td>
<td>64 (4.7)</td>
<td>86 (3.1)</td>
</tr>
<tr>
<td>United States</td>
<td>s 84 (3.0)</td>
<td>s 64 (4.9)</td>
<td>s 42 (5.4)</td>
<td>s 56 (5.0)</td>
<td>s 68 (4.9)</td>
<td>s 42 (5.7)</td>
<td>s 39 (6.7)</td>
</tr>
<tr>
<td>International Avg.</td>
<td>95 (0.7)</td>
<td>88 (0.9)</td>
<td>75 (1.1)</td>
<td>88 (1.0)</td>
<td>83 (1.0)</td>
<td>68 (1.2)</td>
<td>69 (1.3)</td>
</tr>
</tbody>
</table>

* Percentage mostly taught before or in the assessment year.

( ) Standard errors appear in parentheses. Because of rounding some results may appear inconsistent.
A dash (-) indicates comparable data not available.
An “r” indicates data are available for at least 70% but less than 85% of the students. An “s” indicates data are available for at least 50% but less than 70% of the students.

TIMSS Advanced 2015 Wave Phenomena and Atomic/Nuclear Physics Topics
1) Mechanical Waves: Mechanical waves; the relationship between speed, frequency, and wavelength
2) Electromagnetic Radiation: Electromagnetic radiation; wavelength and frequency of various types of waves (radio, infrared, visible light, x-rays, gamma rays)
3) Thermal Radiation: Thermal radiation, temperature, and wavelength
4) Reflection, Refraction, Interference, and Diffraction
5) The Atom: The structure of the atom and its nucleus; atomic number and atomic mass; electromagnetic emission and absorption and the behavior of electrons
6) Wave-Particle Duality: Wave-particle duality and the photoelectric effect; types of nuclear reactions and their role in nature and society; radioactive isotopes
### Exhibit P9.8: Percentages of Students Taught the TIMSS Advanced Physics Topics Averaged Across All Topics and by Content Domain*

*Reported by Physics Teachers*

<table>
<thead>
<tr>
<th>Country</th>
<th>All Physics (22 topics)</th>
<th>Mechanics and Thermodynamics (9 topics)</th>
<th>Electricity and Magnetism (6 topics)</th>
<th>Wave Phenomena and Atomic/Nuclear Physics (7 topics)</th>
</tr>
</thead>
<tbody>
<tr>
<td>France</td>
<td>77 (0.7)</td>
<td>80 (0.8)</td>
<td>52 (1.1)</td>
<td>94 (0.9)</td>
</tr>
<tr>
<td>Italy</td>
<td>84 (0.8)</td>
<td>99 (0.7)</td>
<td>97 (0.6)</td>
<td>55 (1.8)</td>
</tr>
<tr>
<td>Lebanon</td>
<td>r 87 (0.7)</td>
<td>78 (1.0)</td>
<td>94 (0.8)</td>
<td>r 92 (0.5)</td>
</tr>
<tr>
<td>Norway</td>
<td>92 (0.6)</td>
<td>90 (0.8)</td>
<td>94 (1.4)</td>
<td>92 (0.9)</td>
</tr>
<tr>
<td>Portugal</td>
<td>87 (1.0)</td>
<td>92 (0.7)</td>
<td>80 (3.0)</td>
<td>86 (1.7)</td>
</tr>
<tr>
<td>Russian Federation</td>
<td>- -</td>
<td>- -</td>
<td>- -</td>
<td>- -</td>
</tr>
<tr>
<td>Slovenia</td>
<td>98 (0.5)</td>
<td>100 (0.0)</td>
<td>98 (0.8)</td>
<td>95 (1.3)</td>
</tr>
<tr>
<td>Sweden</td>
<td>89 (1.2)</td>
<td>97 (1.0)</td>
<td>93 (1.3)</td>
<td>76 (3.0)</td>
</tr>
<tr>
<td>United States</td>
<td>s 68 (2.9)</td>
<td>s 83 (1.7)</td>
<td>s 59 (4.0)</td>
<td>s 56 (4.3)</td>
</tr>
<tr>
<td>International Avg.</td>
<td>85 (0.5)</td>
<td>90 (0.3)</td>
<td>83 (0.7)</td>
<td>81 (0.8)</td>
</tr>
</tbody>
</table>

* Percentage mostly taught before or in the assessment year.

( ) Standard errors appear in parentheses. Because of rounding some results may appear inconsistent.

A dash (-) indicates comparable data not available.

An “r” indicates data are available for at least 70% but less than 85% of the students. An “s” indicates data are available for at least 50% but less than 70% of the students.

**SOURCE:** IEA’s Trends in International Mathematics and Science Study – TIMSS Advanced 2015
<table>
<thead>
<tr>
<th>Country</th>
<th>Description of National Policies for Technology Use in Physics Instruction</th>
<th>Description of National Policies for Technology Use in Physics Assessment</th>
</tr>
</thead>
<tbody>
<tr>
<td>France</td>
<td>Official curriculum documents encourage Technology Enhanced Teaching (TET) and provide specific suggestions for developing digital skills. Graphing and programmable calculators are frequently used in instruction.</td>
<td>Graphing and programmable calculators are allowed during national examinations.</td>
</tr>
<tr>
<td>Italy</td>
<td>No policy. The national curriculum mentions experimental activities in general, but not specifically the use of technology.</td>
<td>Only scientific calculators are allowed during physics tests or examinations. Programmable calculators are not allowed.</td>
</tr>
<tr>
<td>Lebanon</td>
<td>No policy</td>
<td>No policy</td>
</tr>
<tr>
<td>Norway</td>
<td>Digital skills in physics involve carrying out relevant experiments in the main subject areas and analyzing and assessing mathematical models for physical situations, with and without digital tools.</td>
<td>The written exam in Physics 2 is divided into two parts. The first part (2 hours) is solved by pen and paper only; no technological aids are allowed. The second part (3 hours) allows the use of all aids which cannot communicate, including computers without access to the Internet.</td>
</tr>
<tr>
<td>Portugal</td>
<td>In some subjects, laboratory practices are taught/exemplified with graphing-scientific calculators and computers equipped with simulation software.</td>
<td>Some items in physics examinations require the use of a graphing-scientific calculator.</td>
</tr>
<tr>
<td>Russian Federation</td>
<td>No policy. Teachers may choose methods and technologies for instruction.</td>
<td>In the national examination (USE) in physics or regional physics tests, students may use only non-programmable calculators.</td>
</tr>
<tr>
<td>Slovenia</td>
<td>Physics lessons should be complemented and enriched by the use of computer technology. Lessons should use a computer interface and a set of sensors and measuring systems for capturing and processing the data and as a tool for the analysis and presentation of measurement. Available technology should never replace good demonstrations or laboratory techniques.</td>
<td>No policy. However, calculators can be used on the Matura examination which enable basic calculations and do not support connecting to the Internet, storing pre-loaded data, symbolic computation, programming new functions, or graphing functions.</td>
</tr>
<tr>
<td>Sweden</td>
<td>The national curriculum contains one statement explicitly referring to the use of technology in physics instruction, which dictates that students be given opportunities to use technology to collect, simulate, calculate, process, and present data.</td>
<td>No policy.</td>
</tr>
<tr>
<td>United States</td>
<td>Policies vary by state, but most include standards requiring students to use technology in laboratory courses and use computers or graphing calculators for simulations, modeling, and data analysis. Both AP and IB courses require students to have access to the Internet, electronic sensors for collecting, analyzing, and processing data, and software for laboratory experiments.</td>
<td>Policies vary by state, but some states require students to use calculators in physics examinations. Programs (such as AP and IB) have their own specifications about what kinds of calculators are permissible.</td>
</tr>
</tbody>
</table>

### Exhibit P9.10: Availability of Digital Devices in Physics Lessons

**Reported by Physics Teachers**

Digital devices may include computers, tablets, calculators, or smartphones.

<table>
<thead>
<tr>
<th>Country</th>
<th>Digital Devices Available for Students to Use in Physics Lessons</th>
<th>Percent of Students</th>
<th>Average Achievement</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>France</td>
<td>87 (2.3)</td>
<td>375 (4.2)</td>
<td>371 (9.4)</td>
</tr>
<tr>
<td>Italy</td>
<td>59 (3.8)</td>
<td>372 (8.8)</td>
<td>388 (10.0)</td>
</tr>
<tr>
<td>Lebanon</td>
<td>33 (3.3)</td>
<td>405 (7.0)</td>
<td>413 (6.0)</td>
</tr>
<tr>
<td>Norway</td>
<td>100 (0.0)</td>
<td>505 (4.6)</td>
<td>~ ~</td>
</tr>
<tr>
<td>Portugal</td>
<td>76 (4.5)</td>
<td>469 (5.4)</td>
<td>462 (8.0)</td>
</tr>
<tr>
<td>Russian Federation</td>
<td>90 (2.5)</td>
<td>509 (7.9)</td>
<td>499 (16.9)</td>
</tr>
<tr>
<td>Slovenia</td>
<td>80 (1.8)</td>
<td>529 (3.0)</td>
<td>539 (7.0)</td>
</tr>
<tr>
<td>Sweden</td>
<td>99 (0.9)</td>
<td>456 (6.2)</td>
<td>~ ~</td>
</tr>
<tr>
<td>United States</td>
<td>r 89 (3.8)</td>
<td>440 (11.1)</td>
<td>456 (18.1)</td>
</tr>
<tr>
<td>International Avg.</td>
<td>79 (1.0)</td>
<td>451 (2.3)</td>
<td>447 (4.4)</td>
</tr>
</tbody>
</table>

( ) Standard errors appear in parentheses. Because of rounding some results may appear inconsistent.

A tilde (~) indicates insufficient data to report achievement.

An “r” indicates data are available for at least 70% but less than 85% of the students.

**SOURCE:** IEA’s Trends in International Mathematics and Science Study – TIMSS Advanced 2015

*Reported by Physics Teachers*

For each country, the percent of students in each use category is plotted along a separate axis. The value of each point is represented as the distance from the center of the graph to illustrate the relative emphasis placed on each use of digital devices in physics lessons. Digital devices may include computers, tablets, calculators, or smartphones.

<table>
<thead>
<tr>
<th>Country</th>
<th>International Ave.</th>
<th>France</th>
<th>Italy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Norway</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Portugal</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Russia Federation</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Slovenia</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sweden</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>United States</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

An "r" indicates data are available for at least 70% but less than 85% of the students.

The axis labels correspond with these ways that teachers have their students use digital devices at least monthly:

- **Read**: Read the Textbook or Course Materials
- **Ideas**: Look Up Ideas and Information
- **Data**: Process and Analyze Data
- **Graphs**: Draw Graphs of Functions
- **Solve**: Solve Equations
- **Algebra**: Manipulate Algebraic Expressions
- **Models**: Conduct Modeling and Simulations
- **Integrate**: Perform Numerical Integration
- **Experiment**: Do Scientific Procedures or Experiments

**Reported by Physics Teachers**

<table>
<thead>
<tr>
<th>Country</th>
<th>Read the Textbook or Course Materials</th>
<th>Look Up Ideas and Information</th>
<th>Process and Analyze Data</th>
<th>Draw Graphs of Functions</th>
<th>Solve Equations</th>
<th>Manipulate Algebraic Expressions</th>
<th>Conduct Modeling and Simulations</th>
<th>Perform Numerical Integration</th>
<th>Do Scientific Procedures or Experiments</th>
</tr>
</thead>
<tbody>
<tr>
<td>France</td>
<td>40 (3.1)</td>
<td>67 (3.5)</td>
<td>86 (2.4)</td>
<td>82 (2.5)</td>
<td>61 (3.0)</td>
<td>74 (3.0)</td>
<td>82 (2.6)</td>
<td>8 (1.4)</td>
<td>82 (2.7)</td>
</tr>
<tr>
<td>Italy</td>
<td>36 (3.6)</td>
<td>49 (4.1)</td>
<td>48 (3.4)</td>
<td>46 (3.6)</td>
<td>33 (3.3)</td>
<td>30 (3.2)</td>
<td>35 (3.3)</td>
<td>20 (3.1)</td>
<td>34 (3.5)</td>
</tr>
<tr>
<td>Lebanon</td>
<td>20 (4.2)</td>
<td>25 (3.5)</td>
<td>24 (3.5)</td>
<td>24 (3.5)</td>
<td>30 (3.5)</td>
<td>27 (3.6)</td>
<td>23 (3.5)</td>
<td>27 (3.7)</td>
<td>25 (3.6)</td>
</tr>
<tr>
<td>Norway</td>
<td>49 (3.9)</td>
<td>78 (3.7)</td>
<td>95 (1.8)</td>
<td>92 (2.4)</td>
<td>82 (2.9)</td>
<td>70 (3.4)</td>
<td>78 (3.3)</td>
<td>51 (4.0)</td>
<td>71 (3.5)</td>
</tr>
<tr>
<td>Portugal</td>
<td>38 (4.8)</td>
<td>54 (5.5)</td>
<td>73 (4.9)</td>
<td>74 (4.6)</td>
<td>65 (4.2)</td>
<td>64 (4.1)</td>
<td>59 (5.2)</td>
<td>5 (1.8)</td>
<td>58 (5.3)</td>
</tr>
<tr>
<td>Russian Federation</td>
<td>73 (4.0)</td>
<td>85 (2.5)</td>
<td>78 (4.0)</td>
<td>62 (4.1)</td>
<td>56 (4.0)</td>
<td>59 (3.9)</td>
<td>53 (4.9)</td>
<td>23 (3.6)</td>
<td>67 (3.5)</td>
</tr>
<tr>
<td>Slovenia</td>
<td>39 (4.3)</td>
<td>66 (3.1)</td>
<td>58 (3.9)</td>
<td>59 (3.3)</td>
<td>49 (2.9)</td>
<td>34 (3.8)</td>
<td>58 (3.1)</td>
<td>17 (2.6)</td>
<td>62 (2.4)</td>
</tr>
<tr>
<td>Sweden</td>
<td>38 (4.1)</td>
<td>83 (3.5)</td>
<td>96 (1.2)</td>
<td>92 (3.0)</td>
<td>66 (4.3)</td>
<td>30 (3.8)</td>
<td>80 (3.0)</td>
<td>52 (4.6)</td>
<td>80 (2.8)</td>
</tr>
<tr>
<td>United States</td>
<td>r 44 (6.5)</td>
<td>r 82 (3.8)</td>
<td>r 85 (3.0)</td>
<td>r 76 (3.6)</td>
<td>r 77 (4.4)</td>
<td>r 63 (6.0)</td>
<td>r 74 (4.6)</td>
<td>r 50 (5.4)</td>
<td>r 78 (4.6)</td>
</tr>
<tr>
<td>International Avg.</td>
<td>42 (1.5)</td>
<td>66 (1.3)</td>
<td>71 (1.1)</td>
<td>67 (1.2)</td>
<td>58 (1.2)</td>
<td>50 (1.3)</td>
<td>60 (1.3)</td>
<td>28 (1.2)</td>
<td>62 (1.2)</td>
</tr>
</tbody>
</table>

( ) Standard errors appear in parentheses. Because of rounding some results may appear inconsistent.

An "r" indicates data are available for at least 70% but less than 85% of the students.
Exhibit P9.13: Profiles of Student Use of the Internet for Physics Schoolwork

Reported by Physics Students

For each country, the percentage of students in each use category is plotted along a separate axis. The value of each point is represented as the distance from the center of the graph to illustrate the relative emphasis placed on each use of the Internet in physics schoolwork.

