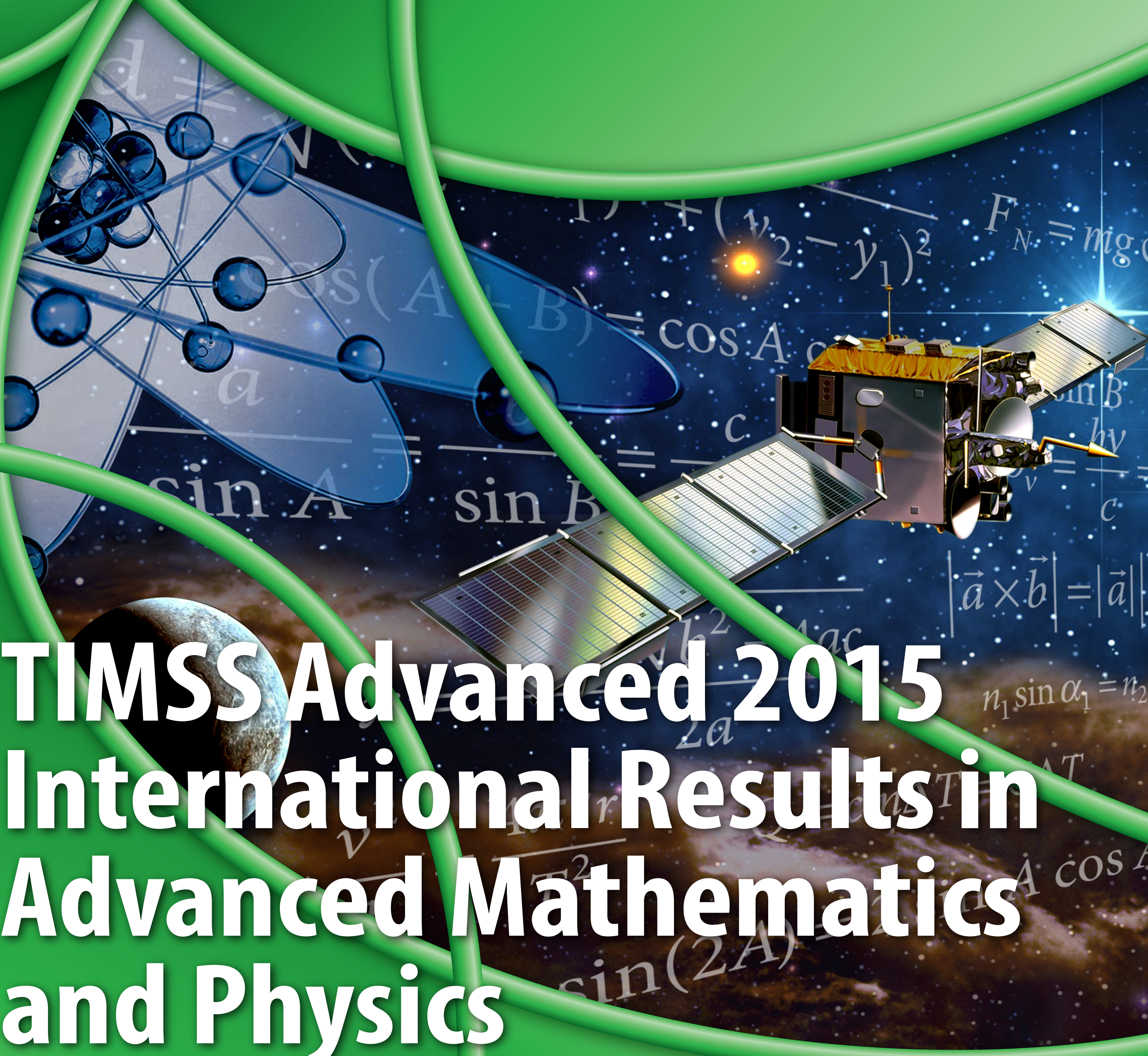
TRENDS IN INTERNATIONAL MATHEMATICS AND SCIENCE STUDY

TIMSS



TIMSS Advanced 2015 International Results in Advanced Mathematics and Physics

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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.

Exhibit 1: Countries Participating in TIMSS Advanced 2015

TIMSS Advanced 2015 Advanced Mathematics & Physics

Country	Also Participated	
France	1995	
Italy	1995	2008
Lebanon		2008
Norway	1995	2008
Portugal		
Russian Federation*	1995	2008
Slovenia	1995	2008
Sweden	1995	2008
United States	1995	

*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.

TIMSS
Advanced
2015

CHAPTER M1: STUDENT ACHIEVEMENT

TIMSS ADVANCED 2015 INTERNATIONAL RESULTS IN ADVANCED MATHEMATICS AND PHYSICS

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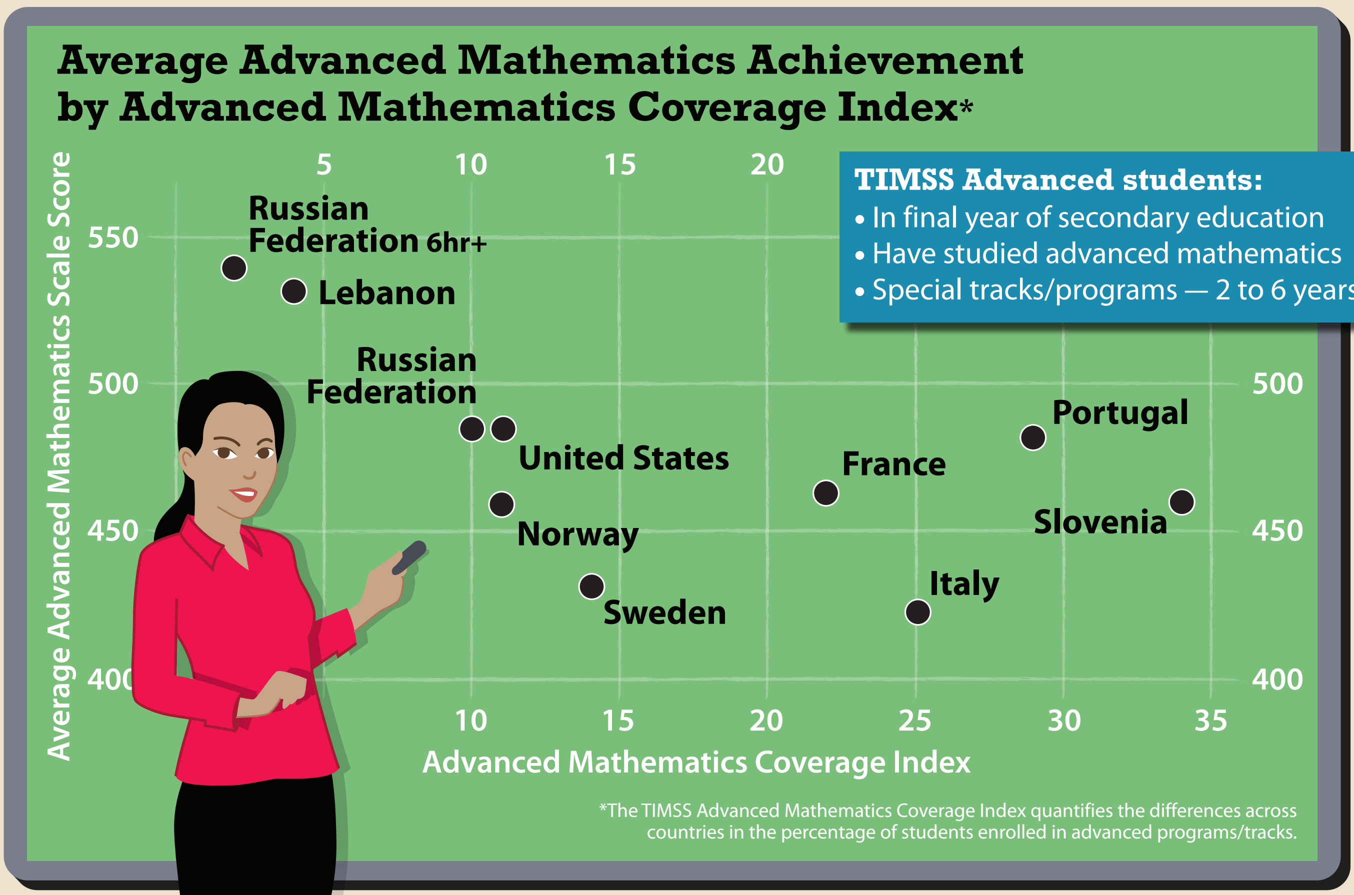
ADVANCED MATHEMATICS **TIMSS** *Advanced* **2015**

International Achievement in Advanced Mathematics



TIMSS Advanced students:

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

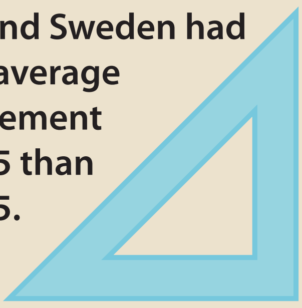
*The TIMSS Advanced Mathematics Coverage Index quantifies the differences across countries in the percentage of students enrolled in advanced programs/tracks.