The axis labels correspond with these ways that students use the Internet for physics schoolwork:

- **Text**: Access the Textbook or Other Course Materials
- **Assign.**: Access Assignments Posted Online by the Teacher
- **Class**: Collaborate with Classmates on Physics Assignments or Projects
- **Teacher**: Communicate with the Teacher
- **Discuss**: Discuss Physics Topics with Other Students
- **Concept**: Find Information, Articles, or Tutorials to Aid in Understanding Physics Concepts
- **Solve**: Find Information, Articles, or Tutorials to Aid in Solving Physics Problems
### Exhibit P9.14: Percentages of Students Who Use the Internet for Physics Schoolwork

*Reported by Physics Students*

<table>
<thead>
<tr>
<th>Country</th>
<th>Access the Textbook or Other Course Materials</th>
<th>Access Assignments Posted Online by the Teacher</th>
<th>Collaborate with Classmates on Physics Assignments or Projects</th>
<th>Communicate with the Teacher</th>
<th>Discuss Physics Topics with Other Students</th>
<th>Find Information, Articles, or Tutorials to Aid in Understanding Physics Concepts</th>
<th>Find Information, Articles, or Tutorials to Aid in Solving Physics Problems</th>
</tr>
</thead>
<tbody>
<tr>
<td>France</td>
<td>56 (1.1)</td>
<td>57 (1.5)</td>
<td>61 (1.1)</td>
<td>31 (2.0)</td>
<td>35 (1.0)</td>
<td>73 (1.0)</td>
<td>74 (0.9)</td>
</tr>
<tr>
<td>Italy</td>
<td>61 (1.2)</td>
<td>44 (2.2)</td>
<td>59 (1.5)</td>
<td>38 (1.8)</td>
<td>40 (1.2)</td>
<td>67 (1.1)</td>
<td>62 (1.2)</td>
</tr>
<tr>
<td>Lebanon</td>
<td>43 (1.6)</td>
<td>29 (1.8)</td>
<td>60 (1.8)</td>
<td>47 (2.0)</td>
<td>58 (2.1)</td>
<td>58 (1.5)</td>
<td>51 (1.5)</td>
</tr>
<tr>
<td>Norway</td>
<td>56 (2.2)</td>
<td>74 (1.7)</td>
<td>65 (1.5)</td>
<td>50 (1.7)</td>
<td>42 (1.6)</td>
<td>77 (1.1)</td>
<td>74 (1.4)</td>
</tr>
<tr>
<td>Portugal</td>
<td>44 (1.6)</td>
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<td>72 (2.3)</td>
<td>40 (2.7)</td>
<td>45 (1.9)</td>
<td>77 (1.5)</td>
<td>74 (1.4)</td>
</tr>
<tr>
<td>Russian Federation</td>
<td>79 (0.7)</td>
<td>49 (2.3)</td>
<td>76 (1.1)</td>
<td>22 (2.4)</td>
<td>58 (0.9)</td>
<td>92 (0.6)</td>
<td>87 (0.8)</td>
</tr>
<tr>
<td>Slovenia</td>
<td>63 (1.2)</td>
<td>61 (1.9)</td>
<td>66 (1.4)</td>
<td>41 (1.8)</td>
<td>51 (1.8)</td>
<td>77 (1.2)</td>
<td>75 (1.3)</td>
</tr>
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<td>Sweden</td>
<td>52 (1.8)</td>
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<td>57 (1.7)</td>
<td>42 (2.4)</td>
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<td>78 (1.2)</td>
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<tr>
<td>International Avg.</td>
<td>56 (0.5)</td>
<td>56 (0.7)</td>
<td>64 (0.6)</td>
<td>42 (0.7)</td>
<td>45 (0.5)</td>
<td>74 (0.4)</td>
<td>72 (0.4)</td>
</tr>
</tbody>
</table>

( ) Standard errors appear in parentheses. Because of rounding some results may appear inconsistent.
### Exhibit P9.15: Resources for Conducting Physics Experiments

**Reported by Physics Teachers**

<table>
<thead>
<tr>
<th>Country</th>
<th>Schools Have a Physics Laboratory</th>
<th>Teachers Have Assistance Available When Students Are Conducting Physics Experiments</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td></td>
<td>Percent of Students</td>
<td>Average Achievement</td>
</tr>
<tr>
<td>France</td>
<td>99 (0.5)</td>
<td>375 (3.9)</td>
</tr>
<tr>
<td>Portugal</td>
<td>95 (1.9)</td>
<td>464 (4.9)</td>
</tr>
<tr>
<td>Lebanon</td>
<td>94 (1.4)</td>
<td>412 (4.7)</td>
</tr>
<tr>
<td>Norway</td>
<td>92 (2.0)</td>
<td>506 (4.7)</td>
</tr>
<tr>
<td>Italy</td>
<td>90 (2.5)</td>
<td>388 (7.4)</td>
</tr>
<tr>
<td>Sweden</td>
<td>88 (2.3)</td>
<td>461 (6.3)</td>
</tr>
<tr>
<td>Russian Federation</td>
<td>87 (2.6)</td>
<td>509 (7.4)</td>
</tr>
<tr>
<td>Slovenia</td>
<td>62 (4.0)</td>
<td>538 (3.8)</td>
</tr>
<tr>
<td>United States</td>
<td>s</td>
<td>59 (6.0)</td>
</tr>
<tr>
<td>International Avg.</td>
<td>85 (1.0)</td>
<td>457 (2.1)</td>
</tr>
</tbody>
</table>

( ) Standard errors appear in parentheses. Because of rounding some results may appear inconsistent.
A tilde (~) indicates insufficient data to report achievement.
An “r” indicates data are available for at least 70% but less than 85% of the students. An “s” indicates data are available for at least 50% but less than 70% of the students.

Source: IEA’s Trends in International Mathematics and Science Study – TIMSS Advanced 2015
Most students (83%) strongly value or value physics. Most students (84%) were positive about their instruction—37% reported very engaging teaching and 47% engaging teaching. Students were less positive about actually learning physics. The 23% that liked learning it very much had more than 100 points higher achievement than the 26% that did not like learning it, again highlighting the strong relationship between excelling at something and liking it.

Exhibit P10.1: Students' Views on Engaging Teaching in Physics Lessons

Reported by Physics Students

Students were scored according to their degree of agreement with fourteen statements on the Students' Views on Engaging Teaching in Physics Lessons scale. Students who experienced Very Engaging Teaching in physics lessons had a score on the scale of at least 10.6, which corresponds to their “agreeing a lot” with seven of the fourteen statements and “agreeing a little” with the other seven, on average. Students who experienced teaching that was Less than Engaging had a score no higher than 8.2, which corresponds to their “disagreeing a little” with seven of the fourteen statements and “agreeing a little” with the other seven, on average. All other students experienced Engaging Teaching in physics lessons.

<table>
<thead>
<tr>
<th>Country</th>
<th>Very Engaging Teaching</th>
<th>Engaging Teaching</th>
<th>Less than Engaging Teaching</th>
<th>Average Scale Score</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Percent of Students</td>
<td>Average Achievement</td>
<td>Percent of Students</td>
<td>Average Achievement</td>
</tr>
<tr>
<td>Lebanon</td>
<td>56 (2.9)</td>
<td>419 (5.2)</td>
<td>33 (1.7)</td>
<td>409 (6.9)</td>
</tr>
<tr>
<td>Russian Federation</td>
<td>55 (1.8)</td>
<td>526 (8.1)</td>
<td>37 (1.1)</td>
<td>493 (7.4)</td>
</tr>
<tr>
<td>United States</td>
<td>45 (2.6)</td>
<td>452 (10.1)</td>
<td>38 (1.5)</td>
<td>442 (9.9)</td>
</tr>
<tr>
<td>Portugal</td>
<td>44 (3.2)</td>
<td>466 (6.4)</td>
<td>41 (2.0)</td>
<td>470 (5.4)</td>
</tr>
<tr>
<td>Norway</td>
<td>43 (1.9)</td>
<td>529 (4.5)</td>
<td>46 (1.7)</td>
<td>500 (5.8)</td>
</tr>
<tr>
<td>Sweden</td>
<td>26 (1.4)</td>
<td>491 (8.1)</td>
<td>54 (1.1)</td>
<td>456 (6.1)</td>
</tr>
<tr>
<td>France</td>
<td>23 (1.5)</td>
<td>402 (7.1)</td>
<td>59 (1.4)</td>
<td>373 (3.9)</td>
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<tr>
<td>Slovenia</td>
<td>23 (1.7)</td>
<td>570 (7.1)</td>
<td>61 (2.1)</td>
<td>534 (4.2)</td>
</tr>
<tr>
<td>Italy</td>
<td>20 (1.4)</td>
<td>387 (14.0)</td>
<td>50 (1.4)</td>
<td>381 (7.0)</td>
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<tr>
<td>International Avg.</td>
<td>37 (0.7)</td>
<td>471 (2.8)</td>
<td>47 (0.5)</td>
<td>451 (2.2)</td>
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</tbody>
</table>

This TIMSS Advanced questionnaire scale was established in 2015 based on the combined response distribution of all countries that participated in TIMSS Advanced 2015. To provide a point of reference for country comparisons, the scale centerpoint of 10 was located at the mean of the combined distribution. The units of the scale were chosen so that 2 scale score points corresponded to the standard deviation of the distribution.

(*) Standard errors appear in parentheses. Because of rounding some results may appear inconsistent.
### Exhibit P10.1: Students' Views on Engaging Teaching in Physics Lessons by Gender

Reported by Physics Students

<table>
<thead>
<tr>
<th>Country</th>
<th>Very Engaging Teaching</th>
<th>Engaging Teaching</th>
<th>Less than Engaging Teaching</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Percent of Students</td>
<td>Average Achievement</td>
<td>Percent of Students</td>
</tr>
<tr>
<td>Lebanon</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Females</td>
<td>64 (3.7)</td>
<td>421 (5.7)</td>
<td>28 (2.5)</td>
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<tr>
<td>Males</td>
<td>52 (3.5)</td>
<td>417 (7.1)</td>
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<tr>
<td>Russian Federation</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Females</td>
<td>54 (2.2)</td>
<td>519 (9.4)</td>
<td>37 (1.6)</td>
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<tr>
<td>Males</td>
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<td>531 (8.0)</td>
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<tr>
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<td></td>
<td></td>
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<tr>
<td>Females</td>
<td>40 (3.3)</td>
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<td>41 (1.9)</td>
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<tr>
<td>Males</td>
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<td>467 (10.4)</td>
<td>36 (1.9)</td>
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<tr>
<td>Portugal</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Females</td>
<td>51 (4.4)</td>
<td>449 (7.6)</td>
<td>35 (3.5)</td>
</tr>
<tr>
<td>Males</td>
<td>42 (3.2)</td>
<td>473 (6.8)</td>
<td>43 (2.1)</td>
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<td>Norway</td>
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<td></td>
</tr>
<tr>
<td>Females</td>
<td>35 (2.8)</td>
<td>509 (7.3)</td>
<td>51 (2.5)</td>
</tr>
<tr>
<td>Males</td>
<td>47 (2.1)</td>
<td>536 (4.8)</td>
<td>44 (1.9)</td>
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<tr>
<td>Sweden</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Females</td>
<td>23 (1.6)</td>
<td>483 (10.7)</td>
<td>52 (1.8)</td>
</tr>
<tr>
<td>Males</td>
<td>28 (1.7)</td>
<td>496 (8.9)</td>
<td>55 (1.4)</td>
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<tr>
<td>France</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Females</td>
<td>21 (1.5)</td>
<td>382 (8.2)</td>
<td>60 (1.6)</td>
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<tr>
<td>Males</td>
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<td>58 (1.7)</td>
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<tr>
<td>Slovenia</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Females</td>
<td>19 (2.2)</td>
<td>564 (11.8)</td>
<td>62 (3.1)</td>
</tr>
<tr>
<td>Males</td>
<td>24 (2.3)</td>
<td>572 (9.4)</td>
<td>61 (2.4)</td>
</tr>
<tr>
<td>Italy</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Females</td>
<td>19 (1.7)</td>
<td>360 (16.1)</td>
<td>50 (1.7)</td>
</tr>
<tr>
<td>Males</td>
<td>21 (1.6)</td>
<td>407 (15.9)</td>
<td>49 (1.7)</td>
</tr>
<tr>
<td>International Avg.</td>
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<td></td>
</tr>
<tr>
<td>Females</td>
<td>36 (0.9)</td>
<td>457 (3.5)</td>
<td>46 (0.8)</td>
</tr>
<tr>
<td>Males</td>
<td>38 (0.8)</td>
<td>400 (3.1)</td>
<td>47 (0.6)</td>
</tr>
</tbody>
</table>

This TIMSS Advanced questionnaire scale was established in 2015 based on the combined response distribution of all countries that participated in TIMSS Advanced 2015. To provide a point of reference for country comparisons, the scale centerpoint of 10 was located at the mean of the combined distribution. The units of the scale were chosen so that 2 scale score points corresponded to the standard deviation of the distribution.

( ) Standard errors appear in parentheses. Because of rounding some results may appear inconsistent.
### Exhibit P10.2: Students Like Learning Physics

Reported by Physics Students

Students were scored according to their degree of agreement with twelve statements on the Students Like Learning Physics scale. Students who **Very Much Like Learning Physics** had a score on the scale of at least 11.4, which corresponds to their “agreeing a lot” with six of the twelve statements and “agreeing a little” with the other six, on average. Students who **Do Not Like Learning Physics** had a score no higher than 8.8, which corresponds to their “disagreeing a little” with six of the twelve statements and “agreeing a little” with the other six, on average. All other students **Like Learning Physics**.

<table>
<thead>
<tr>
<th>Country</th>
<th>Very Much Like Learning Physics</th>
<th>Like Learning Physics</th>
<th>Do Not Like Learning Physics</th>
<th>Average Scale Score</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Percent of Students</td>
<td>Average Achievement</td>
<td>Percent of Students</td>
<td>Average Achievement</td>
</tr>
<tr>
<td>Norway</td>
<td>36 (1.2)</td>
<td>560 (3.7)</td>
<td>49 (1.1)</td>
<td>494 (5.4)</td>
</tr>
<tr>
<td>Lebanon</td>
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<td>Portugal</td>
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<td>51 (1.3)</td>
<td>455 (5.6)</td>
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<td>568 (9.2)</td>
<td>50 (1.2)</td>
<td>501 (6.2)</td>
</tr>
<tr>
<td>United States</td>
<td>21 (1.6)</td>
<td>513 (6.7)</td>
<td>51 (1.3)</td>
<td>442 (8.0)</td>
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<tr>
<td>Sweden</td>
<td>15 (0.6)</td>
<td>540 (6.8)</td>
<td>51 (1.4)</td>
<td>472 (6.1)</td>
</tr>
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<td>Italy</td>
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<td>467 (10.0)</td>
<td>45 (0.9)</td>
<td>384 (7.4)</td>
</tr>
<tr>
<td>Slovenia</td>
<td>15 (1.0)</td>
<td>599 (8.5)</td>
<td>63 (1.7)</td>
<td>538 (3.3)</td>
</tr>
<tr>
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<td>54 (0.8)</td>
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<tr>
<td>International Avg.</td>
<td>23 (0.5)</td>
<td>517 (2.6)</td>
<td>51 (0.4)</td>
<td>452 (2.0)</td>
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</table>

This TIMSS Advanced questionnaire scale was established in 2015 based on the combined response distribution of all countries that participated in TIMSS Advanced 2015. To provide a point of reference for country comparisons, the scale centerpoint of 10 was located at the mean of the combined distribution. The units of the scale were chosen so that 2 scale score points corresponded to the standard deviation of the distribution.

Standard errors appear in parentheses. Because of rounding some results may appear inconsistent.

**How much do you agree with these statements about the physics you are studying?**

1. I enjoy conducting experiments or investigations in physics
2. I get a sense of satisfaction when I solve physics problems
3. I feel bored when I do my physics schoolwork
4. I like studying for my physics class outside of school
5. It is interesting to learn physics laws and principles
6. I dread my physics class
7. I am studying physics because I like to learn new things
8. I enjoy figuring out challenging physics
9. Physics is one of my favorite subjects
10. Jobs that require physics skills seem interesting to me
11. I wish I did not have to study physics
12. I enjoy thinking about the world in terms of laws of physics

* Reverse coded

**Very Much Like Learning Physics:** 11.4  
**Like Learning Physics:** 8.8  
**Do Not Like Learning Physics:**
## Exhibit P10.2: Students Like Learning Physics (Continued)

### Students Like Learning Physics by Gender

*Reported by Physics Students*

<table>
<thead>
<tr>
<th>Country</th>
<th>Very Much Like Learning Physics</th>
<th>Like Learning Physics</th>
<th>Do Not Like Learning Physics</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Percent of Students</td>
<td>Average Achievement</td>
<td>Percent of Students</td>
</tr>
<tr>
<td>Norway</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Females</td>
<td>27 (1.7)</td>
<td>541 (6.3)</td>
<td>52 (1.8)</td>
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<tr>
<td>Males</td>
<td>40 (1.5)</td>
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<td></td>
</tr>
<tr>
<td>Females</td>
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<td>Males</td>
<td>35 (2.8)</td>
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<tr>
<td>Females</td>
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<tr>
<td>Males</td>
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<tr>
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<td>48 (1.5)</td>
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<tr>
<td>Males</td>
<td>34 (2.0)</td>
<td>568 (8.2)</td>
<td>51 (1.6)</td>
</tr>
<tr>
<td>United States</td>
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</tr>
<tr>
<td>Females</td>
<td>13 (1.9)</td>
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<td>42 (2.1)</td>
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<td>Males</td>
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<td>521 (10.1)</td>
<td>51 (1.7)</td>
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<tr>
<td>Sweden</td>
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</tr>
<tr>
<td>Females</td>
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<td>536 (13.2)</td>
<td>41 (2.1)</td>
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<td>19 (0.8)</td>
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<td>Italy</td>
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<tr>
<td>Females</td>
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<td>430 (13.2)</td>
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<td>Males</td>
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<td>486 (11.1)</td>
<td>48 (1.4)</td>
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<tr>
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<td></td>
</tr>
<tr>
<td>Females</td>
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<td>595 (15.3)</td>
<td>53 (2.8)</td>
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<tr>
<td>Males</td>
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<td>601 (9.2)</td>
<td>67 (2.1)</td>
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<tr>
<td>France</td>
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<tr>
<td>Females</td>
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<td>52 (1.2)</td>
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<td>57 (1.1)</td>
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<tr>
<td>International Avg.</td>
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</tr>
<tr>
<td>Females</td>
<td>18 (0.7)</td>
<td>503 (4.1)</td>
<td>48 (0.7)</td>
</tr>
<tr>
<td>Males</td>
<td>26 (0.6)</td>
<td>522 (2.8)</td>
<td>53 (0.5)</td>
</tr>
</tbody>
</table>

This TIMSS Advanced questionnaire scale was established in 2015 based on the combined response distribution of all countries that participated in TIMSS Advanced 2015. To provide a point of reference for country comparisons, the scale centerpoint of 10 was located at the mean of the combined distribution. The units of the scale were chosen so that 2 scale score points corresponded to the standard deviation of the distribution.

( ) Standard errors appear in parentheses. Because of rounding some results may appear inconsistent.
Students were scored according to their degree of agreement with nine statements on the Students Value Physics scale. Students who **Strongly Value Physics** had a score on the scale of at least 11.3, which corresponds to their "agreeing a lot" with five of the nine statements and "agreeing a little" with the other four, on average. Students who **Do Not Value Physics** had a score no higher than 8.2, which corresponds to their "disagreeing a little" with five of the nine statements and "agreeing a little" with the other four, on average. All other students **Value Physics**.

### Exhibit P10.3: Students Value Physics

<table>
<thead>
<tr>
<th>Country</th>
<th>Strongly Value Physics</th>
<th>Value Physics</th>
<th>Do Not Value Physics</th>
<th>Average Scale Score</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Percent of Students</td>
<td>Average</td>
<td>Percent of Students</td>
<td>Average</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Achievement</td>
<td></td>
<td>Achievement</td>
</tr>
<tr>
<td>Portugal</td>
<td>44 (1.6)</td>
<td>489 (4.9)</td>
<td>50 (1.6)</td>
<td>456 (5.5)</td>
</tr>
<tr>
<td>Lebanon</td>
<td>43 (2.6)</td>
<td>431 (6.5)</td>
<td>50 (1.9)</td>
<td>399 (5.3)</td>
</tr>
<tr>
<td>United States</td>
<td>35 (2.1)</td>
<td>483 (8.7)</td>
<td>55 (1.9)</td>
<td>422 (11.0)</td>
</tr>
<tr>
<td>Russian Federation</td>
<td>28 (1.4)</td>
<td>549 (6.6)</td>
<td>48 (1.1)</td>
<td>514 (7.2)</td>
</tr>
<tr>
<td>Norway</td>
<td>27 (1.2)</td>
<td>538 (6.4)</td>
<td>62 (1.1)</td>
<td>507 (4.5)</td>
</tr>
<tr>
<td>Sweden</td>
<td>21 (0.8)</td>
<td>492 (7.0)</td>
<td>66 (0.8)</td>
<td>456 (5.9)</td>
</tr>
<tr>
<td>Italy</td>
<td>12 (0.8)</td>
<td>435 (10.2)</td>
<td>56 (1.0)</td>
<td>386 (7.0)</td>
</tr>
<tr>
<td>France</td>
<td>10 (0.5)</td>
<td>431 (6.2)</td>
<td>65 (0.9)</td>
<td>382 (3.9)</td>
</tr>
<tr>
<td>Slovenia</td>
<td>4 (0.6)</td>
<td>563 (16.3)</td>
<td>75 (1.3)</td>
<td>538 (2.8)</td>
</tr>
<tr>
<td><strong>International Avg.</strong></td>
<td>25 (0.5)</td>
<td>490 (2.9)</td>
<td>58 (0.4)</td>
<td>451 (2.1)</td>
</tr>
</tbody>
</table>

This TIMSS Advanced questionnaire scale was established in 2015 based on the combined response distribution of all countries that participated in TIMSS Advanced 2015. To provide a point of reference for country comparisons, the scale centerpoint of 10 was located at the mean of the combined distribution. The units of the scale were chosen so that 2 scale score points corresponded to the standard deviation of the distribution.

* Standard errors appear in parentheses. Because of rounding some results may appear inconsistent.

---

**How much do you agree with these statements about the physics you are studying?**

1. Learning physics will help me get ahead in the world
2. It is important to do well in my physics class
3. The physics I am studying is not useful for my future*
4. My parents are pleased that I am taking physics
5. Doing well in physics will help me get into the university of my choice
6. Learning physics does not seem to be a worthwhile exercise*
7. My parents think that it is important that I do well in my physics class
8. I like telling people I am studying physics
9. Learning physics will give me more job opportunities

*Reverse coded

---

**SOURCE:** IEA’s Trends in International Mathematics and Science Study – TIMSS Advanced 2015
### Exhibit P10.3: Students Value Physics (Continued)

#### Students Value Physics by Gender

*Reported by Physics Students*

<table>
<thead>
<tr>
<th>Country</th>
<th>Strongly Value Physics</th>
<th>Value Physics</th>
<th>Do Not Value Physics</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Percent of Students</td>
<td>Average Achievement</td>
<td>Percent of Students</td>
</tr>
<tr>
<td><strong>Portugal</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Females</td>
<td>37 (3.6)</td>
<td>485 (8.9)</td>
<td>54 (4.2)</td>
</tr>
<tr>
<td>Males</td>
<td>46 (2.0)</td>
<td>490 (6.1)</td>
<td>49 (1.7)</td>
</tr>
<tr>
<td><strong>Lebanon</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Females</td>
<td>45 (3.1)</td>
<td>431 (8.4)</td>
<td>49 (2.8)</td>
</tr>
<tr>
<td>Males</td>
<td>42 (3.1)</td>
<td>431 (7.9)</td>
<td>50 (2.5)</td>
</tr>
<tr>
<td><strong>United States</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Females</td>
<td>27 (2.5)</td>
<td>450 (11.4)</td>
<td>61 (2.5)</td>
</tr>
<tr>
<td>Males</td>
<td>40 (2.3)</td>
<td>497 (8.6)</td>
<td>51 (2.2)</td>
</tr>
<tr>
<td><strong>Russian Federation</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Females</td>
<td>20 (1.4)</td>
<td>548 (8.9)</td>
<td>46 (1.5)</td>
</tr>
<tr>
<td>Males</td>
<td>34 (1.7)</td>
<td>549 (7.0)</td>
<td>50 (1.3)</td>
</tr>
<tr>
<td><strong>Norway</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Females</td>
<td>21 (1.6)</td>
<td>522 (9.4)</td>
<td>66 (1.8)</td>
</tr>
<tr>
<td>Males</td>
<td>29 (1.5)</td>
<td>543 (7.0)</td>
<td>60 (1.3)</td>
</tr>
<tr>
<td><strong>Sweden</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Females</td>
<td>21 (1.6)</td>
<td>477 (9.2)</td>
<td>64 (1.4)</td>
</tr>
<tr>
<td>Males</td>
<td>21 (1.0)</td>
<td>502 (7.8)</td>
<td>67 (1.2)</td>
</tr>
<tr>
<td><strong>Italy</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Females</td>
<td>11 (0.8)</td>
<td>397 (14.8)</td>
<td>56 (1.4)</td>
</tr>
<tr>
<td>Males</td>
<td>13 (1.2)</td>
<td>460 (12.5)</td>
<td>57 (1.1)</td>
</tr>
<tr>
<td><strong>France</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Females</td>
<td>8 (0.6)</td>
<td>395 (8.2)</td>
<td>64 (1.3)</td>
</tr>
<tr>
<td>Males</td>
<td>12 (0.8)</td>
<td>452 (7.0)</td>
<td>66 (1.2)</td>
</tr>
<tr>
<td><strong>Slovenia</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Females</td>
<td>3 (0.9)</td>
<td>545 (44.4)</td>
<td>71 (2.6)</td>
</tr>
<tr>
<td>Males</td>
<td>5 (0.8)</td>
<td>568 (16.1)</td>
<td>76 (1.5)</td>
</tr>
<tr>
<td><strong>International Avg.</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Females</td>
<td>21 (0.7)</td>
<td>472 (5.9)</td>
<td>59 (0.8)</td>
</tr>
<tr>
<td>Males</td>
<td>27 (0.6)</td>
<td>499 (3.1)</td>
<td>58 (0.5)</td>
</tr>
</tbody>
</table>

This TIMSS Advanced questionnaire scale was established in 2015 based on the combined response distribution of all countries that participated in TIMSS Advanced 2015. To provide a point of reference for country comparisons, the scale centerpoint of 10 was located at the mean of the combined distribution. The units of the scale were chosen so that 2 scale score points corresponded to the standard deviation of the distribution.

() Standard errors appear in parentheses. Because of rounding some results may appear inconsistent.
CHAPTER P11: DESCRIPTION OF PHYSICS PROGRAMS AND CURRICULUM

TIMSS ADVANCED 2015 INTERNATIONAL RESULTS IN ADVANCED MATHEMATICS AND PHYSICS
Description of the Physics Programs and Curriculum

France

In 2010–2011 and 2012, a new curriculum was gradually implemented for upper-secondary school (Grades 10, 11, and 12) with more emphasis on skills. The Grade 11 and Grade 12 scientific curricula allow students to aim at careers in science, technology, engineering, and mathematics (STEM). The physics and chemistry curriculum is meant to develop students’ scientific and critical thinking and strengthen their interest in and affinity for scientific reasoning and research. Together with introducing new science knowledge and content, the curriculum targets developing the following skills:

- Appropriating a subject (e.g., students are trained to extract relevant information)
- Analyzing (e.g., students are trained to organize knowledge and information or modeling)
- Realizing (e.g., students are trained to experiment or to execute calculation techniques)
- Validating (e.g., students are trained to validate results of experience)
- Communicating (e.g., students are trained to use appropriate scientific vocabulary)

With a variety of information supports (scientific texts, data structure tables/charts, experimental videos, etc.) students have to solve problems using scientific reasoning. They are expected to identify the appropriate physical quantity to measure and to identify trends in data using various digital tools for data processing and graphing.

The curricula for 11th and 12th grades are both structured around three aspects of the scientific process: to observe, to understand, and to act, with a focus on modern inputs. The Grade 12 physics topics in each content area are listed below.

<table>
<thead>
<tr>
<th>Scientific Processes</th>
<th>Content Areas</th>
<th>Topics</th>
</tr>
</thead>
<tbody>
<tr>
<td>To Observe: Waves and Matter</td>
<td>Waves and particles; Properties and characteristics of a wave; and Spectral analysis</td>
<td>Electromagnetic radiation in the universe, including the electromagnetic spectrum, emission and detection of various types of waves and particles (radio, infrared, visible light, UV), interference, diffraction and Doppler Effect</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Mechanical waves, including the emission and detection of various types of mechanical waves (acoustic waves, seismic waves, swell), magnitude of an earthquake, sound intensity level, the relationship among speed, frequency, and wavelength, and interference, diffraction and Doppler Effect</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Spectral analysis, including visible and UV spectroscopy, infrared spectroscopy, nuclear magnetic resonance spectroscopy</td>
</tr>
</tbody>
</table>

Experimental videos, etc.) students have to solve problems using scientific reasoning. They are expected to identify the appropriate physical quantity to measure and to identify trends in data using various digital tools for data processing and graphing.
Scientific Processes | Content Areas | Topics
--- | --- | ---
To Understand: Laws and Models | Time, motion and evolution; Structure of matter and matter transformation processes; and Energy, matter, and radiation | Motion (displacement, velocity and acceleration), Newton's Laws of Motion, the principle of the conservation of linear momentum, circular motion principles for satellites, Kepler’s three laws, work, potential energy, mechanical energy in the absence and in the presence of friction, time, special relativity (Einstein’s postulate that the speed of light is constant in a vacuum and is the same for all observers, proper times, time dilation) Internal energy, specific heat capacity, modes of heat transfer (conduction, convection, radiation), quantum emission and absorption, stimulated emission and optical amplification (LASER quantum principle), electron vibrations, molecular vibrations, wave and particle duality, De Broglie's formula, probabilistic effect

To Act: 21st Century Challenges | Sustainable development, respect for the environment; and the storage and transmission of information | Energy, matter and radiation, including energy chains (the economy of energy) Systems for information transmission, digital images, analog-to-digital converters, physical processes of data transmission (cable, optical fiber, radio transmission), digital storage on optical disc

Some topics from Grade 11 are also included in TIMSS Advanced 2015 Frameworks:

- Wien's law
- Particle model and quantum theory of light, energy levels
- Radioactivity, fusion and fission reactions, law of conservation of matter and energy
- Ohm's law, Joule-Lenz's law
- Difference between electric power and electric energy
## Italy

Students assessed in TIMSS Advanced 2015 followed the National Guidelines of 2010 for the upper secondary schools (Licei, Istituti Tecnici, Istituti Professionali). The five-year curriculum is divided into three parts by grade. The topics taught at each grade are listed below.