In today's technological world, countries need STEM experts. The big question: How many to educate at how high a level?

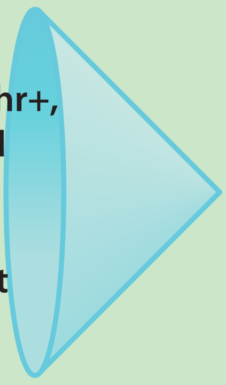
- The **2%** of Russian students in intensive study (6 hours-plus per week) and the **4%** of Lebanese students in TIMSS Advanced had the highest achievement
- The Russian Federation, with a total of **10%** of its students in TIMSS Advanced, the United States with **11%**, and Portugal with **29%** (nearly 3 times that of Russia and the U.S.) had the next highest achievement
- Norway (**11%**), France (**22%**), and Slovenia (**34%**) had comparable achievement
- Sweden (**14%**) and Italy (**25%**) had comparable achievement

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.



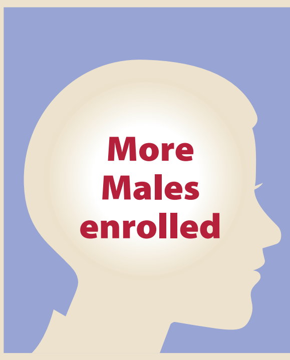
The Russian Federation 6hr+, Slovenia, and the United States had no significant difference.



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.



6 Countries
France, Sweden, Norway, Italy, Lebanon, the United States

2 Countries
Slovenia, Portugal

Males had higher achievement than **Females** in **6** countries.

6 Countries
Russian Federation, Norway, Sweden, France, Slovenia, the United States

0 Countries

SOURCE: IEA's Trends in International Mathematics and Science Study – TIMSS Advanced 2015.
http://timss2015.org/advanced/download-center/

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Lynch School of Education, Boston College

Exhibit M1.1: Structural Characteristics of the Advanced Mathematics Programs (Tracks)

Reported by National Research Coordinators

Country	Description of How the Programs (Tracks) Fit into the Overall Curriculum	Number of Years Students are Taught in These Programs (Tracks)	Number of Hours of Advanced Mathematics Instruction per Year	Criteria for Admission to These Programs (Tracks)	Prerequisites for Admission to These Programs (Tracks)
France	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.	2 years	173	Students' skills and attitudes towards science, their grades in mathematics and science, and teachers' and principals' opinions and reports all contribute.	Completion of Grade 10
Italy	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.	5 years	132	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.	No prerequisites
Lebanon	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.	6 years	250	Students must obtain a grade of 12 out of 20 or higher in mathematics in Grade 11.	Since the system is spiral, students are prepared from Grade 1 on to take the courses in advanced mathematics.
Norway	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.	2 years	140	Students must successfully complete a theoretical mathematics course in Grade 11.	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.
Portugal	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.	3 years	146	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.	No prerequisites

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

Exhibit M1.1: Structural Characteristics of the Advanced Mathematics Programs (Tracks) (Continued)

Country	Description of How the Programs (Tracks) Fit into the Overall Curriculum	Number of Years Students are Taught in These Programs (Tracks)	Number of Hours of Advanced Mathematics Instruction per Year	Criteria for Admission to These Programs (Tracks)	Prerequisites for Admission to These Programs (Tracks)
Russian Federation The TIMSS Advanced 2015 mathematics students assessed in the Russian Federation include both the Profile and Intensive streams of students. However, results also are provided separately for the students in the Intensive stream because this is the group of students assessed in TIMSS Advanced 1995 and TIMSS Advanced 2008. The results for the Intensive stream students are designated Russian Federation 6hr+.	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.	2 years	158 (Profile) 210 (Intensive)	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.	No prerequisites
Slovenia	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. All general gymnasia students study the same mathematics course during their 4-year program.	4 years	105	Completion of elementary schooling.	No prerequisites

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

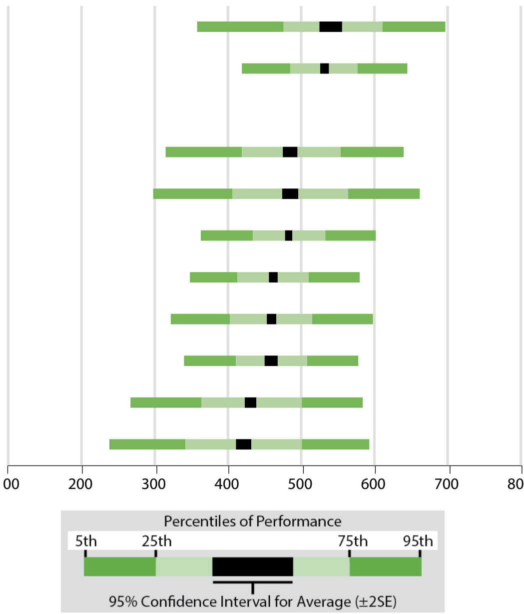
Exhibit M1.1: Structural Characteristics of the Advanced Mathematics Programs (Tracks) (Continued)

Country	Description of How the Programs (Tracks) Fit into the Overall Curriculum	Number of Years Students are Taught in These Programs (Tracks)	Number of Hours of Advanced Mathematics Instruction per Year	Criteria for Admission to These Programs (Tracks)	Prerequisites for Admission to These Programs (Tracks)
Sweden	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.	3 years	Varying, but approximately 150 on average	Completion of 9-year compulsory school with passing grades in Swedish, English, mathematics, biology, physics, chemistry, and at least six other subjects.	No prerequisites
United States	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.	Varies by school and by course	Varies by school and by course	Varies by district and school	Varies by school and by course

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

Exhibit M1.2: Distribution of Advanced Mathematics Achievement

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



▲ Country average significantly higher than TIMSS scale centerpoint

▼ Country average significantly lower than TIMSS scale centerpoint

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

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

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

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.

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.

Average Advanced Mathematics Achievement by Advanced Mathematics Coverage Index*

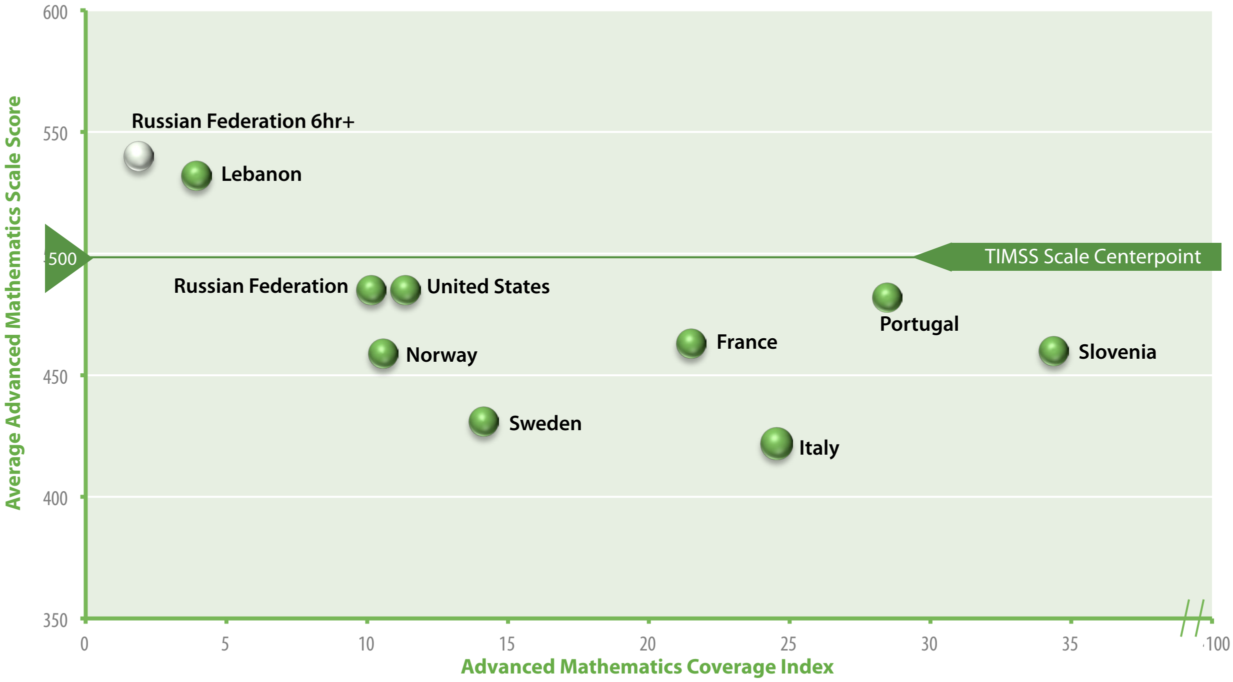


Exhibit M1.3: Multiple Comparisons of Average Advanced Mathematics Achievement

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.