<table>
<thead>
<tr>
<th>Grade</th>
<th>Topics</th>
</tr>
</thead>
</table>
| Grades 9 and 10 | - Scalar quantity and vector quantity, unit of measurement  
                  - Geometrical optics: reflection and refraction, optical instruments  
                  - Thermic phenomena (macroscopic viewpoint): temperature, definition of heat, calorimetry, thermal equilibrium, changes in states of matter  
                  - Forces and equilibrium: machines and mechanical advantage  
                  - Equilibrium of fluids: density and pressure, Pascal’s principle, Archimedes’ principle and buoyant force  
                  - Kinematics: one-dimensional motion, displacement, velocity, acceleration  
                  - Forces and Newton’s laws of motion  
                  - Work and energy: potential energy, kinetic energy, conservation of energy, power |
| Grades 11 and 12| - Two-dimensional motion  
                  - Forces and Newton’s laws of motion (study in depth): inertial and not inertial reference frame, Galilean principle of relativity; Conservation of energy (study in depth)  
                  - Fluid Dynamics: volume flow rate and equation of continuity, Bernoulli’s equation  
                  - Linear momentum, conservation of momentum, and elastic collisions  
                  - Center of mass, torque, angular velocity and angular momentum, conservation of angular momentum  
                  - Gravitation: from Kepler to Newton  
                  - Ideal gas, ideal gas law  
                  - Molecular theory of gases  
                  - Laws of thermodynamics, entropy  
                  - Oscillatory motion: harmonic motion  
                  - Mechanical waves: amplitude, period, frequency and wavelength of periodic waves  
                  - Wave propagation: absorption, reflection, interference, refraction, diffraction, polarization, dispersion  
                  - Acoustic waves  
                  - Light waves  
                  - Coulomb’s Law, Electric field  
                  - Electric potential energy, electric potential and voltage  
                  - Capacitors and capacitance, dielectrics in capacitors, energy of a capacitor |
<table>
<thead>
<tr>
<th>Grade</th>
<th>Topics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grades 11 and 12</td>
<td>Circuits and Ohm's law, resistors in series and in parallel, resistivity and conductivity, voltmeters and ammeters, electrolytic conductivity, R-C circuits</td>
</tr>
<tr>
<td></td>
<td>Magnets and magnetic force: magnetic force on a charge, magnetic force on a current carrying wire</td>
</tr>
<tr>
<td></td>
<td>Magnetic field created by a current carrying wire, magnetic force between two currents going in the same and in opposite direction</td>
</tr>
<tr>
<td></td>
<td>Electric motors</td>
</tr>
<tr>
<td>Grade 13</td>
<td>Electromagnetic induction</td>
</tr>
<tr>
<td></td>
<td>Applications of induction</td>
</tr>
<tr>
<td></td>
<td>R-L circuits</td>
</tr>
<tr>
<td></td>
<td>Maxwell’s Equations</td>
</tr>
<tr>
<td></td>
<td>Electromagnetic radiation and electromagnetic spectrum</td>
</tr>
<tr>
<td></td>
<td>Relativity, mass-energy equivalence</td>
</tr>
<tr>
<td></td>
<td>The photoelectric effect and the nature of light</td>
</tr>
<tr>
<td></td>
<td>Planck’s theory of blackbody radiation</td>
</tr>
<tr>
<td></td>
<td>Atomic spectra and quantum theory</td>
</tr>
<tr>
<td></td>
<td>Structure of the nucleus, radioactivity</td>
</tr>
<tr>
<td></td>
<td>Recommended insights: astrophysics and cosmology</td>
</tr>
<tr>
<td></td>
<td>Elementary particles</td>
</tr>
<tr>
<td></td>
<td>Nano- and micro-technologies, new materials</td>
</tr>
<tr>
<td></td>
<td>Solid state physics: semiconductors</td>
</tr>
<tr>
<td></td>
<td>Renewable energy</td>
</tr>
</tbody>
</table>
Lebanon

The rapid expansion of science and technology in the present century necessitates the renovation of its teaching from both the conceptual and methodological points of view. From this perspective, the new international and global tendencies towards science teaching were the main inspirations for preparing the science curriculum. The science curriculum presents the main concepts in a global approach based on the understanding of scientific principles in relation to everyday life in the domains of health, environment, technology, and ethics. The adopted pedagogical innovation focuses on mastery of the scientific method, communication techniques, and the transfer of knowledge. The curriculum defines conceptual objectives, both technical and methodological, that permit the establishment of a relationship between teaching and evaluation. Several teaching approaches are favored in the proposed curriculum, in particular putting learners in research situations to support students' construction of personal knowledge.

Science plays an important role in our everyday life. It manifests itself in all aspects of human activity. Consequently, it is important that students become life-long learners of science, starting with science at school, and continuing to learn science beyond their school years. To achieve the above, science teaching aims to realize the general objectives listed in the table below.

<table>
<thead>
<tr>
<th>General Objectives</th>
</tr>
</thead>
<tbody>
<tr>
<td>Develop learners’ intellectual and practical scientific skills</td>
</tr>
<tr>
<td>Deepen learners’ awareness of the ability of humans to understand, invent, and create</td>
</tr>
<tr>
<td>Understand the nature of science and technology, their development across history, and their impact on human thought</td>
</tr>
<tr>
<td>Insure that learners have acquired the facts, concepts, and principles necessary to understand natural phenomena</td>
</tr>
<tr>
<td>Motivate students to apply basic scientific principles in all sciences</td>
</tr>
<tr>
<td>Explain the scientific concepts and principles behind commonly used machines and devices</td>
</tr>
<tr>
<td>Acquire knowledge about health, environment, and safety practices and behave accordingly</td>
</tr>
<tr>
<td>Realize that some natural resources can be depleted and make the learner aware of the role of science in sustaining these resources</td>
</tr>
<tr>
<td>Encourage learners to use scientific knowledge and skills in novel situations, especially in everyday life</td>
</tr>
<tr>
<td>Emphasize the role of scientists in the advancement of human kind</td>
</tr>
<tr>
<td>Encourage learners to be open to the ideas of scientists from different cultures and to their contribution to the advancement of science</td>
</tr>
<tr>
<td>Encourage learners to abide by scientific values such as honesty and objectivity</td>
</tr>
<tr>
<td>Develop learners’ scientific curiosity and orientation toward scientific research</td>
</tr>
<tr>
<td>Encourage learners to work independently and cooperatively when solving scientific problems</td>
</tr>
<tr>
<td>Make learners aware of career possibilities in different science-related areas</td>
</tr>
</tbody>
</table>

Norway

TIMSS 2003 and PISA 2003 showed a decrease in Norwegian students’ performance in mathematics and science in compulsory school compared with TIMSS 1995 and PISA 2000. This resulted in a broad discussion about how to improve the learning outcomes in Norway. A big effort was made to change the curriculum for all subjects in all 13 grades. There was an agreement nationally that something had to be done, and the new curriculum received support across all political parties in the parliament. It was called the Knowledge Promotion Reform, and was implemented in the autumn of 2006. The last cohort using the previous curriculum was in Grade 13 in the 2007–2008 school year, which means that these students were assessed in TIMSS Advanced 2008. Students assessed in TIMSS Advanced 2015 have been taught according to the 2006 curriculum.

In the present curriculum, two features stand out. First, the learning goals are formulated as competencies. Second, there are five basic skills (literacies) which are supposed to be used and developed in all subjects and at all levels: the ability to express oneself orally, the ability to read, the ability to express oneself in writing, the ability to use digital tools, and numeracy. Digital devices are supposed to be widely used in teaching, learning, and testing.

The following table indicates topics taught in the courses Physics 1 and Physics 2, normally taken in Grades 12 and 13, respectively.

<table>
<thead>
<tr>
<th>Content Area</th>
<th>Topics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Classical Physics (Physics 1 and 2)</td>
<td>Force vectors and Newton’s Three Laws of Motion; the concepts of energy, work and effect, conservation of mechanical energy; friction, air resistance, calculations in situations with constant friction; qualitative understanding of the first and second laws of thermodynamics; current, voltage and resistance, conservation of charge, simple and branched direct current circuits; frequency, period, wavelength and wave speed, bending and interference; electric fields, Coulomb’s law; Newton’s law of gravitation; magnetic fields around permanent magnets and electric currents, magnetic flux, magnetic flux density around a straight conductor, force on a conductor in a magnetic field, Faraday’s induction law; application of Newton’s laws in vector form for motion in homogeneous magnetic fields and in a homogeneous gravitational fields; acceleration and forces in circular motion, and on objects at the top and bottom of a vertical circular path; conservation of momentum for one-dimensional collisions</td>
</tr>
<tr>
<td>Modern Physics (Physics 1 and 2)</td>
<td>Bohr’s atom model, frequencies and wavelengths of spectral lines in emission and absorption spectra; fission and fusion processes; Stefan-Boltzmann’s law and Wien’s displacement law; HR diagrams; the life-cycle of a star, how elements are produced in stars; the standard model for the evolution of the universe; the basis for the special theory of relativity, qualitative discussion of some consequences of this theory for time, momentum and energy, qualitative description of the general theory of relativity; Einstein’s explanation of photoelectric effect, qualitative discussion of experiments with the photoelectric effect, Compton scattering and the wave nature of particles; conservation laws that apply in processes with elementary particles, the interaction between elementary particles; Heisenberg’s uncertainty relations, “entangled photons”</td>
</tr>
<tr>
<td>Content Area</td>
<td>Topics</td>
</tr>
<tr>
<td>-----------------------------------</td>
<td>----------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Explaining Nature Through Mathematics (Physics 1 and 2)</td>
<td>Parameter presentation of rectilinear movement of a particle; creation of mathematical models for relations between physical quantities found experimentally; the use of mathematical models as sources for qualitative and quantitative information; the use of differential and integral calculus to find position, velocity and acceleration; the use of calculus to find work and change in potential energy in central fields and for a spring that stretches</td>
</tr>
<tr>
<td>The Young Researcher (Physics 1 and 2)</td>
<td>Key features of scientific method in physics; examples of explanation models that are inconsistent with physics and scientific methodology; how a researcher’s approach, expectations and experiences can affect research; planning and implementation of experiments; collecting and processing data, presentation and evaluation of results; simulation programs; examples of scientific experiments, uncertainty in data and results, assessing the limitations of methods</td>
</tr>
<tr>
<td>Physics and Technology (Physics 1 and 2)</td>
<td>The difference between conductors, semi-conductors and insulators based on the atom model, doping of semi-conductors; the construction and use of a diode and a transistor; light detectors in digital photography; how modern sensors are characterized, and how the sensors’ characteristics set limits for measurements; technological applications of induction; physical principles behind medical examinations such as X-rays, ultrasonography and magnetic resonance imaging; sampling and digital processing of sound</td>
</tr>
</tbody>
</table>

The previous curriculum for physics involved a more quantitative approach to the subject than the present one in certain subject areas. For instance, thermodynamics (including the ideal gas law) is only discussed qualitatively in the present curriculum. In the previous curriculum, students were required to perform simple calculations concerning heating and cooling of physical objects and similar processes. In the present curriculum, there is instead a greater emphasis on a qualitative knowledge of a broader range of physical topics, including the theory of relativity, quantum theory, and technological applications of physics. Also, discussions on a meta-level (such as can be found under the heading “the young researcher”) are more emphasized in the present curriculum. There have only been minor adjustments made to the curriculum after 2006.

Not all students have to take a national written exam in physics. For Physics 1 there is no national written exam, since Physics 1 is defined as an “oral-practical” subject. For Physics 2, about 60 percent of the students are sampled for a written exam. For the local oral exam about 7 percent and 20 percent of the students in the respective courses are sampled for testing. Both the new and the previous curriculum emphasize the use of digital tools in physics. Under previous curricula, a liberal policy was developed to encourage and allow an extensive use of aids in all teaching and testing. Written notes and advanced calculators were normally allowed in local tests as well as in national written examinations. This has changed in the present curriculum. The written exam in Physics 2 is now divided into two parts. The first part is solved by pen and paper only; no aids are allowed. The second part allows the use of all aids which cannot communicate.
There is no national certification of teaching materials, such as textbooks, in Norway. The authors and publishers are free to decide the content of a textbook; the responsibility for covering the national curriculum rests on the school and the teacher.

Generally, one may say that the present curriculum emphasizes qualitative aspects of physics more, and quantitative aspects less, than the previous curriculum did. There are fewer and simpler calculations made in physics now than before.
Portugal

Physics is offered as an optional subject in the Grade 12 Science and Technology upper secondary academic track and some professional/vocational tracks. Its main objective is to promote and develop students’ basic knowledge of concepts, laws and theories of physics, as well as their applications in explaining natural phenomena and technological devices. The curriculum is organized into units under three main areas: Mechanics, Electricity and Magnetism, and Modern Physics. The topics included in each unit are listed below.

<table>
<thead>
<tr>
<th>Content Area</th>
<th>Units</th>
<th>Topics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mechanics</td>
<td>Particle Mechanics</td>
<td>Particle kinematics and dynamics in more than one dimension: reference frames, position, vector, trajectory equations, displacement, average velocity, instantaneous velocity, average acceleration and instantaneous acceleration vectors, motion equations, tangential and radial acceleration, Newton’s Second Law, circular motion</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Motion under the action of a constant force: importance of motion initial conditions, motion equations, projectile motion</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Applying Newton’s Laws: objects connected by a cord, car in a banked circular turn, vertical circular loop, static frictional force and kinetic frictional force</td>
</tr>
<tr>
<td>Oscillations</td>
<td>Hooke’s Law</td>
<td>Hooke’s Law, simple harmonic motion (period, frequency and angular frequency, displacement from equilibrium and amplitude), velocity and acceleration in SHM, energy of a simple harmonic oscillator, and damped oscillations</td>
</tr>
<tr>
<td>Linear Momentum</td>
<td>Center of mass</td>
<td>Center of mass (extended object and system of particles), velocity and acceleration of the CM, linear momentum (particle and system of particles), momentum and Newton’s second Law, conservation of linear momentum, elastic and inelastic collisions</td>
</tr>
<tr>
<td>Fluids</td>
<td>Hydrostatic</td>
<td>Hydrostatic: density, pressure, variation of pressure with depth, Pascal’s Law, buoyant force, Archimedes’ Principle, floating objects equilibrium</td>
</tr>
<tr>
<td></td>
<td>Fluid dynamics</td>
<td>Fluid dynamics: steady flow, equation of continuity, Bernoulli’s equation, viscosity</td>
</tr>
<tr>
<td>Gravitation</td>
<td>Kepler’s Laws</td>
<td>Kepler’s Laws, Newton’s law of gravitation, gravitational constant and Cavendish experiment, gravitational field, gravitational force and weight, gravitational potential energy, orbital speed, escape speed</td>
</tr>
<tr>
<td>Electricity and Magnetism</td>
<td>Electricity and Magnetism</td>
<td>Coulomb’s law and electric fields: charge conservation, conductors and insulators, charging objects by induction and by contact, polarization, Coulomb’s law and its similarity to Newton’s laws, electric field, properties of conductors in electrostatic equilibrium</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Electrical potential: electric potential energy, electric potential, equipotential surfaces, capacitors</td>
</tr>
<tr>
<td>Content Area</td>
<td>Units</td>
<td>Topics</td>
</tr>
<tr>
<td>----------------------------------</td>
<td>------------------------</td>
<td>------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Electricity and Magnetism (Continued)</td>
<td>Electric Circuits</td>
<td>Electric current: microscopic model of current, current and potential difference, resistance and resistivity, Ohm's law</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Energy in electrical circuits: Joule's law, electromotive force and total power output of a battery, internal resistance of a battery and power delivered to the external load resistance, terminal voltage of a battery, electromotive force of a motor, internal resistance of a motor, terminal voltage of a motor</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Electric circuits equations: resistors in series and parallel, applying Ohm's law to circuits with batteries, motors and resistors, R-C circuits</td>
</tr>
<tr>
<td>Magnetic Fields</td>
<td>Sources of magnetic fields, magnetic field lines, magnetic force acting on a charge moving in a magnetic field, motion of charged particles in crossed electric and magnetic fields, Thomson's experiment, mass spectrometer, cyclotrons, magnetic force on a current-carrying wire, and Earth's magnetic field</td>
<td></td>
</tr>
<tr>
<td>Modern Physics</td>
<td>Relativity</td>
<td>Relative motion: inertial frames and accelerated frames, the principle of Galilean relativity, Galilean transformation equations</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Einstein's relativity: postulates of special theory of relativity, relativity of simultaneity, time dilation and length contraction, rest energy of a particle, general theory of relativity (curvature of space-time, principle of equivalence)</td>
</tr>
<tr>
<td>Introduction to Quantum Physics</td>
<td>Planck's energy quantization, Einstein theory of light, wave-matter duality for light, ionizing and non-ionizing radiations, photoelectric effect, Compton scattering, X-rays, wave-matter duality for matter, De Broglie wavelength, and Heisenberg's principle</td>
<td></td>
</tr>
<tr>
<td>Nuclear Physics and Radioactivity</td>
<td>Nuclear binding energy and nuclear stability, natural radioactivity, alpha, beta and gamma emission, law of radioactive decay, half-life and mean life, activity, biological effects of radioactive emissions, absorbed dose and dose equivalent, ionizing radiation detectors, applications of ionizing radiations, and nuclear reactions (nuclear fusion and nuclear fission)</td>
<td></td>
</tr>
</tbody>
</table>
Russian Federation

The physics curriculum (program) for the Russian students assessed in TIMSS Advanced 2015 followed the 2004 Federal Education Standards for Upper Secondary Education (Grades 10-11) of 2004. The content of this program are presented at two levels: Basic and Profile. These levels are distinguished by the amount of the material being studied and the amount of instructional time. The Basic level program is designed for those students who plan to learn a profession that is not related to physics. The Profile level program includes at least 4 lessons (3 hours) per week and provides sufficient depth of physics study to make it possible for students to enter a profession where physics is actively used. It includes a large amount of content and has higher requirements for its mastery. The mastery of this content makes it possible for students to continue to university-level studies in physics disciplines.

The Profile level curriculum includes an explanation of the main goals of the program and provides for the organization and planning of physics courses, including:
- General characteristics of the Profile course
- Compulsory content and learning outcomes
- The number of lessons per week and per year
- General learning skills and activities

The goals of studying physics at the Profile level of secondary general education are:
- To develop knowledge of scientific methods, a contemporary physical picture of the world, properties of matter and energy, dynamic and statistical laws of nature, elementary particles and fundamental interactions, the structure and evolution of the universe, and the basics of fundamental physical theories
- To master skills to observe, plan, and carry out experiments; process measurement results; hypothesize; and build models and establish the boundaries of their application
- To apply knowledge to explain natural phenomena, properties of matter, and principles of technical devices; to solve physical problems; and to evaluate the reliability of new information
- To develop cognitive interests, intellectual and creative abilities in problem solving in physics, and independent acquisition of new knowledge; and abilities to execute experimental studies and prepare reports, essays and other creative works
- To develop respect for opposing opinions and work cooperatively; the ability to evaluate scientific achievements morally and ethically; and respect for the creators of science and technology
- To use acquired knowledge and skills to solve practical problems, manage and protect the environment, and promote the safety of human life and society
The compulsory learning content lists the topics to be taught in secondary school physics courses. A list of requirements for graduates of secondary school includes the learning outcomes related to the topics taught. These requirements are generally described in terms of what students should know and what they should be able to do. In addition, students should be able to use the knowledge and skills that they acquire in everyday life. These program has been in place since 2004 and was updated by the Ministry of Education and Science in 2012. The content and topics of the Profile physics course are listed below.

<table>
<thead>
<tr>
<th>Content Area</th>
<th>Topics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Physics as a Science and the Nature of Science</td>
<td>Scientific methods; the role of experiment and theory in the study of nature; modelling of natural phenomena and objects; scientific hypotheses; the role of mathematics in physics; physical laws and theories and the limits of their applicability; the physical picture of the world</td>
</tr>
<tr>
<td>Mechanics</td>
<td>Motion; equations of uniformly accelerated rectilinear motion; circular motion with constant velocity; centripetal acceleration; the principle of superposition of forces; the laws of dynamics; inertial reference frames; Galileo's principle of relativity; forces in mechanics: gravity, elasticity, friction; Newton's Law of Universal Gravitation; weight and weightlessness; the laws of conservation of momentum and mechanical energy; moment of force; equilibrium of a solid body; mechanical vibrations; amplitude, period, and frequency of oscillation; the equation of harmonic oscillations; free and forced vibrations; resonance; mechanical waves; wavelength</td>
</tr>
<tr>
<td>Molecular Physics</td>
<td>The atomic hypothesis of the structure of matter and its experimental evidence; the model of the ideal gas, absolute temperature scale; temperature as a measure of the average kinetic energy of the thermal motion of particles; the relationship between the pressure of an ideal gas and the average kinetic energy of thermal motion of its molecules; the equation of state of an ideal gas; gas processes; model of the structure of liquids; saturated and unsaturated vapor; humidity in air; model of the structure of solids; changes in aggregate states of matter; the first law of thermodynamics; adiabatic processes; the second law of thermodynamics; principles of thermal machines; efficiency of a heat engine; problems of energy and environmental protection</td>
</tr>
<tr>
<td>Electrodynamics</td>
<td>Elementary electric charge; the law of conservation of electric charge; Coulomb's Law; the principle of superposition of electric fields; the potential of an electric field; conductors and dielectrics in an electric field; energy of an electric field; electrical current; series and parallel circuits; electromotive force (EMF); Ohm's law for a complete circuit; electric current in metals, liquids, gases and vacuum; plasma; semiconductors; conductivity of semiconductors; semiconductor diodes; semiconductors; induced magnetic fields; Ampere's force law; Lorentz force; magnetic flux; Faraday's law of induction; Lenz's law; self-inductance; inductance; energy of a magnetic field; magnetic properties of matter; oscillating circuits; free electromagnetic oscillations; forced electromagnetic waves; alternating current; production, transmission and consumption of electrical energy; electromagnetic fields; speed of electromagnetic waves; properties of electromagnetic radiation; light as an electromagnetic wave; the speed of light; interference of light; diffraction of light; diffraction grating; the laws of reflection and refraction of light; total internal reflection; dispersion of light; various types of electromagnetic radiation and their practical application; the formula of thin lens; optical instruments</td>
</tr>
<tr>
<td>Content Area</td>
<td>Topics</td>
</tr>
<tr>
<td>----------------------</td>
<td>--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Quantum Physics</td>
<td>Max Planck’s quantum hypothesis; the photoelectric effect; Stoletov experiments; Einstein’s equation for the photoelectric effect; photons; the planetary model of the atom; Bohr’s quantum postulates and line spectra; de Broglie’s hypothesis and wave-particle duality; electron diffraction; lasers; models of nuclear structure; nuclear forces; nucleon models; nuclear binding energy; nuclear spectra; nuclear reactions; chain reactions in nuclear fission; radioactivity; radioactive decay</td>
</tr>
<tr>
<td>Structure of the Universe</td>
<td>The solar system; stars and their sources of energy; modern ideas about the origin and evolution of the Sun and stars; our galaxy; other galaxies; the spatial scale of the observable universe; the applicability of the laws of physics to explain the nature of space objects; redshift in the spectra of galaxies; modern views on the structure and evolution of the universe</td>
</tr>
</tbody>
</table>

Textbooks are written specifically in accordance with the approved program and teachers develop classroom materials based on the curricular documents. It is up to both textbook authors and classroom teachers to decide additional topics to include beyond what is specified in the physics program. Teachers are given the autonomy to develop their own approaches to teaching the course content in terms of sequencing the topics and can adapt their teaching to the need of their students in terms of knowledge and development.
Slovenia

The published physics curriculum used for the student population assessed in TIMSS Advanced 2015 Physics describes the goals, contents, competences, expected results, cross-curricular connections, and didactic recommendations for teaching Physics in Grades 10 to 13 as well as requirements for grading students.

Physics is taught as a fundamental natural science to develop students’ ability to study natural phenomena and emphasis is placed on understanding and evaluating achievements of modern science and technology. Physics education in secondary school builds on knowledge of physics and mathematics from primary school and gives appropriate basis for study of science.

Students develop basic competences in science in technology, in mathematics, in digital literacy, in communicating science in their mother language as well as in foreign languages, in learning to learn, and in entrepreneurship.

The curriculum puts emphasis on cross-curricular links at the levels of content, process skills and conceptual level. Interdisciplinary cooperation creates the possibility of transferability of knowledge, thereby creating conditions for a better understanding, greater usability of knowledge and hence greater creativity in all subject areas.

Teachers have autonomy to decide how best to implement their teaching, methods and forms of assignments and the order of reading material. In each year from Grade 10 to 12, all gymnasia students have 70 45-minutes classes (52.5 hours) of compulsory physics lessons. These hours of lessons comprise 80 percent prescribed compulsory content and 20 percent elective content, specified by teachers. The prescribed topics in each compulsory and elective content are listed below.

<table>
<thead>
<tr>
<th>Compulsory Content Areas</th>
<th>Topics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Measurement, Physical Quantities and Units</td>
<td>Use and measurement of physical quantities, conversion of units, calculating error (absolute and relative)</td>
</tr>
<tr>
<td>Motion</td>
<td>Displacement, average and instantaneous velocity, acceleration, circular motion (frequency, period, angular velocity and radial acceleration)</td>
</tr>
<tr>
<td>Force and Moments of Force</td>
<td>Composing and decomposing forces (graphically), equilibrium of forces, Newton’s Third Law, frictional force, resistance force, moments of force, pressure and pressure in fluids</td>
</tr>
<tr>
<td>Newton’s Laws of Motion and Law of Gravitation</td>
<td>Applying Newton’s law in motion and circular motion, Newton’s law of gravitation, Kepler’s Laws</td>
</tr>
<tr>
<td>Work and Energy</td>
<td>Work, kinetic energy, potential energy, mechanical energy and law of conservation of mechanical energy</td>
</tr>
<tr>
<td>Structure of Matter and Temperature</td>
<td>Calculate the number of particles (molecules or atoms) in a given mass of a pure substance and the mass of one of the components; Kelvin temperature scale, thermal expansion of solids, liquids and gases, linear and spatial extensibility, law of ideal gases</td>
</tr>
<tr>
<td>Internal Energy and Heat</td>
<td>Apply the first law of thermodynamics, specific heat capacity, phase transition, heat flux, Stefan’s law, thermal conductivity, heat engine, reversible and irreversible processes, second law of thermodynamics</td>
</tr>
</tbody>
</table>
In Grade 13, physics is a compulsory subject only for students who choose physics as one of their five *matura* examination subjects. Physics in Grade 13 has 140 45-minutes lessons. Half of these, 70 lessons (52.5 hours), is intended to deepen and enhance the physics knowledge acquired in Grades 10 to 12 as well as learning some special contents. Teachers decide which two or three themes from Mechanics, Heat, Electrics with Magnetism, Waves and Optics, and Modern Physics will be in focus of the course. The course includes 20 lessons (15 hours) of laboratory work and 50 lessons (37.5 hours) for lecture and assessment.

The physics curriculum prescribes the standards of knowledge that students should acquire by the end of Grade 12 and includes a separate list of standards for the *matura* examination at the end.
of Grade 13. The standards for the *matura* examination, listed below, are more detailed descriptions of topics from the standards for Grade 12.

**Grade 12 Standards**

| Fundamental physical quantities and units of the international measurement system |
| The scientific method of studying natural phenomena |
| Description of linear motion and the main features of curvilinear motion and its graphic representations |
| Vector quantities and mathematical operations with vectors |
| Newton’s laws and law of gravity |
| Work, power, and energy |
| Microscopic view and description of the structure of matter |
| Temperature, heat, and internal energy |
| Laws of thermodynamics |
| Conservation laws for mass, energy, and electric charge |
| Electric charge and electric field |
| Simple electrical circuits |
| Magnetic fields |
| Induction |
| The fundamental laws of oscillation and waves, especially electromagnetic radiation |
| The visible spectrum of electromagnetic radiation |
| Sound |
| Wave nature of light |
| Light as a form of energy and basic optical equipment |
| Basic structures and characteristics of atoms |
| The basic structure of the atomic nucleus and the charges and masses of the nucleons |
| Qualitatively explain the mass defect in terms of energy |
| Radioactive decay |
| Fission and fusion of nuclei |
| The operation of a nuclear reactor |
| The structure of our solar system and the fundamental processes taking place on the Sun |
| Characteristics of the most important objects in the universe |

Didactic recommendations in the curriculum relate to the implementation of the curriculum, laboratory work, project and term papers, the use of ICT, and about active forms of teaching. In physics, in addition to content knowledge, it is also important for students to acquire procedural knowledge and skills, so teachers incorporate independent work and group work, problem solving, project work, modern laboratory work, and field work into their classroom practice. Increasingly, traditional experimental work is gradually being replaced with more modern laboratory approaches, the objectives of which include the development of observation skills, thinking, reasoning, and research skills. The physics curriculum recommends that teachers should enhance their physics lessons with the use of computer technology. It recommends also interactive forms of lessons to promote the active participation of all students.
Sweden

Two consecutive physics courses, Physics 1 and 2, comprise the physics curriculum covered by Swedish students participating in TIMSS Advanced 2015 Physics. Both courses are defined by a national curriculum that includes the goal of the subject, core content, and assessment criteria. These curricula describe learning objectives in short texts and teachers are expected to interpret the brief descriptions.