Country	Average Scale Score	Russian Federation 6hr+	Lebanon	United States	Russian Federation	Portugal	France	Slovenia	Norway	Sweden	Italy
Russian Federation 6hr+	540 (7.8)			▲	▲	▲	▲	▲	▲	▲	▲
Lebanon	532 (3.1)			▲	▲	▲	▲	▲	▲	▲	▲
United States	485 (5.2)	▼	▼				▲	▲	▲	▲	▲
Russian Federation	485 (5.7)	▼	▼				▲	▲	▲	▲	▲
Portugal	482 (2.5)	▼	▼				▲	▲	▲	▲	▲
France	463 (3.1)	▼	▼	▼	▼	▼				▲	▲
Slovenia	460 (3.4)	▼	▼	▼	▼	▼				▲	▲
Norway	459 (4.6)	▼	▼	▼	▼	▼				▲	▲
Sweden	431 (4.0)	▼	▼	▼	▼	▼	▼	▼	▼		
Italy	422 (5.3)	▼	▼	▼	▼	▼	▼	▼	▼		

▲ 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.

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

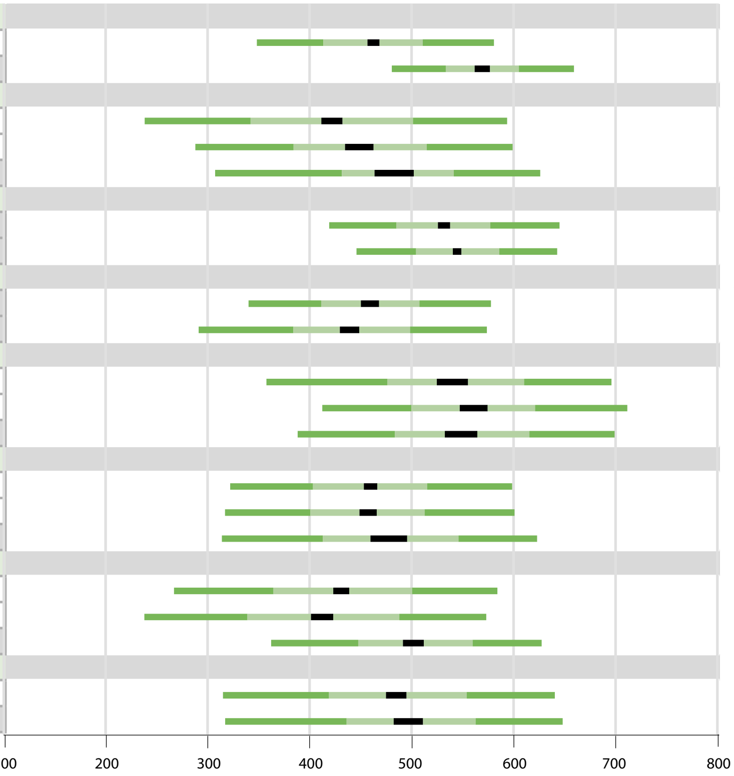
SOURCE: IEA's Trends in International Mathematics and Science Study – TIMSS Advanced 2015

Exhibit 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.

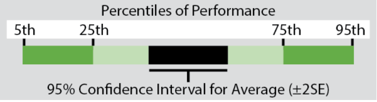
Country	Advanced Mathematics Coverage Index*	Average Scale Score	Differences Between Years	
			2008	1995
France				
2015	21.5%	463 (3.1)		-107 ▼
1995	19.9%	569 (3.9)		
Italy				
2015	24.5%	422 (5.3)	-27 ▼	-61 ▼
2008	19.7%	449 (7.2)		-34 ▼
1 ‡ 1995	14.1%	483 (9.8)		
Lebanon				
‡ 2015	3.9%	532 (3.1)	-13 ▼	
2008	5.9%	545 (2.2)		
Norway				
2015	10.6%	459 (4.6)	20 ▲	
2008	10.9%	439 (4.9)		
Russian Federation 6hr+				
2015	1.9%	540 (7.8)	-21 ▼	-9
2008	1.4%	561 (7.0)		12
1995	2.0%	549 (8.2)		
Slovenia				
2015	34.4%	460 (3.4)	2	-18
2008	40.5%	457 (4.3)		-20 ▼
‡ 1995	75.4%	478 (9.3)		
Sweden				
2015	14.1%	431 (4.0)	19 ▲	-71 ▼
2008	12.8%	412 (5.6)		-89 ▼
1995	16.2%	502 (5.2)		
United States				
‡ 2015	11.4%	485 (5.2)		-12
‡ 1995	6.4%	497 (7.4)		

Advanced Mathematics Achievement Distribution



▲ More recent year significantly higher

▼ More recent year significantly lower



* 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.

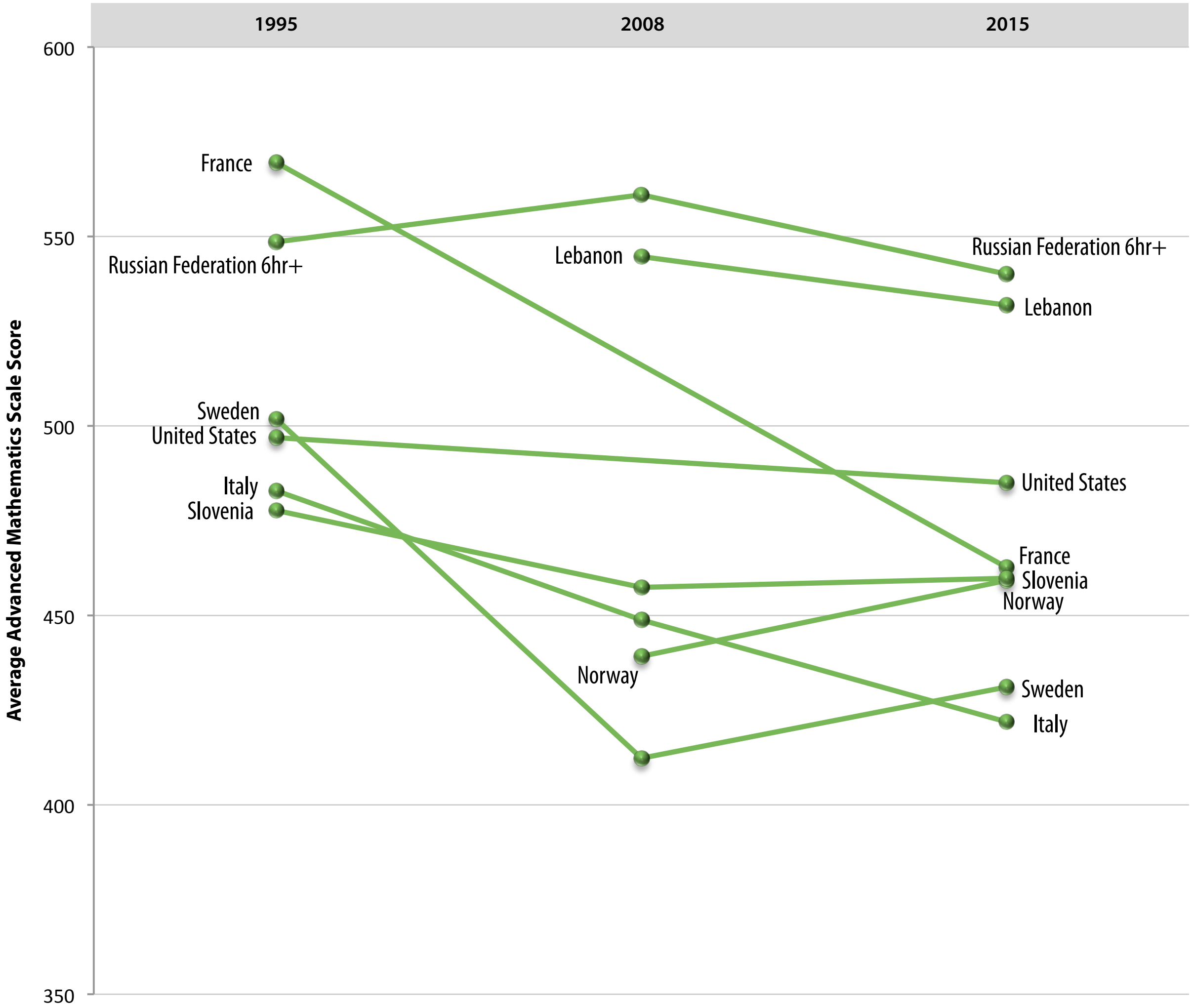
See Appendix MC.1 for target population coverage notes 1, 2, and 3.

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.