The curriculum dictates that physics courses should give students opportunity to develop

♦ Knowledge of the concepts, models, theories, and methods of physics, and how they have developed

♦ The ability to analyze and find answers to subject-related questions, and to identify, formulate, and solve problems as well as the ability to reflect on and evaluate strategies, methods and results

♦ The ability to plan, carry out, interpret and report experiments and observations, and to handle materials and equipment

♦ Knowledge of the importance of physics for the individual and society

♦ The ability to use knowledge in physics to communicate, and to evaluate and use information

In Physics 1, motion and force content deals with speed, momentum, acceleration and force. Students learn about equilibrium and linear motion in homogenous gravitational and electrical fields, and also pressure, pressure variations, and Archimedes’ principle. In addition, the core content touches on relativistic and nuclear physics. In Physics 2, content related to motion and force is added by including two-dimensional motion in gravitational and electrical fields. Students learn about central motion and torque and about simulating two-dimensional motion using simple numerical methods.

Energy and energy resources are covered as content in Physics 1. Work, force, potential energy and kinetic energy are used to describe different forms of energy. Students learn about the principle of conservation of energy, entropy, and efficiency to describe energy transformation, energy quality, and energy storage, as well as thermal energy (internal energy, heat capacity, heat transfer, temperature, and phase transformation). Students also learn about electrical energy (electrical charges, field strength, potential, voltage, current, and resistance) and nuclear energy (the structure of an atom and nuclear binding energy, strong forces, mass-energy equivalence, nuclear reactions, fission, and fusion). The core content also includes a resource perspective on energy and the use of energy for a sustainable society. Radiation in medicine and technology in Physics 1 covers radioactive disintegration, ionizing radiation, particle radiation, half-life and activity. Students are introduced to electromagnetic radiation and the particle properties of light and learn about
the interaction between different types of radiation and biological systems. Radiation content is further covered in Physics 2 under the heading of waves, electromagnetism, and signals. Students learn about harmonic oscillation and resonance with applications in everyday life and technology. Students also learn about reflection, refraction and interference of light, sound, and other waves. The Doppler Effect is covered briefly. The core content includes relationships between electric and magnetic fields (magnetic fields around conductors, the motion of electric charges in magnetic fields, and induction). Students are introduced to wave and particle descriptions of electromagnetic radiation, the propagation of electromagnetic waves, photoelectric effects, and photons. Students also learn about wave properties of matter, de Broglie's hypotheses, and wave-particle duality.

In Physics 1, under the heading of climate and weather forecasts, students learn about the ideal gas law as a model for describing the physics of the atmosphere. They are given a brief introduction to how physical models and methods of measurement are used to forecast climate and weather, as well as reliability and limitations of forecasts. In Physics 2, students work with content related to the development and structure of the universe. The core content specifies the electron structure of atoms and absorption and emission spectra. Students are introduced to methods for studying the universe, including electromagnetic radiation from stars and interstellar space.

A substantial amount of the core content descriptions in Physics 1 and 2 is given to a domain described as the nature, working methods, and mathematical methods of physics. This large content area deals with the characteristics of scientific problems, method, and theory. It also covers the identification and study of problems using reasoning from physics and mathematical modelling covering linear and non-linear functions, equations, graphs, trigonometry, and vectors. Views on societal questions based on explanatory models of physics are also covered, e.g., questions about sustainable development. This wider perspective is further developed in Physics 2 by relations and links between physics and ethical, philosophical, and religious issues.
United States

The United States does not have a uniform curriculum for physics. For TIMSS Advanced 2015, students were sampled from courses identified as second-year physics using the definitions from the School Codes for the Exchange of Data (SCED) course classification system. The SCED courses included five College Board Advanced Placement (AP) courses (Physics B, Physics 1, Physics 2, Physics C: mechanics, and Physics C: electricity and magnetism), two International Baccalaureate (IB) Diploma Programme courses (IB Physics Standard Level and IB Physics High Level), and other courses implemented at the state, district, or school level. Descriptions of courses and their content in school catalogues were reviewed to determine course eligibility. As a result, the students assessed in TIMSS Advanced 2015 participated in varying curricula. The AP and IB courses have specific curricula that are taught to all students regardless of the state, district, or school in which they take them.

AP Physics B is a second-year algebra-based physics course. The curriculum is divided into five main topic areas: Newtonian Mechanics; Fluid and Thermal Physics; Electricity and Magnetism; Waves and Optics; Atomic and Nuclear Physics. Under Newtonian Mechanics, the curriculum covers kinematics; Newton’s laws of motion; work, energy, power; systems of particles, linear momentum; circular motion and rotation; oscillations and gravitation. Under Fluid Mechanics and Thermal Physics, the curriculum covers fluid mechanics; temperature and heat; kinetic theory and thermodynamics. Under Electricity and Magnetism, the curriculum covers electrostatics; conductors, capacitors, dielectrics; electric circuits; magnetic fields; electromagnetism. Under Waves and Optics, the curriculum covers wave motion; physical optics; geometric optics. Under Atomic and Nuclear Physics, the curriculum covers atomic physics and quantum effects; nuclear physics.

In 2014, AP Physics B was revised by the College Board and replaced by the two-year series of AP Physics 1 and AP Physics 2. Thus, in the 2014-15 school year, schools stopped teaching AP Physics B and instead began teaching a two-year sequence of algebra-based physics: AP Physics 1 and Physics 2. These two courses collectively cover similar content as AP Physics B but in more depth. AP Physics 1 focuses on Newtonian mechanics (including rotational motion); work, energy, and power; mechanical waves and sound; electrostatics and electric circuits. AP Physics 2 focuses on more advanced topics including principles of fluids; thermodynamics; electromagnetism; optics; and topics in modern physics, including quantum, atomic and nuclear physics. Both Physics B and the Physics 1 and 2 courses are included in the TIMSS Advanced 2015 sample, as the specific courses offered during students’ junior and senior year may vary across states and school districts during the transition year.

AP Physics C: Mechanics covers all of the same content under Newtonian Mechanics as AP Physics B, but in greater depth. AP Physics C: Electricity and Magnetism covers all of the same content under Electricity and Magnetism as AP Physics B, but in greater depth. Both AP Physics C courses are calculus-based.
IB Physics Standard Level (SL) has a core curriculum which covers physics and physical measurement, mechanics, thermal physics, oscillations and waves, electric currents, fields and forces, atomic and nuclear physics, energy, power, and climate change. The curriculum also includes 30 hours of instruction on two of the following topics: light and wave phenomena, quantum physics and nuclear physics, digital technology, relativity and particle physics, astrophysics, communication, and electromagnetic waves. Finally, the curriculum includes 40 hours of practical work, composed of investigations and a project.

IB Physics Higher Level (HL) has the same core curriculum as IB Physics SL, but includes six additional required topics: motion in fields, thermal physics, wave phenomena, electromagnetic induction, quantum physics and nuclear physics, and digital technology. The curriculum also contains 45 hours of instruction on two of the following additional topics: astrophysics, communications, electromagnetic waves, relativity, medical physics, and particle physics. The curriculum includes 60 hours of practical work, composed of investigations and a project.

Students were also sampled from other second year physics courses, with course curriculums varying by state, district, or school.
PHYSICS APPENDICES

TIMSS ADVANCED 2015 INTERNATIONAL RESULTS IN ADVANCED MATHEMATICS AND PHYSICS
**Exhibit PA.1: Countries Participating in the TIMSS Advanced 2015 Physics Assessment and in Earlier TIMSS Advanced Assessments**

<table>
<thead>
<tr>
<th>Country</th>
<th>2015</th>
<th>2008</th>
<th>1995</th>
</tr>
</thead>
<tbody>
<tr>
<td>France</td>
<td>●</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>Italy</td>
<td>●</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>Lebanon</td>
<td>●</td>
<td>●</td>
<td></td>
</tr>
<tr>
<td>Norway</td>
<td>●</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>Portugal</td>
<td>●</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Russian Federation</td>
<td>●</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>Slovenia</td>
<td>●</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>Sweden</td>
<td>●</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>United States</td>
<td>●</td>
<td>●</td>
<td>●</td>
</tr>
</tbody>
</table>

● Indicates participation in that testing cycle.

**SOURCE:** IEA, Trends in International Mathematics and Science Study – TIMSS Advanced 2015
### Appendix PB.1: Distribution of Items Included in the Physics Assessment by Content Domain, Cognitive Domain, and Item Format

<table>
<thead>
<tr>
<th>Physics Items</th>
<th>Multiple-Choice Items</th>
<th>Constructed Response Items</th>
<th>Total Items</th>
<th>Percentage of Score Points</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Content Domain</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mechanics and Thermodynamics</td>
<td>24 (24)</td>
<td>16 (24)</td>
<td>40 (48)</td>
<td>41%</td>
</tr>
<tr>
<td>Electricity and Magnetism</td>
<td>18 (18)</td>
<td>10 (13)</td>
<td>28 (31)</td>
<td>26%</td>
</tr>
<tr>
<td>Wave Phenomena and Atomic/Nuclear Physics</td>
<td>19 (19)</td>
<td>16 (19)</td>
<td>35 (38)</td>
<td>33%</td>
</tr>
<tr>
<td>Total</td>
<td>61 (61)</td>
<td>42 (56)</td>
<td>103 (117)</td>
<td>100%</td>
</tr>
<tr>
<td>Percentage of Score Points</td>
<td>52%</td>
<td>48%</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

| **Cognitive Domain**                 |                       |                             |             |                             |
| Knowing                              | 24 (24)               | 7 (8)                       | 31 (32)     | 27%                         |
| Applying                             | 18 (18)               | 24 (33)                     | 42 (51)     | 44%                         |
| Reasoning                            | 19 (19)               | 11 (15)                     | 30 (34)     | 29%                         |
| Total                                | 61 (61)               | 42 (56)                     | 103 (117)   | 100%                        |
| Percentage of Score Points           | 52%                   | 48%                         |             |                             |

Score points are shown in parentheses. Because of rounding some results may appear inconsistent.
## Appendix PC.1: Coverage of the TIMSS Advanced 2015 Target Population for Physics

<table>
<thead>
<tr>
<th>Country</th>
<th>International Target Population Coverage</th>
<th>Exclusions from National Target Population</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>School-Level Exclusions</td>
</tr>
<tr>
<td>France</td>
<td>100%</td>
<td>4.6%</td>
</tr>
<tr>
<td>Italy</td>
<td>100%</td>
<td>0.4%</td>
</tr>
<tr>
<td>Lebanon</td>
<td>100%</td>
<td>1.3%</td>
</tr>
<tr>
<td>Norway</td>
<td>100%</td>
<td>3.3%</td>
</tr>
<tr>
<td>Portugal</td>
<td>100%</td>
<td>0.4%</td>
</tr>
<tr>
<td>Russian Federation</td>
<td>100%</td>
<td>0.2%</td>
</tr>
<tr>
<td>Slovenia</td>
<td>100%</td>
<td>1.1%</td>
</tr>
<tr>
<td>Sweden</td>
<td>100%</td>
<td>1.9%</td>
</tr>
<tr>
<td>United States</td>
<td>100%</td>
<td>0.0%</td>
</tr>
</tbody>
</table>

1 National Target Population does not include all of the International Target Population.
2 National Defined Population covers 90% to 95% of National Target Population.
3 National Defined population covers less than 90% of National Target population (but at least 77%).

SOURCE: IEA’s Trends in International Mathematics and Science Study – TIMSS Advanced 2015
## Exhibit PC.2: Size of the TIMSS Advanced 2015 Target Population for Physics, the Age Cohort, and the TIMSS Advanced Physics Coverage Index

<table>
<thead>
<tr>
<th>Country</th>
<th>Years of Formal Schooling*</th>
<th>Age Cohort Corresponding to the Final Year of Secondary School</th>
<th>Estimated Size of the Population of Students in the Final Year of Secondary School Taking the Physics Track or Program Targeted by TIMSS Advanced (Derived from TIMSS Advanced Student Sample)</th>
<th>Size of the Age Cohort Corresponding to the TIMSS Advanced Population Based on National Census Figures**</th>
<th>TIMSS Advanced Physics Coverage Index – the Percentage of the Entire Corresponding Age Cohort Covered by the TIMSS Advanced Target Population</th>
</tr>
</thead>
<tbody>
<tr>
<td>France</td>
<td>12</td>
<td>18</td>
<td>172,178</td>
<td>801,889</td>
<td>21.5%</td>
</tr>
<tr>
<td>Italy</td>
<td>13</td>
<td>19</td>
<td>104,650</td>
<td>576,506</td>
<td>18.2%</td>
</tr>
<tr>
<td>Lebanon</td>
<td>12</td>
<td>18</td>
<td>4,464</td>
<td>113,204</td>
<td>3.9%</td>
</tr>
<tr>
<td>Norway</td>
<td>13</td>
<td>19</td>
<td>4,163</td>
<td>63,894</td>
<td>6.5%</td>
</tr>
<tr>
<td>Portugal</td>
<td>12</td>
<td>18</td>
<td>5,661</td>
<td>109,984</td>
<td>5.1%</td>
</tr>
<tr>
<td>Russian Federation</td>
<td>11</td>
<td>18</td>
<td>66,746</td>
<td>1,365,790</td>
<td>4.9%</td>
</tr>
<tr>
<td>Slovenia</td>
<td>13</td>
<td>19</td>
<td>1,491</td>
<td>19,598</td>
<td>7.6%</td>
</tr>
<tr>
<td>Sweden</td>
<td>12</td>
<td>19</td>
<td>15,423</td>
<td>108,138</td>
<td>14.3%</td>
</tr>
<tr>
<td>United States</td>
<td>12</td>
<td>18</td>
<td>199,944</td>
<td>4,168,000</td>
<td>4.8%</td>
</tr>
</tbody>
</table>

** Represents years of schooling counting from the first year of primary or basic education (first year of ISCED Level 1).


Italy: Value is the total population of 19-year olds in Italy in 2015. Data retrieved from ISTAT (the National Statistics Institute); http://dati.istat.it/Index.aspx?datasetcode=DCIS_POPRES1.


United States: Value is the total population of 18-year olds in December 31, 2014. Data retrieved from the US Census Annual Estimates of the Resident Population by Single Year of Age and Sex for the United States: April 1, 2010 to July 1, 2013; https://www.census.gov/popest/data/national/asrh/2013/. The post-census estimates are as of July 1 of each year. For the 18-year-olds estimate in 2015, the 2015 population was projected using the year to year changes from 2010 to 2013 and extending it to 2015.

The TIMSS Advanced Physics Coverage Index reflects the differences across countries in the proportion of the age cohort that are enrolled in these advanced courses in the final year of secondary education. In some countries, only a very select group of students was considered eligible for the study, while in others, a much larger group was included.

The TIMSS Advanced Physics Coverage Index (TAPCI) is defined as follows:

\[
\text{TAPCI} = \left(\frac{\text{Estimated total number of students in the physics target population in 2015}}{\text{Total national population in the corresponding age cohort in 2015}}\right) \times 100\%
\]

The numerator is the total number of students eligible for TIMSS Advanced, estimated from the weighted sample data. These are students in the final year of secondary school taking the physics track or program targeted by TIMSS Advanced, based on the TIMSS Advanced sample. The denominator is the size of the population age cohort corresponding to the average age of the students in the target populations and is based on national census figures.
### Appendix PC.3: School Sample Sizes - Physics

<table>
<thead>
<tr>
<th>Country</th>
<th>Number of Schools in Original Sample</th>
<th>Number of Eligible Schools in Original Sample</th>
<th>Number of Schools in Original Sample that Participated</th>
<th>Number of Replacement Schools that Participated</th>
<th>Total Number of Schools that Participated</th>
</tr>
</thead>
<tbody>
<tr>
<td>France</td>
<td>146</td>
<td>145</td>
<td>144</td>
<td>0</td>
<td>144</td>
</tr>
<tr>
<td>Italy</td>
<td>120</td>
<td>120</td>
<td>106</td>
<td>8</td>
<td>114</td>
</tr>
<tr>
<td>Lebanon</td>
<td>356</td>
<td>355</td>
<td>250</td>
<td>0</td>
<td>250</td>
</tr>
<tr>
<td>Norway</td>
<td>130</td>
<td>130</td>
<td>127</td>
<td>0</td>
<td>127</td>
</tr>
<tr>
<td>Portugal</td>
<td>251</td>
<td>173</td>
<td>142</td>
<td>7</td>
<td>149</td>
</tr>
<tr>
<td>Russian Federation</td>
<td>193</td>
<td>193</td>
<td>187</td>
<td>6</td>
<td>193</td>
</tr>
<tr>
<td>Slovenia</td>
<td>59</td>
<td>59</td>
<td>50</td>
<td>0</td>
<td>50</td>
</tr>
<tr>
<td>Sweden</td>
<td>134</td>
<td>134</td>
<td>132</td>
<td>1</td>
<td>133</td>
</tr>
<tr>
<td>United States</td>
<td>348</td>
<td>237</td>
<td>156</td>
<td>9</td>
<td>165</td>
</tr>
</tbody>
</table>

**SOURCE:** IEA's Trends in International Mathematics and Science Study – TIMSS Advanced 2015
### Appendix PC.4: Student Sample Sizes - Physics

<table>
<thead>
<tr>
<th>Country</th>
<th>Within-School Student Participation (Weighted Percentage)</th>
<th>Number of Sampled Students in Participating Schools</th>
<th>Number of Students Withdrawn from Class/School</th>
<th>Number of Students Excluded</th>
<th>Number of Eligible Students</th>
<th>Number of Students Absent</th>
<th>Number of Students Assessed</th>
</tr>
</thead>
<tbody>
<tr>
<td>France</td>
<td>96%</td>
<td>4,297</td>
<td>41</td>
<td>7</td>
<td>4,249</td>
<td>291</td>
<td>3,958</td>
</tr>
<tr>
<td>Italy</td>
<td>97%</td>
<td>3,652</td>
<td>25</td>
<td>20</td>
<td>3,607</td>
<td>183</td>
<td>3,424</td>
</tr>
<tr>
<td>Lebanon</td>
<td>98%</td>
<td>1,215</td>
<td>0</td>
<td>0</td>
<td>1,215</td>
<td>59</td>
<td>1,156</td>
</tr>
<tr>
<td>Norway</td>
<td>94%</td>
<td>2,674</td>
<td>44</td>
<td>2</td>
<td>2,628</td>
<td>156</td>
<td>2,472</td>
</tr>
<tr>
<td>Portugal</td>
<td>93%</td>
<td>1,968</td>
<td>21</td>
<td>4</td>
<td>1,943</td>
<td>160</td>
<td>1,783</td>
</tr>
<tr>
<td>Russian Federation</td>
<td>98%</td>
<td>3,925</td>
<td>2</td>
<td>8</td>
<td>3,915</td>
<td>93</td>
<td>3,822</td>
</tr>
<tr>
<td>Slovenia</td>
<td>86%</td>
<td>1,302</td>
<td>6</td>
<td>12</td>
<td>1,284</td>
<td>178</td>
<td>1,106</td>
</tr>
<tr>
<td>Sweden</td>
<td>90%</td>
<td>4,236</td>
<td>65</td>
<td>3</td>
<td>4,168</td>
<td>441</td>
<td>3,727</td>
</tr>
<tr>
<td>United States</td>
<td>85%</td>
<td>3,539</td>
<td>114</td>
<td>6</td>
<td>3,419</td>
<td>487</td>
<td>2,932</td>
</tr>
</tbody>
</table>

Students attending a sampled class at the time the sample was chosen but leaving the class before the assessment was administered were classified as "withdrawn."

Students with a disability or language barrier that prevented them from participating in the assessment were classified as "excluded."

Students not present when the assessment was administered, and not subsequently assessed in a make-up session, were classified as "absent."

SOURCE: IEA’s Trends in International Mathematics and Science Study – TIMSS Advanced 2015
<table>
<thead>
<tr>
<th>Country</th>
<th>Before Replacement</th>
<th>After Replacement</th>
<th>School Participation</th>
<th>Class Participation</th>
<th>Student Participation</th>
<th>Overall Participation</th>
<th>Before Replacement</th>
<th>After Replacement</th>
</tr>
</thead>
<tbody>
<tr>
<td>France</td>
<td>99%</td>
<td>99%</td>
<td>100%</td>
<td>96%</td>
<td>95%</td>
<td>95%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Italy</td>
<td>89%</td>
<td>95%</td>
<td>99%</td>
<td>97%</td>
<td>85%</td>
<td>91%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>‡ Lebanon</td>
<td>70%</td>
<td>70%</td>
<td>100%</td>
<td>98%</td>
<td>68%</td>
<td>68%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Norway</td>
<td>98%</td>
<td>98%</td>
<td>100%</td>
<td>94%</td>
<td>93%</td>
<td>93%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Portugal</td>
<td>83%</td>
<td>87%</td>
<td>100%</td>
<td>93%</td>
<td>78%</td>
<td>81%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Russian Federation</td>
<td>97%</td>
<td>100%</td>
<td>100%</td>
<td>98%</td>
<td>95%</td>
<td>98%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Slovenia</td>
<td>86%</td>
<td>86%</td>
<td>100%</td>
<td>86%</td>
<td>74%</td>
<td>74%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sweden</td>
<td>99%</td>
<td>100%</td>
<td>99%</td>
<td>90%</td>
<td>88%</td>
<td>89%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>‡ United States</td>
<td>65%</td>
<td>68%</td>
<td>100%</td>
<td>85%</td>
<td>55%</td>
<td>58%</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Source:** IEA's Trends in International Mathematics and Science Study – TIMSS Advanced 2015

TIMSS Advanced guidelines for sampling participation: The minimum acceptable participation rates were 85% of both schools and students, or a combined rate (the product of school and student participation) of 75%. Participants not meeting these guidelines were annotated as follows:

† Met guidelines for sample participation rates only after replacement schools were included.
‡ Nearly satisfied guidelines for sample participation rates after replacement schools were included.
¶ Did not satisfy guidelines for sample participation rates.
### Appendix PC.6: Trends in Student Populations – Physics

<table>
<thead>
<tr>
<th>Country</th>
<th>Years of Formal Schooling*</th>
<th>Average Age at Time of Testing</th>
<th>Overall Exclusion Rates**</th>
<th>Physics Coverage Index***</th>
<th>Overall Participation Rates</th>
</tr>
</thead>
<tbody>
<tr>
<td>France</td>
<td>12</td>
<td>12</td>
<td>18.0</td>
<td>18.2</td>
<td>4.7%</td>
</tr>
<tr>
<td>Italy</td>
<td>13</td>
<td>13</td>
<td>18.9</td>
<td>18.9</td>
<td>0.8%</td>
</tr>
<tr>
<td>Lebanon</td>
<td>12</td>
<td>12</td>
<td>17.8</td>
<td>17.9</td>
<td>3.9%</td>
</tr>
<tr>
<td>Norway</td>
<td>13</td>
<td>12</td>
<td>18.8</td>
<td>19.0</td>
<td>4.0%</td>
</tr>
<tr>
<td>Russian Federation</td>
<td>11</td>
<td>10/11</td>
<td>10</td>
<td>17.7</td>
<td>17.1</td>
</tr>
<tr>
<td>Slovenia</td>
<td>13</td>
<td>12</td>
<td>18.8</td>
<td>18.8</td>
<td>2.0%</td>
</tr>
<tr>
<td>Sweden</td>
<td>12</td>
<td>12</td>
<td>18.8</td>
<td>18.9</td>
<td>2.0%</td>
</tr>
<tr>
<td>United States</td>
<td>12</td>
<td>12</td>
<td>18.1</td>
<td>18.0</td>
<td>0.1%</td>
</tr>
</tbody>
</table>

* Represents years of schooling counting from the first year of ISCED Level 1.

** In 1995 exclusion rates for Physics were computed based on exclusion rates among all students in the final year of schooling. In the case of the Russian Federation, the figure presented in the 1995 International Report (43.0%) greatly overestimates the level of exclusions in the advanced mathematics population. The figure presented above (2.0%) includes two regions, North Ossetia and Chechen Republic, as well as non-Russian speaking students.

*** See Appendix PC.2 for a description of the Physics Coverage Index.

The United States adjusted the 1995 sample to correspond with the course-taking definitions used in 2015, and the 1995 results were recomputed. An empty cell indicates a country did not participate in that year’s assessment.
### Appendix PD.1: Average Percent Correct in the Physics Content and Cognitive Domains

<table>
<thead>
<tr>
<th>Country</th>
<th>Overall Physics</th>
<th>Mechanics and Thermodynamics</th>
<th>Electricity and Magnetism</th>
<th>Wave Phenomena and Atomic/Nuclear Physics</th>
<th>Knowing</th>
<th>Applying</th>
<th>Reasoning</th>
</tr>
</thead>
<tbody>
<tr>
<td>France</td>
<td>32 (0.4)</td>
<td>26 (0.4)</td>
<td>30 (0.4)</td>
<td>40 (0.5)</td>
<td>40 (0.5)</td>
<td>28 (0.4)</td>
<td>30 (0.5)</td>
</tr>
<tr>
<td>Italy</td>
<td>32 (0.6)</td>
<td>30 (0.7)</td>
<td>37 (0.8)</td>
<td>30 (0.7)</td>
<td>39 (0.7)</td>
<td>30 (0.7)</td>
<td>29 (0.6)</td>
</tr>
<tr>
<td>Lebanon</td>
<td>35 (0.4)</td>
<td>31 (0.6)</td>
<td>33 (0.6)</td>
<td>41 (0.6)</td>
<td>40 (0.6)</td>
<td>37 (0.6)</td>
<td>26 (0.5)</td>
</tr>
<tr>
<td>Norway</td>
<td>49 (0.7)</td>
<td>48 (0.7)</td>
<td>48 (0.8)</td>
<td>52 (0.8)</td>
<td>60 (0.7)</td>
<td>46 (0.7)</td>
<td>44 (0.7)</td>
</tr>
<tr>
<td>Portugal</td>
<td>42 (0.6)</td>
<td>45 (0.8)</td>
<td>37 (0.7)</td>
<td>44 (0.8)</td>
<td>52 (0.7)</td>
<td>40 (0.8)</td>
<td>37 (0.7)</td>
</tr>
<tr>
<td>Russian Federation</td>
<td>50 (1.1)</td>
<td>49 (1.2)</td>
<td>50 (1.1)</td>
<td>51 (1.0)</td>
<td>58 (1.0)</td>
<td>50 (1.3)</td>
<td>42 (0.9)</td>
</tr>
<tr>
<td>Slovenia</td>
<td>52 (0.5)</td>
<td>54 (0.6)</td>
<td>51 (0.5)</td>
<td>52 (0.7)</td>
<td>58 (0.7)</td>
<td>54 (0.5)</td>
<td>45 (0.6)</td>
</tr>
<tr>
<td>Sweden</td>
<td>42 (0.8)</td>
<td>41 (0.9)</td>
<td>41 (0.8)</td>
<td>44 (0.8)</td>
<td>49 (0.7)</td>
<td>41 (0.9)</td>
<td>36 (0.7)</td>
</tr>
<tr>
<td>United States</td>
<td>39 (1.1)</td>
<td>42 (1.3)</td>
<td>34 (1.2)</td>
<td>41 (1.1)</td>
<td>48 (1.3)</td>
<td>37 (1.2)</td>
<td>35 (1.0)</td>
</tr>
<tr>
<td>International Avg.</td>
<td>41 (0.2)</td>
<td>40 (0.3)</td>
<td>40 (0.3)</td>
<td>44 (0.3)</td>
<td>49 (0.3)</td>
<td>40 (0.3)</td>
<td>36 (0.2)</td>
</tr>
</tbody>
</table>

() Standard errors appear in parentheses. Because of rounding some results may appear inconsistent.

Appendix PE: Test-Curriculum Matching Analysis

TIMSS Advanced 2015 went to great lengths to ensure that comparisons of student achievement across countries would be as fair and equitable as possible. The TIMSS Advanced 2015 Assessment Frameworks were designed to specify the important aspects of physics that participating countries agreed should be the focus of an international assessment of student achievement. The assessment items were developed through a collaborative process with national representatives to faithfully represent the specifications in the frameworks and were field tested extensively in participating countries. Finalizing the TIMSS Advanced 2015 physics assessment involved a series of reviews by representatives of the participating countries, experts in physics, and testing specialists. At the end of this process, the National Research Coordinators (NRCs) from each country formally approved the TIMSS Advanced 2015 physics assessment, thus accepting it as being sufficiently fair to compare their students’ physics achievement with that of students from other countries.

Although the assessment was developed to represent agreed upon frameworks and was intended to have as much in common across countries as possible, it was unavoidable that the match between the physics assessment (or test) and the physics curriculum would not be the same in all countries. To restrict test items to just those topics included in the curricula of all participating countries and covered in the same sequence would severely limit test coverage and restrict the research questions that the study is designed to address. The test, therefore, inevitably has some items measuring topics unfamiliar to some students in some countries.

The Test-Curriculum Matching Analysis (TCMA) was conducted to investigate the extent to which the TIMSS Advanced 2015 physics assessment matched each country’s curriculum. The TCMA also investigated the impact on a country’s performance of including only achievement items that were judged to be relevant to its own curriculum.¹

To gather data about the extent to which the TIMSS Advanced 2015 physics test matched the curricula of the participating countries, National Research Coordinators were asked to examine each achievement item and indicate whether the item was in their country’s intended curriculum for the physics program(s) or track(s) assessed by TIMSS Advanced. Since an item might be in the curriculum for some but not all students in a country, coordinators were asked to consider an item included if it was in the intended curriculum for more than 50 percent of the students. All TIMSS Advanced 2015 participants took part in the TCMA analysis.

Exhibits PE.1 and PE.2 present the TCMA results for the TIMSS Advanced 2015 physics test. Exhibit PE.1 shows the average percent correct on the physics items judged appropriate by each

¹ Because there may also be curriculum areas covered in some countries that are not covered by the TIMSS Advanced 2015 tests, the TCMA does not provide complete information about how well the tests cover the curricula of the countries.
country. Exhibit PE.2 shows the standard errors corresponding to the percentages presented in Exhibit PE.1.

In Exhibit PE.1, the bottom row of the exhibit shows the number of items, in terms of score points, identified as appropriate in each country. For physics, the maximum number of score points in the assessment was 115 points. Generally, the proportion of items judged appropriate was fairly high. From the bottom row, it can be seen that Slovenia and Italy judged all of the items (115 score points) to be appropriate and the United States judged almost all of the items (111 score points) to be appropriate. Norway (107), Sweden (107), and the Russian Federation (104) judged over 90 percent of the items to be included in the curriculum, and Portugal (94), Lebanon (93), and France (92) judged at least 80 percent to be included.