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

Exhibit M1.4: Differences in Advanced Mathematics Achievement Across Assessment Years (Continued)



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

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

Country	Achievement Difference from TIMSS Scale Centerpoint (500)	
Russian Federation	44 (4.9)	▲
United States	29 (2.5)	▲
Italy	7 (3.1)	▲
Sweden	3 (2.6)	
Slovenia	2 (1.8)	
Norway (4)	-27 (2.6)	▼
France	◊ ◊	
Lebanon	◊ ◊	

2011 - TIMSS Fourth Grade Mathematics

Country	Achievement Difference from TIMSS Scale Centerpoint (500)	
Russian Federation	42 (3.7)	▲
United States	41 (1.9)	▲
Slovenia	13 (2.1)	▲
Italy	8 (2.6)	▲
Sweden	4 (2.1)	
Norway (4)	-5 (2.8)	
France	◊ ◊	
Lebanon	◊ ◊	

2015 - TIMSS Fourth Grade Mathematics

Country	Achievement Difference from TIMSS Scale Centerpoint (500)	
Russian Federation	64 (3.4)	▲
United States	39 (2.3)	▲
Slovenia	20 (1.9)	▲
Sweden	19 (2.8)	▲
Italy	7 (2.6)	▲
Norway (4)	-7 (2.3)	▼
France	-12 (2.9)	▼
Lebanon	◊ ◊	

2007 - TIMSS Eighth Grade Mathematics

Country	Achievement Difference from TIMSS Scale Centerpoint (500)	
Russian Federation	12 (4.0)	▲
United States	8 (2.9)	▲
Slovenia	1 (2.2)	
Sweden	-9 (2.3)	▼
Italy	-20 (3.1)	▼
Norway (8)	-31 (2.0)	▼
Lebanon	-51 (4.1)	▼
France	◊ ◊	

2011 - TIMSS Eighth Grade Mathematics

Country	Achievement Difference from TIMSS Scale Centerpoint (500)	
Russian Federation	39 (3.6)	▲
United States	9 (2.7)	▲
Slovenia	5 (2.2)	▲
Italy	-2 (2.3)	
Sweden	-16 (1.9)	▼
Norway (8)	-25 (2.5)	▼
Lebanon	-51 (3.9)	▼
France	◊ ◊	

2015 - TIMSS Eighth Grade Mathematics

Country	Achievement Difference from TIMSS Scale Centerpoint (500)	
Russian Federation	38 (4.7)	▲
United States	18 (3.1)	▲
Slovenia	16 (2.1)	▲
Sweden	1 (2.8)	
Italy	-6 (2.5)	▼
Norway (8)	-13 (2.0)	▼
Lebanon	-58 (3.6)	▼
France	◊ ◊	

2008 - TIMSS Advanced Advanced Mathematics

Country	Achievement Difference from TIMSS Scale Centerpoint (500)	
Russian Federation 6hr+	61 (7.0)	▲
Lebanon	45 (2.2)	▲
Slovenia	-43 (4.3)	▼
Italy	-51 (7.2)	▼
Norway	-61 (4.9)	▼
Sweden	-88 (5.6)	▼
France	◊ ◊	
Russian Federation	◊ ◊	
United States	◊ ◊	

2015 - TIMSS Advanced Advanced Mathematics

Country	Achievement Difference from TIMSS Scale Centerpoint (500)	
Russian Federation 6hr+	40 (7.8)	▲
Lebanon	32 (3.1)	▲
United States	-15 (5.2)	▼
Russian Federation	-15 (5.7)	▼
France	-37 (3.1)	▼
Slovenia	-40 (3.4)	▼
Norway	-41 (4.6)	▼
Sweden	-69 (4.0)	▼
Italy	-78 (5.3)	▼

▲ 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.

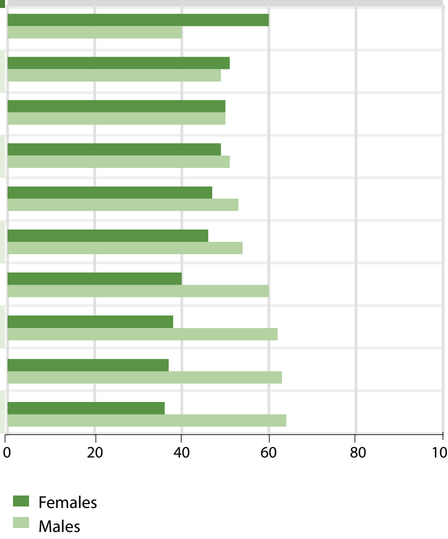
* TIMSS 2007 data from: *TIMSS 2007 International Mathematics Report*
TIMSS 2011 data from: *TIMSS 2011 International Results in Mathematics*
TIMSS 2015 data from: *TIMSS 2015 International Results in Mathematics*
TIMSS Advanced 2008 data from: *TIMSS Advanced 2008 International Report*

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

Exhibit M1.6: Advanced Mathematics Participation and Average Achievement by Gender

Participation in Advanced Mathematics by Gender

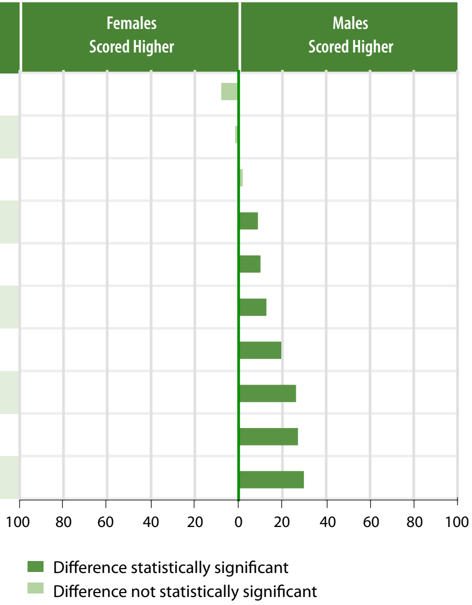
Country	Percent of Students	
	Females	Males
Slovenia	60 (1.1)	40 (1.1)
† Portugal	51 (1.2)	49 (1.2)
Russian Federation	50 (1.3)	50 (1.3)
‡ United States	49 (0.9)	51 (0.9)
France	47 (1.1)	53 (1.1)
Russian Federation 6hr+	46 (1.1)	54 (1.1)
Sweden	40 (1.2)	60 (1.2)
Norway	38 (1.4)	62 (1.4)
Italy	37 (1.3)	63 (1.3)
‡ Lebanon	36 (2.0)	64 (2.0)



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

Average Advanced Mathematics Achievement by Gender

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



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.

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.

Country		Females				Males			
		Percent of Students	Average Scale Score	Differences Between Years		Percent of Students	Average Scale Score	Differences Between Years	
				2008	1995			2008	1995
France									
	2015	47 (1.1)	449 (3.1)		-112 ▼	53 (1.1)	475 (3.4)		-100 ▼
	1995	37 (2.0)	561 (4.8)			63 (2.0)	575 (4.6)		
Italy									
	2015	37 (1.3)	427 (6.1)	-27 ▼	-50 ▼	63 (1.3)	419 (6.6)	-27 ▼	-68 ▼
	2008	34 (2.5)	454 (9.5)		-23	66 (2.5)	446 (8.3)		-41 ▼
1 ‡	1995	39 (3.8)	477 (12.5)			61 (3.8)	487 (11.6)		
Lebanon									
‡	2015	36 (2.0)	533 (4.8)	-21 ▼		64 (2.0)	531 (3.9)	-10 ▼	
	2008	29 (1.6)	554 (3.1)			71 (1.6)	541 (2.5)		
Norway									
	2015	38 (1.4)	453 (5.1)	19 ▲		62 (1.4)	463 (5.2)	21 ▲	
	2008	38 (1.7)	434 (5.3)			62 (1.7)	442 (5.6)		
Russian Federation 6hr+									
	2015	46 (1.1)	530 (9.0)	-21	4	54 (1.1)	549 (7.5)	-20	-21
	2008	45 (1.8)	551 (7.5)		25 ▲	55 (1.8)	569 (7.3)		0
	1995	48 (2.4)	526 (9.1)			52 (2.4)	570 (8.7)		
Slovenia									
	2015	60 (1.1)	449 (3.5)	1	-20	40 (1.1)	476 (4.9)	4	-10
	2008	60 (1.8)	448 (5.3)		-21	40 (1.8)	472 (4.7)		-14
‡	1995	50 (4.2)	469 (11.4)			50 (4.2)	486 (11.1)		
Sweden									
	2015	40 (1.2)	424 (5.1)	20 ▲	-68 ▼	60 (1.2)	436 (4.6)	18 ▲	-70 ▼
	2008	40 (2.1)	404 (6.6)		-88 ▼	60 (2.1)	418 (6.5)		-88 ▼
	1995	31 (3.5)	492 (4.8)			69 (3.5)	506 (6.9)		
United States									
‡	2015	49 (0.9)	470 (5.3)		-16	51 (0.9)	500 (6.4)		-7
‡	1995	47 (3.2)	486 (10.1)			53 (3.2)	507 (7.6)		

▲ 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.

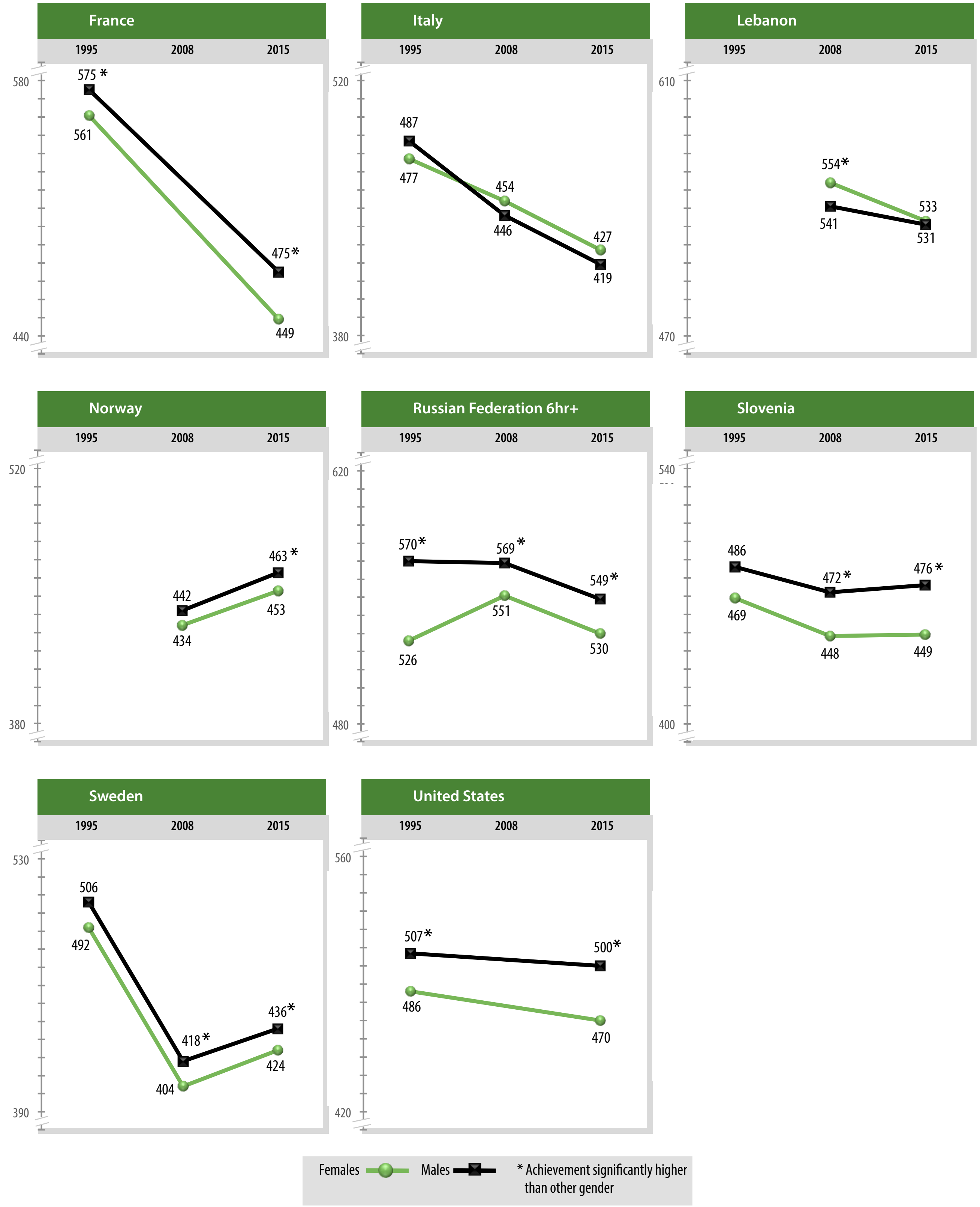
See Appendix MC.5 for sampling guidelines and sampling participation notes †, ‡, and ‡.

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

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

Exhibit M1.7: Differences in Advanced Mathematics Achievement by Gender Across Assessment Years (Continued)

Trends in Advanced Mathematics Achievement by Gender



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

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.

TIMSS
Advanced
2015

CHAPTER M2: PERFORMANCE AT INTERNATIONAL BENCHMARKS

TIMSS ADVANCED 2015 INTERNATIONAL RESULTS IN ADVANCED MATHEMATICS AND PHYSICS

IEA
TIMSS & PIRLS
International Study Center
Lynch School of Education, Boston College

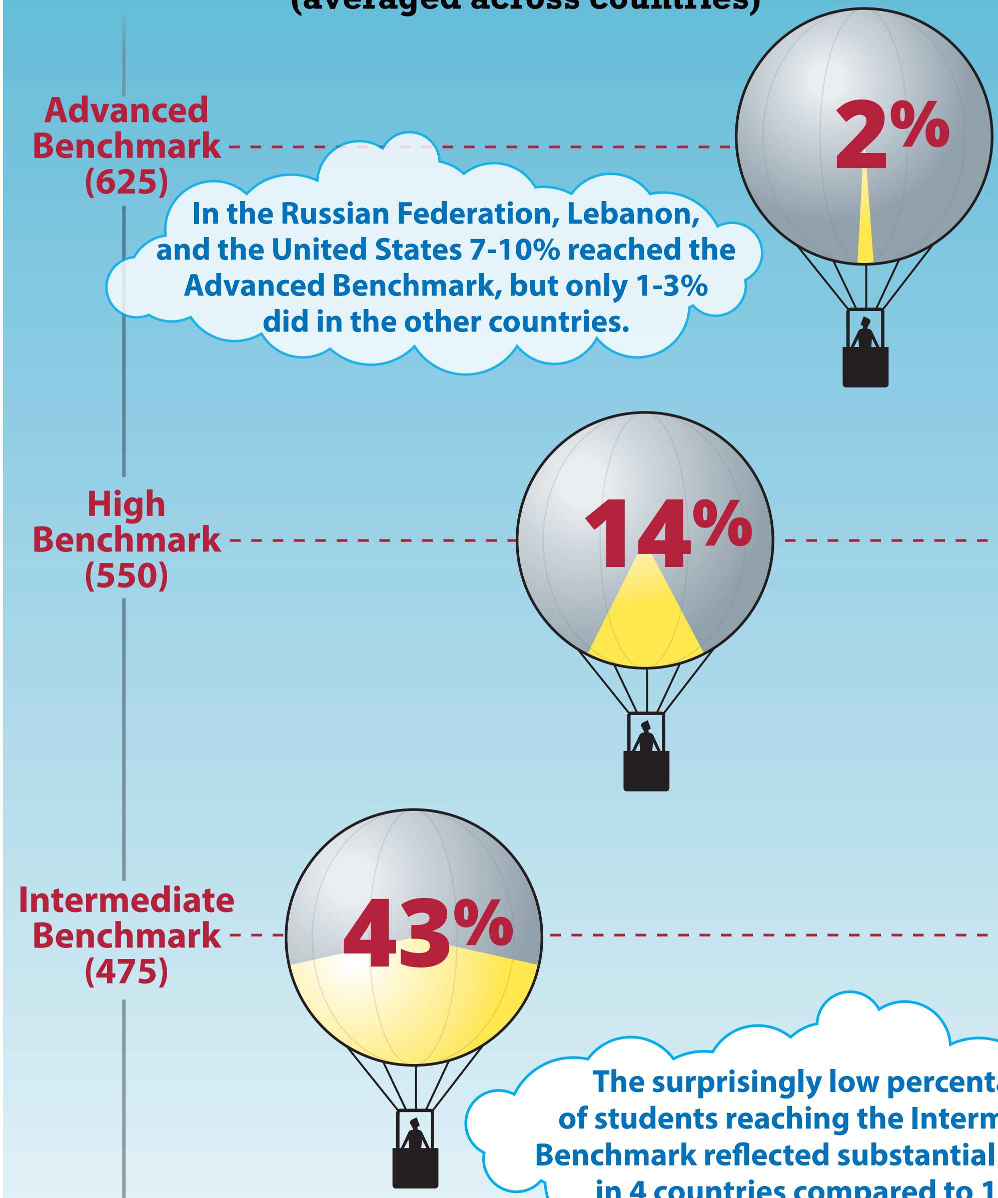
ADVANCED MATHEMATICS

TIMSS
Advanced
2015

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)



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

Advanced Benchmark (625) – 2%: 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.

High Benchmark (550) – 14%: 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.

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

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

SOURCE: IEA's Trends in International Mathematics and Science Study – TIMSS Advanced 2015.
http://timss2015.org/advanced/download-center/

IEA
TIMSS & PIRLS
International Study Center
Lynch School of Education, Boston College

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.