Because most countries indicated that at least some items were not included in their intended curriculum at the grade tested, the data were analyzed to determine whether the inclusion of these items had any effect on the international performance comparisons.

The first data column in Exhibit PE.1 shows the average percent correct on all physics test items for each country, together with its standard error. Subsequent columns show the performance of every country on those items judged appropriate by the country listed at the head of the column. Countries are presented in order of their performance based on average percent correct on all of the physics items, from highest to lowest. To interpret this exhibit, choosing a country and reading across its row provides the average percent correct for the students in that country on the items selected by each of the countries listed along the top of the exhibit. For example, Slovenia, where the average percent correct was 52 percent on the set of physics items that it judged appropriate, had, on average, 54 percent correct on the items judged appropriate by the Russian Federation, 51 percent on the items selected by Norway, 52 percent on the items selected by Portugal, and so forth.

The column for a country listed at the top shows how each of the other countries performed on the set of items selected as appropriate for that country’s students. Using the set of physics items selected by Portugal as an example, 52 percent of these items, on average, were answered correctly by students in Slovenia, 49 percent by students in the Russian Federation, 50 percent by students in Norway, and so forth. The shaded diagonal element in the exhibit shows how each country performed on the set of items that it selected based on its own curriculum. Thus, students from Portugal averaged 44 percent correct on the set of items identified by Portugal for the analysis.

For each country’s selected items, the international averages across the participating countries are presented in a row in the lower part of the exhibit for each subject. These show that the selections of items by the participating countries varied only slightly in average difficulty, which is not surprising given that countries included most items in the physics assessment.

Comparing the diagonal element for a country with the overall average percent correct shows the difference between performance on the set of items chosen as appropriate for that country and

---

2 The TIMSS Advanced 2015 physics assessment contained 103 items yielding 117 score points. However, following item review, the 103 items and 117 score points in the physics assessment were reduced to 101 items and 115 score points.

3 It should be noted that the physics achievement presented in Exhibits PE.1 is based on average percent correct (the percentage of students in a country answering each item correctly, averaged across all items), which is different from the average scale scores that are presented in main tables of the report.
### Exhibit PE.1: Average Percent Correct for the Test-Curriculum Matching Analyses in Physics

Based on a subset of items specifically identified by each country as addressing its curriculum.

Read across the row to compare that country’s performance based on the test items included by each of the countries across the top. Read down the column under a country name to compare the performance of the country down the left on the items included by the country listed on the top. Read along the diagonal to compare performance for each different country based on its own decisions about the test items to include.

<table>
<thead>
<tr>
<th>Country</th>
<th>Average Percent Correct on All Items</th>
<th>Slovenia</th>
<th>Russian Federation</th>
<th>Norway</th>
<th>Portugal</th>
<th>Sweden</th>
<th>United States</th>
<th>Lebanon</th>
<th>Italy</th>
<th>France</th>
</tr>
</thead>
<tbody>
<tr>
<td>Slovenia</td>
<td>52 (0.5)</td>
<td>52</td>
<td>54</td>
<td>51</td>
<td>52</td>
<td>53</td>
<td>53</td>
<td>52</td>
<td>52</td>
<td>52</td>
</tr>
<tr>
<td>Russian Federation</td>
<td>50 (1.1)</td>
<td>50</td>
<td>51</td>
<td>49</td>
<td>50</td>
<td>50</td>
<td>50</td>
<td>49</td>
<td>49</td>
<td>49</td>
</tr>
<tr>
<td>Norway</td>
<td>49 (0.7)</td>
<td>49</td>
<td>49</td>
<td>51</td>
<td>50</td>
<td>49</td>
<td>50</td>
<td>50</td>
<td>49</td>
<td>49</td>
</tr>
<tr>
<td>Portugal</td>
<td>42 (0.6)</td>
<td>42</td>
<td>44</td>
<td>43</td>
<td>43</td>
<td>43</td>
<td>43</td>
<td>42</td>
<td>42</td>
<td>42</td>
</tr>
<tr>
<td>Sweden</td>
<td>42 (0.8)</td>
<td>42</td>
<td>43</td>
<td>42</td>
<td>42</td>
<td>42</td>
<td>42</td>
<td>42</td>
<td>42</td>
<td>42</td>
</tr>
<tr>
<td>United States</td>
<td>39 (1.1)</td>
<td>39</td>
<td>40</td>
<td>40</td>
<td>39</td>
<td>39</td>
<td>39</td>
<td>40</td>
<td>39</td>
<td>39</td>
</tr>
<tr>
<td>Lebanon</td>
<td>35 (0.4)</td>
<td>35</td>
<td>36</td>
<td>35</td>
<td>34</td>
<td>35</td>
<td>36</td>
<td>35</td>
<td>35</td>
<td>35</td>
</tr>
<tr>
<td>Italy</td>
<td>32 (0.6)</td>
<td>32</td>
<td>33</td>
<td>32</td>
<td>31</td>
<td>32</td>
<td>31</td>
<td>32</td>
<td>31</td>
<td>32</td>
</tr>
<tr>
<td>France</td>
<td>31 (0.4)</td>
<td>31</td>
<td>31</td>
<td>32</td>
<td>31</td>
<td>31</td>
<td>31</td>
<td>31</td>
<td>31</td>
<td>32</td>
</tr>
<tr>
<td>International Avg.</td>
<td>41 (0.2)</td>
<td>41</td>
<td>42</td>
<td>42</td>
<td>42</td>
<td>42</td>
<td>42</td>
<td>41</td>
<td>41</td>
<td>42</td>
</tr>
</tbody>
</table>

*Of the 103 items in the Physics assessment, some extended-response items were scored on a two-point scale, resulting in 117 total score points. Following item review, two items were deleted, resulting in 101 items and 115 score points.


Performance on the test as a whole. Countries generally performed similarly or a little better on their own items when compared to their performance on all items. To illustrate, the average percent correct for the Russian Federation across all the physics items was 50 percent. The diagonal element shows that students from the Russian Federation had a slightly greater average percent correct (51 percent) across the set of items selected as appropriate for Russian students than they did overall. Norway and Portugal had the biggest differences between the two measures with Norwegian students achieving 51 percent correct on the items judged to be in their curriculum while achieving 49 percent correct on all items, and Portuguese students achieving 44 percent correct on the items judged to be in their curriculum while achieving 42 percent correct on all items.

It is clear that the selection of items did not have a major effect on the relative performance in physics among TIMSS Advanced 2015 countries. Countries that had relatively high or low performance across all of the items in the assessment also had relatively high or low performance on each of the various sets of items selected for the TCMA. For example, Slovenia had the highest average percent correct not only on the assessment as a whole, but also on all of the different item
The TCMA results provide evidence that the TIMSS Advanced 2015 physics assessment constitutes a reasonable basis for comparing the achievement of the participating countries. This result is not unexpected, since making the assessment as fair as possible was a major consideration in test development. The fact that all countries indicated that most items were appropriate for their students means that the different average percent correct estimates were based on many of the same items. Insofar as countries rejected items that would be difficult for their students, these items do not greatly affect the overall pattern of relative performance.

4 Small differences in performance between adjacent countries shown in this exhibit usually are not statistically significant. The standard errors for the average percent correct statistics based on the TIMSS Advanced 2015 sample are provided in Exhibit PE.2. For any sample average shown in Exhibit PE.1, it can be said with 95 percent confidence that the corresponding value in the population falls between the sample estimate plus or minus 2 standard errors.
### Appendix PF.1: Percentiles of Achievement in Physics

<table>
<thead>
<tr>
<th>Country</th>
<th>5th Percentile</th>
<th>10th Percentile</th>
<th>25th Percentile</th>
<th>50th Percentile</th>
<th>75th Percentile</th>
<th>90th Percentile</th>
<th>95th Percentile</th>
</tr>
</thead>
<tbody>
<tr>
<td>France</td>
<td>226 (5.7)</td>
<td>258 (6.4)</td>
<td>311 (5.9)</td>
<td>373 (4.3)</td>
<td>434 (4.5)</td>
<td>490 (5.2)</td>
<td>521 (5.9)</td>
</tr>
<tr>
<td>Italy</td>
<td>158 (13.3)</td>
<td>206 (12.4)</td>
<td>286 (10.0)</td>
<td>380 (8.1)</td>
<td>465 (6.8)</td>
<td>533 (5.9)</td>
<td>573 (9.0)</td>
</tr>
<tr>
<td>Lebanon</td>
<td>253 (10.2)</td>
<td>290 (7.2)</td>
<td>348 (4.8)</td>
<td>412 (5.3)</td>
<td>476 (6.0)</td>
<td>526 (8.3)</td>
<td>557 (9.3)</td>
</tr>
<tr>
<td>Norway</td>
<td>333 (8.6)</td>
<td>377 (10.0)</td>
<td>443 (6.8)</td>
<td>511 (5.5)</td>
<td>577 (5.0)</td>
<td>632 (5.9)</td>
<td>664 (5.3)</td>
</tr>
<tr>
<td>Portugal</td>
<td>380 (8.3)</td>
<td>361 (5.6)</td>
<td>412 (6.5)</td>
<td>466 (6.1)</td>
<td>522 (6.5)</td>
<td>573 (6.7)</td>
<td>603 (8.5)</td>
</tr>
<tr>
<td>Russian Federation</td>
<td>303 (10.1)</td>
<td>348 (9.3)</td>
<td>427 (8.1)</td>
<td>513 (7.6)</td>
<td>592 (8.5)</td>
<td>657 (11.1)</td>
<td>695 (14.9)</td>
</tr>
<tr>
<td>Slovenia</td>
<td>367 (10.1)</td>
<td>408 (8.1)</td>
<td>468 (6.2)</td>
<td>532 (4.2)</td>
<td>596 (5.9)</td>
<td>655 (7.9)</td>
<td>693 (7.0)</td>
</tr>
<tr>
<td>Sweden</td>
<td>245 (10.2)</td>
<td>295 (9.2)</td>
<td>380 (8.3)</td>
<td>463 (7.1)</td>
<td>537 (5.7)</td>
<td>600 (6.0)</td>
<td>636 (6.3)</td>
</tr>
<tr>
<td>United States</td>
<td>235 (16.7)</td>
<td>283 (15.6)</td>
<td>357 (13.0)</td>
<td>440 (10.9)</td>
<td>522 (9.9)</td>
<td>589 (10.0)</td>
<td>626 (10.3)</td>
</tr>
</tbody>
</table>

( ) Standard errors appear in parentheses. Because of rounding some results may appear inconsistent.

Note: Percentiles are defined in terms of percentages of students at or below a point on the scale.

SOURCE: IEA’s Trends in International Mathematics and Science Study – TIMSS Advanced 2015
## Appendix PF.2: Standard Deviations of Achievement in Physics

<table>
<thead>
<tr>
<th>Country</th>
<th>Overall</th>
<th>Females</th>
<th>Males</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>Standard Deviation</td>
<td>Mean</td>
</tr>
<tr>
<td>France</td>
<td>373 (4.0)</td>
<td>90 (1.7)</td>
<td>354 (4.2)</td>
</tr>
<tr>
<td>Italy</td>
<td>374 (6.9)</td>
<td>126 (3.5)</td>
<td>356 (7.3)</td>
</tr>
<tr>
<td>Lebanon</td>
<td>410 (4.5)</td>
<td>94 (2.7)</td>
<td>417 (5.2)</td>
</tr>
<tr>
<td>Norway</td>
<td>507 (4.6)</td>
<td>100 (2.5)</td>
<td>489 (6.0)</td>
</tr>
<tr>
<td>Portugal</td>
<td>467 (4.6)</td>
<td>83 (2.2)</td>
<td>456 (6.2)</td>
</tr>
<tr>
<td>Russian Federation</td>
<td>508 (7.1)</td>
<td>119 (4.3)</td>
<td>498 (7.9)</td>
</tr>
<tr>
<td>Slovenia</td>
<td>531 (2.5)</td>
<td>98 (2.7)</td>
<td>510 (6.5)</td>
</tr>
<tr>
<td>Sweden</td>
<td>455 (5.9)</td>
<td>118 (2.5)</td>
<td>448 (6.1)</td>
</tr>
<tr>
<td>United States</td>
<td>437 (9.7)</td>
<td>118 (4.3)</td>
<td>409 (11.9)</td>
</tr>
</tbody>
</table>

( ) Standard errors appear in parentheses. Because of rounding some results may appear inconsistent.
Appendix PG: Organizations and Individuals Responsible for TIMSS Advanced 2015

Introduction

TIMSS Advanced 2015 was a collaborative effort involving hundreds of individuals around the world. This appendix acknowledges the individuals and organizations for their contributions. Given that work on TIMSS Advanced 2015 has spanned approximately four years and has involved so many people and organizations, this list may not include all who contributed. Any omission is inadvertent. TIMSS Advanced 2015 also acknowledges the students, teachers, and school principals who contributed their time and effort to the study. This report would not be possible without them.

Management and Coordination

TIMSS Advanced was conducted by IEA’s TIMSS & PIRLS International Study Center at Boston College, which has responsibility for the direction and management of the TIMSS and PIRLS projects, including design, development, and implementation. Headed by Executive Directors Drs. Ina V.S. Mullis and Michael O. Martin, the study center is located in the Lynch School of Education. In carrying out the project, the TIMSS & PIRLS International Study Center worked closely with the IEA Secretariat in Amsterdam, which managed country participation, was responsible for verification of all translations produced by the participating countries, and coordinated the school visits by International Quality Control Monitors. Staff at the IEA Data Processing and Research Center in Hamburg worked closely with participating countries to organize sampling and data collection operations and to check all data for accuracy and consistency within and across countries; Statistics Canada in Ottawa was responsible for school and student sampling activities; and Educational Testing Service in Princeton, New Jersey consulted on psychometric methodology, provided software for scaling the achievement data, and replicated the achievement scaling for quality assurance.

The Project Management Team, comprising the study directors and representatives from the TIMSS & PIRLS International Study Center, IEA Secretariat and IEA Data Processing and Research Center, Statistics Canada, and ETS met twice a year throughout the study to discuss the study’s progress, procedures, and schedule. In addition, the study directors met with members of IEA’s Technical Executive Group twice yearly to review technical issues.
To work with the international team and coordinate within-country activities, each participating country designates an individual to be the TIMSS National Research Coordinator (NRC). The NRCs have the challenging task of implementing TIMSS in their countries in accordance with the TIMSS guidelines and procedures. In addition, the NRCs provide feedback and contributions throughout the development of the TIMSS assessment. The quality of the TIMSS assessment and data depends on the work of the NRCs and their colleagues in carrying out the complex sampling, data collection, and scoring tasks involved. Continuing the tradition of exemplary work established in previous cycles of TIMSS, the TIMSS Advanced 2015 NRCs performed their many tasks with dedication, competence, energy, and goodwill, and have been commended by the IEA Secretariat, the TIMSS & PIRLS International Study Center, the IEA Data Processing and Research Center, and Statistics Canada for their commitment to the project and the high quality of their work.

**Funding**

Funding for TIMSS Advanced 2015 was provided primarily by the participating countries. Boston College also is gratefully acknowledged for its generous financial support and stimulating educational environment.
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Paul Connolly, Director, Graphic Design and Publications
Ieva Johansone, Associate Research Director, Operations and Quality Control
Marcie Bligh, Manager, Events and Administration
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Susan Farrell, Lead Web and Database Designer
Bethany Fishbein, Research Specialist, TIMSS Science
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