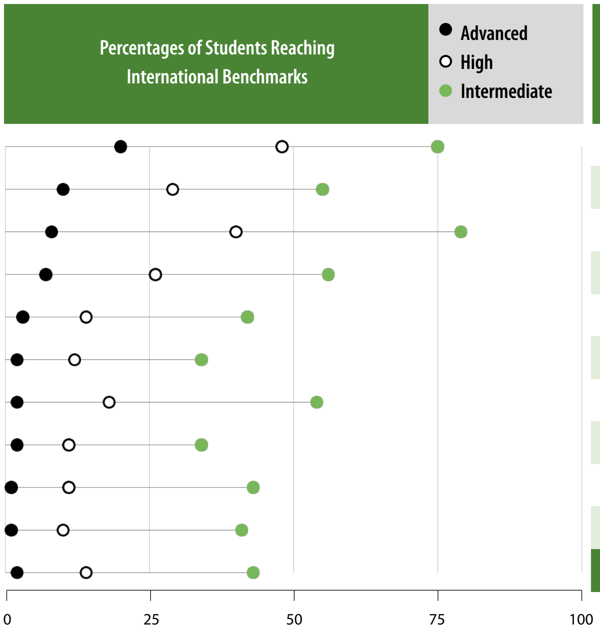
Students can apply and transform a formula to solve a word problem. They can determine a term in a geometric sequence and analyze a proposed solution of a simple logarithmic equation. They can recognize a graph of the absolute value of a function and identify and evaluate composite functions.

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.

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

Exhibit M2.2: Performance at the International Benchmarks of Advanced Mathematics Achievement



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

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

* 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

Country	Advanced International Benchmark (625)			High International Benchmark (550)			Intermediate International Benchmark (475)		
	Percent of Students			Percent of Students			Percent of Students		
	2015	2008	1995	2015	2008	1995	2015	2008	1995
Russian Federation 6hr+	20	24	22	48	55	51	75	83 ▼	78
Lebanon	8	9		40	47 ▼		79	88 ▼	
United States	7		8	26		30	56		62
Slovenia	3	3	5	14	14	23 ▼	42	41	54 ▼
Italy	2	3	5	12	14	22 ▼	34	41 ▼	59 ▼
Sweden	2	1	6 ▼	11	9	30 ▼	34	29	64 ▼
France	1		15 ▼	11		64 ▼	43		96 ▼
Norway	1	1		10	9		41	35	

▲ 2015 percent significantly higher

▼ 2015 percent significantly lower

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

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.

Exhibit M2.4: Description of the TIMSS Advanced 2015 Intermediate International Benchmark (475) of Advanced Mathematics Achievement

475 Intermediate International Benchmark

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.

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

Exhibit M2.4.1: Intermediate International Benchmark – Example Item 1

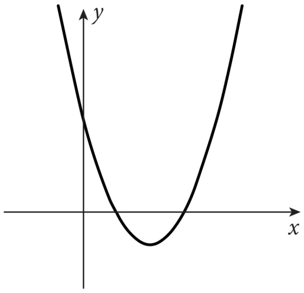
Country	Percent Correct	
Slovenia	88 (1.6)	▲
† Portugal	86 (1.4)	▲
Russian Federation 6hr+	84 (2.2)	▲
Russian Federation	71 (2.2)	▲
‡ Lebanon	70 (2.9)	
International Avg.	65 (0.7)	
France	62 (1.5)	▼
Italy	60 (2.5)	▼
Norway	54 (2.1)	▼
‡ United States	54 (2.5)	▼
Sweden	43 (2.8)	▼

Content Domain: Algebra

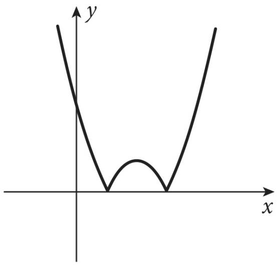
Cognitive Domain: Knowing

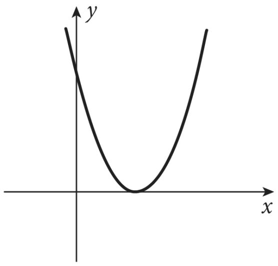
Description: Recognizes the graph of the absolute value of a function given the graph of the function

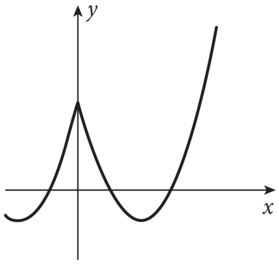
The graph of $y = f(x)$ is shown here.

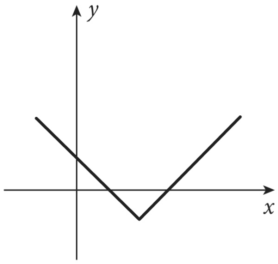


Which one of the following graphs shows $y = |f(x)|$?

●


Ⓑ


Ⓒ


Ⓓ


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

▲ 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 M2.4.1: Intermediate International Benchmark – Example Item 1 (Continued)

Country	Percent of Students Responding to Each Answer Option				
	A	B	C	D	NR*
Slovenia	88 (1.6)	6 (1.1)	4 (0.7)	1 (0.3)	0 (0.3)
† Portugal	86 (1.4)	7 (1.0)	2 (0.4)	5 (0.7)	0 (0.2)
Russian Federation 6hr+	84 (2.2)	3 (0.8)	6 (1.9)	6 (1.4)	0 (0.1)
Russian Federation	71 (2.2)	12 (1.5)	6 (0.9)	10 (1.2)	0 (0.1)
‡ Lebanon	70 (2.9)	21 (2.6)	5 (1.3)	3 (1.1)	1 (0.4)
France	62 (1.5)	23 (1.3)	2 (0.4)	12 (0.9)	1 (0.3)
Italy	60 (2.5)	25 (2.2)	8 (1.1)	4 (0.7)	3 (0.7)
Norway	54 (2.1)	29 (1.6)	6 (0.7)	9 (1.1)	3 (0.4)
‡ United States	54 (2.5)	14 (1.7)	1 (0.5)	29 (2.0)	1 (0.5)
Sweden	43 (2.8)	20 (1.6)	9 (1.0)	26 (1.9)	1 (0.3)

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

* 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

Country	Percent Correct	
Russian Federation 6hr+	79 (1.9)	▲
Russian Federation	71 (1.8)	▲
‡ United States	61 (2.0)	▲
Norway	59 (2.2)	▲
Slovenia	57 (2.4)	▲
International Avg.	50 (0.7)	
‡ Lebanon	47 (3.7)	
† Portugal	45 (1.7)	▼
Sweden	45 (1.3)	▼
Italy	36 (1.8)	▼
France	34 (1.4)	▼

Content Domain: Algebra

Cognitive Domain: Knowing

Description: Determines which term has a given value in a geometric sequence

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

Ⓐ t_6

● t_7

Ⓒ t_8

Ⓓ t_{81}

▲ 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.

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

Exhibit M2.4.2: Intermediate International Benchmark – Example Item 2 (Continued)

Country	Percent of Students Responding to Each Answer Option				
	A	B	C	D	NR*
Russian Federation 6hr+	9 (1.1)	79 (1.9)	3 (0.6)	8 (1.2)	1 (0.2)
Russian Federation	11 (1.0)	71 (1.8)	5 (0.5)	13 (1.4)	1 (0.2)
‡ United States	14 (1.4)	61 (2.0)	8 (1.1)	12 (1.2)	6 (2.1)
Norway	15 (1.3)	59 (2.2)	7 (1.1)	16 (1.4)	3 (0.6)
Slovenia	11 (1.0)	57 (2.4)	8 (1.2)	19 (1.7)	5 (0.9)
‡ Lebanon	24 (2.7)	47 (3.7)	4 (0.9)	19 (2.5)	6 (1.0)
† Portugal	10 (1.2)	45 (1.7)	12 (1.0)	24 (1.6)	9 (0.8)
Sweden	14 (1.0)	45 (1.3)	12 (1.0)	24 (1.2)	6 (0.8)
Italy	13 (1.4)	36 (1.8)	11 (1.2)	27 (1.7)	14 (1.3)
France	31 (1.5)	34 (1.4)	5 (0.7)	26 (1.5)	3 (0.5)

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

* 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

Country	Percent Correct	
France	80 (1.1)	▲
Norway	79 (1.7)	▲
Russian Federation 6hr+	77 (1.9)	▲
Russian Federation	74 (1.7)	▲
‡ Lebanon	72 (2.6)	▲
† Portugal	71 (1.5)	▲
International Avg.	62 (0.6)	
‡ United States	59 (2.6)	
Slovenia	47 (1.7)	▼
Sweden	37 (1.4)	▼
Italy	37 (1.7)	▼

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 $\vec{b} = \begin{pmatrix} 0 \\ 3 \end{pmatrix}$.

Ⓐ $\begin{pmatrix} -4 \\ -2 \end{pmatrix}$

● $\begin{pmatrix} -4 \\ 1 \end{pmatrix}$

Ⓒ $\begin{pmatrix} 4 \\ -1 \end{pmatrix}$

Ⓓ $\begin{pmatrix} 4 \\ 2 \end{pmatrix}$

Ⓔ $\begin{pmatrix} 4 \\ 5 \end{pmatrix}$

▲ 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.

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

Exhibit M2.4.3: Intermediate International Benchmark – Example Item 3 (Continued)

Country	Percent of Students Responding to Each Answer Option					
	A	B	C	D	E	NR*
France	1 (0.2)	80 (1.1)	12 (0.9)	1 (0.2)	1 (0.3)	5 (0.7)
Norway	1 (0.2)	79 (1.7)	14 (1.4)	1 (0.3)	1 (0.4)	4 (0.7)
Russian Federation 6hr+	1 (0.2)	77 (1.9)	18 (1.4)	1 (0.3)	2 (0.3)	2 (0.4)
Russian Federation	1 (0.3)	74 (1.7)	20 (1.4)	1 (0.4)	3 (0.6)	2 (0.3)
‡ Lebanon	2 (1.1)	72 (2.6)	13 (2.1)	2 (0.3)	2 (0.7)	9 (1.9)
† Portugal	1 (0.2)	71 (1.5)	22 (1.1)	1 (0.3)	1 (0.2)	5 (0.7)
‡ United States	2 (0.7)	59 (2.6)	30 (2.2)	2 (0.6)	3 (0.9)	4 (1.0)
Slovenia	4 (0.7)	47 (1.7)	32 (1.9)	8 (1.1)	3 (0.5)	6 (0.9)
Sweden	4 (0.6)	37 (1.4)	29 (1.0)	9 (0.8)	7 (0.9)	14 (1.2)
Italy	3 (0.7)	37 (1.7)	28 (1.7)	7 (1.0)	5 (0.7)	20 (1.3)

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

* 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.

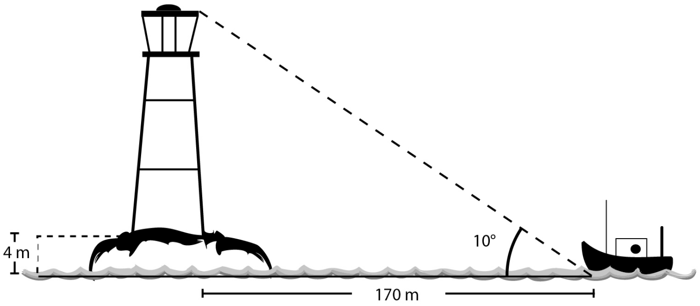
Exhibit M2.4.4: Intermediate International Benchmark – Example Item 4

Country	Percent Correct	
Sweden	65 (1.3)	▲
† Portugal	65 (1.7)	▲
Norway	63 (1.7)	▲
Russian Federation 6hr+	62 (2.9)	
‡ Lebanon	61 (2.3)	
Slovenia	59 (2.0)	
International Avg.	58 (0.6)	
‡ United States	58 (2.5)	
Russian Federation	53 (2.1)	▼
France	52 (1.5)	▼
Italy	50 (1.8)	▼

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?

Ⓐ 22 m

● 26 m

Ⓒ 30 m

Ⓓ 34 m

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

▲ 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 M2.4.4: Intermediate International Benchmark – Example Item 4 (Continued)

Country	Percent of Students Responding to Each Answer Option				
	A	B	C	D	NR*
Sweden	5 (0.7)	65 (1.3)	18 (1.0)	5 (0.7)	7 (0.8)
† Portugal	5 (0.6)	65 (1.7)	16 (1.2)	8 (1.0)	7 (0.7)
Norway	4 (0.8)	63 (1.7)	19 (1.3)	5 (0.7)	8 (1.1)
Russian Federation 6hr+	9 (1.3)	62 (2.9)	14 (1.4)	7 (0.9)	8 (1.2)
‡ Lebanon	2 (0.9)	61 (2.3)	18 (1.8)	6 (1.4)	11 (1.9)
Slovenia	4 (0.6)	59 (2.0)	21 (1.6)	5 (0.9)	11 (1.1)
‡ United States	5 (0.9)	58 (2.5)	20 (1.8)	8 (0.9)	10 (2.3)
Russian Federation	11 (1.0)	53 (2.1)	18 (1.4)	10 (1.3)	8 (1.1)
France	6 (0.7)	52 (1.5)	25 (1.2)	8 (0.8)	11 (0.9)
Italy	10 (1.0)	50 (1.8)	21 (1.6)	8 (1.0)	11 (1.2)

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

* 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

550 High International Benchmark ○

Summary

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.

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

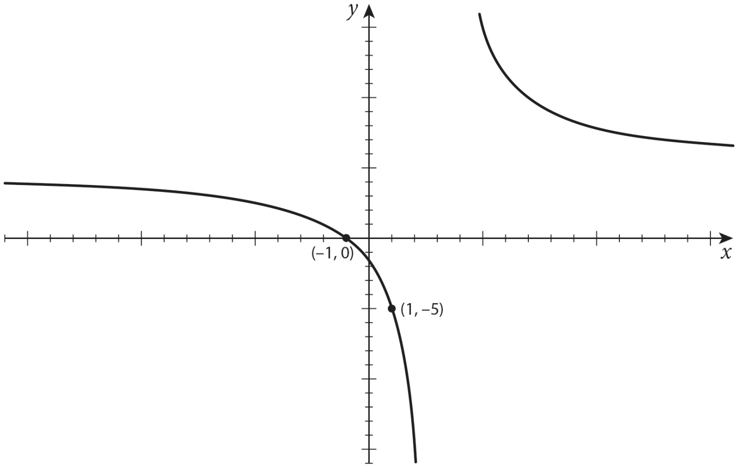
Exhibit M2.5.1: High International Benchmark – Example Item 1

Country	Percent Full Credit
‡ Lebanon	65 (3.3) ▲
Russian Federation 6hr+	58 (3.1) ▲
Russian Federation	41 (2.1) ▲
Italy	36 (2.0)
Slovenia	34 (2.0)
International Avg.	33 (0.7)
† Portugal	31 (1.6)
‡ United States	26 (2.3) ▼
France	26 (1.4) ▼
Norway	22 (1.7) ▼
Sweden	18 (1.1) ▼

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 $f(x)=\dfrac{ax+5}{x+b}$ is shown above. Find the values of a and b.

$a =$ 5

$b =$ -3

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

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

▲ 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

Code	Response	Item: MA33179
	Correct Response	
10	$a = 5$ $b = -3$	
	Incorrect Response	
70	$a = 5$ correct only	
71	$b = -3$ correct only	
79	Other incorrect (including crossed out, erased, stray marks, illegible, or off task)	
	Nonresponse	
NR	No Response	

Country	Percent of Students in Each Scoring Guide Category				
	Correct Student Response	Incorrect Student Responses			
	10	70	71	79	NR*
‡ Lebanon	65 (3.3)	16 (2.0)	0 (0.2)	12 (2.7)	7 (1.7)
Russian Federation 6hr+	58 (3.1)	12 (1.2)	0 (0.1)	14 (1.4)	16 (2.9)
Russian Federation	41 (2.1)	14 (1.4)	1 (0.2)	23 (1.7)	22 (1.6)
Italy	36 (2.0)	13 (1.2)	0 (0.2)	21 (1.7)	31 (2.2)
Slovenia	34 (2.0)	28 (2.5)	0 (0.2)	30 (1.5)	8 (1.2)
† Portugal	31 (1.6)	20 (1.4)	2 (0.4)	32 (1.7)	16 (1.3)
‡ United States	26 (2.3)	16 (1.4)	1 (0.4)	48 (2.1)	9 (1.2)
France	26 (1.4)	13 (0.9)	1 (0.4)	34 (1.5)	26 (1.5)
Norway	22 (1.7)	15 (1.0)	2 (0.4)	38 (2.0)	23 (1.3)
Sweden	18 (1.1)	12 (0.8)	2 (0.4)	48 (1.4)	21 (1.4)

* 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.

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

Exhibit M2.5.2: High International Benchmark – Example Item 2

Country	Percent Full Credit	
Sweden	57 (1.4)	▲
Russian Federation 6hr+	55 (3.0)	▲
Norway	51 (2.0)	▲
† Portugal	43 (1.7)	
‡ United States	41 (2.4)	
International Avg.	41 (0.7)	
Russian Federation	39 (1.9)	
‡ Lebanon	36 (2.7)	
France	32 (1.6)	▼
Slovenia	32 (1.8)	▼
Italy	32 (1.9)	▼

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 cm^3 of soup. He wants to change the diameter of the cans, leaving the height unchanged so that they will hold 750 cm^3 of soup. What will the new diameter be?

Show your work.

$$V_1 = \pi r_1^2 h \qquad V_2 = \pi r_2^2 h$$

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

$$r_2^2 = \frac{V_2}{V_1} r_1^2 = \frac{750}{600}(3^2)$$

$$= \frac{5}{4}(3^2)$$

$$= \frac{3\sqrt{5}}{2}$$

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.

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

▲ 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 ‡.

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Exhibit M2.5.2: High International Benchmark – Example Item 2 (Continued)

Scoring Guide

Code	Response	Item: MA23187
	Correct Response	
20	Any of $3\sqrt{5}$ cm, 6.72 cm, 6.7 cm, or other equivalent with correct work	
21	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	
	Partially Correct Response	
10	Correct method but numerical error	
11	A correct equation for finding the new diameter is given but there is a subsequent error	
12	Code 10 or code 11, but using calculator	
	Incorrect Response	
70	Calculator used—answer incorrect or explanation inadequate	
79	Other incorrect (including crossed out, erased, stray marks, illegible, or off task)	
	Nonresponse	
NR	No Response	

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

Country	Percent of Students in Each Scoring Guide Category							
	Correct Student Responses					Incorrect Student Responses		
	20	21	10	11	12	70	79	NR*
Sweden	57 (1.4)	0 (0.1)	8 (1.0)	1 (0.2)	0 (0.0)	0 (0.0)	25 (1.0)	8 (0.8)
Russian Federation 6hr+	54 (3.0)	1 (0.4)	12 (1.4)	0 (0.2)	0 (0.1)	0 (0.1)	20 (1.9)	12 (1.8)
Norway	51 (2.0)	0 (0.2)	9 (1.0)	15 (1.3)	0 (0.0)	0 (0.0)	17 (1.7)	8 (1.0)
† Portugal	43 (1.7)	0 (0.1)	5 (0.7)	9 (0.9)	0 (0.0)	0 (0.1)	35 (1.6)	8 (0.9)
‡ United States	40 (2.5)	1 (0.4)	12 (1.8)	6 (1.0)	0 (0.2)	0 (0.1)	36 (2.7)	4 (1.0)
Russian Federation	39 (1.9)	1 (0.4)	11 (1.3)	1 (0.3)	0 (0.1)	0 (0.1)	31 (1.5)	17 (1.5)
‡ Lebanon	36 (2.7)	0 (0.0)	11 (1.9)	2 (0.7)	0 (0.0)	0 (0.0)	32 (2.6)	19 (2.1)
France	32 (1.6)	0 (0.0)	10 (0.8)	2 (0.4)	0 (0.1)	0 (0.2)	42 (1.6)	14 (1.2)
Slovenia	32 (1.8)	0 (0.0)	16 (1.9)	17 (1.5)	0 (0.1)	0 (0.0)	27 (2.0)	7 (0.8)
Italy	32 (1.9)	0 (0.0)	3 (0.7)	6 (0.8)	0 (0.0)	0 (0.1)	35 (2.0)	24 (1.8)

* 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

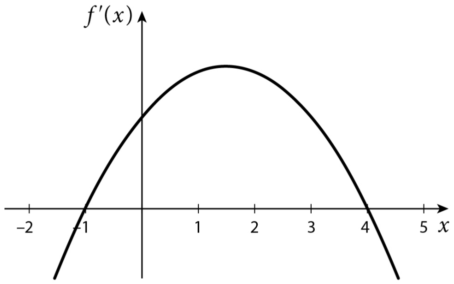
Country	Percent Correct
Russian Federation 6hr+	69 (2.8) ▲
‡ Lebanon	60 (2.8) ▲
‡ United States	58 (2.8) ▲
Russian Federation	58 (2.4) ▲
† Portugal	54 (1.7) ▲
Norway	53 (2.3)
France	50 (1.6)
International Avg.	50 (0.7)
Sweden	49 (1.5)
Slovenia	34 (2.1) ▼
Italy	32 (1.7) ▼

Content Domain: Calculus

Cognitive Domain: Reasoning

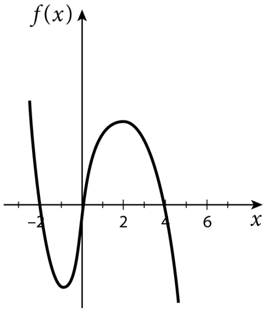
Description: Identifies the graph of a function given the graph of its first derivative

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

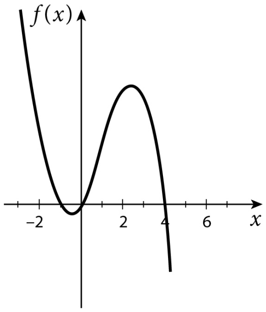


Which graph best represents the function f ?

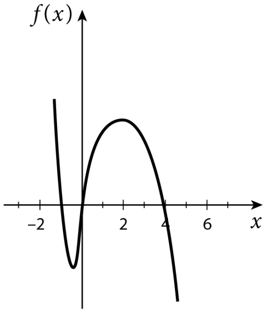
Ⓐ



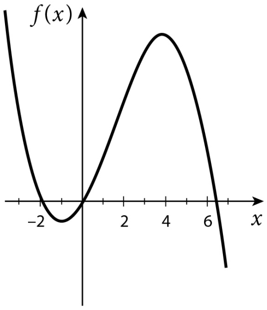
Ⓑ



Ⓒ



●



▲ 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.

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

Exhibit M2.5.3: High International Benchmark – Example Item 3 (Continued)

Country	Percent of Students Responding to Each Answer Option				
	A	B	C	D	NR*
Russian Federation 6hr+	7 (1.2)	13 (1.9)	8 (1.0)	69 (2.8)	4 (0.8)
‡ Lebanon	7 (1.5)	15 (2.1)	11 (1.7)	60 (2.8)	8 (1.6)
‡ United States	9 (1.0)	21 (1.6)	7 (1.1)	58 (2.8)	5 (2.0)
Russian Federation	8 (1.0)	17 (1.2)	14 (1.3)	58 (2.4)	4 (0.6)
† Portugal	7 (1.0)	23 (1.5)	11 (1.0)	54 (1.7)	5 (0.6)
Norway	11 (1.2)	21 (2.1)	9 (1.1)	53 (2.3)	7 (0.8)
France	9 (0.9)	23 (1.2)	13 (1.0)	50 (1.6)	5 (0.7)
Sweden	11 (1.1)	22 (1.1)	11 (0.8)	49 (1.5)	7 (0.7)
Slovenia	13 (1.2)	31 (1.5)	17 (1.6)	34 (2.1)	5 (1.0)
Italy	10 (1.1)	28 (1.6)	17 (1.3)	32 (1.7)	13 (1.2)

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

* 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.

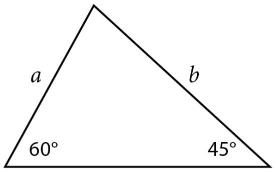
Exhibit M2.5.4: High International Benchmark – Example Item 4

Country	Percent Correct
Russian Federation 6hr+	69 (2.5) ▲
‡ Lebanon	62 (3.4) ▲
Russian Federation	59 (1.5) ▲
‡ United States	43 (2.7)
Italy	42 (2.0)
International Avg.	42 (0.7)
Slovenia	38 (1.5) ▼
Norway	35 (1.6) ▼
Sweden	34 (1.4) ▼
† Portugal	33 (1.4) ▼
France	29 (1.4) ▼

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 $\frac{a^2}{b^2}$?

● $\frac{2}{3}$

Ⓑ $\frac{3}{2}$

Ⓒ $\frac{2}{\sqrt{3}}$

Ⓓ $\frac{\sqrt{2}}{\sqrt{3}}$

▲ 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.

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

Exhibit M2.5.4: High International Benchmark – Example Item 4 (Continued)

Country	Percent of Students Responding to Each Answer Option				
	A	B	C	D	NR*
Russian Federation 6hr+	69 (2.5)	12 (1.4)	9 (1.3)	6 (0.9)	4 (0.9)
‡ Lebanon	62 (3.4)	12 (1.9)	8 (1.6)	4 (1.2)	14 (2.2)
Russian Federation	59 (1.5)	16 (1.0)	11 (0.9)	10 (1.0)	4 (0.7)
‡ United States	43 (2.7)	14 (1.3)	20 (1.9)	12 (1.6)	11 (2.5)
Italy	42 (2.0)	18 (1.3)	14 (1.5)	12 (1.2)	14 (1.2)
Slovenia	38 (1.5)	21 (1.5)	18 (1.4)	13 (1.2)	11 (1.0)
Norway	35 (1.6)	13 (1.3)	21 (1.7)	17 (1.2)	14 (1.0)
Sweden	34 (1.4)	14 (1.0)	21 (1.3)	19 (1.3)	12 (1.0)
† Portugal	33 (1.4)	24 (1.2)	17 (1.4)	10 (1.2)	16 (1.1)
France	29 (1.4)	19 (1.2)	20 (1.3)	12 (0.9)	20 (1.3)

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

* 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

Country	Percent Full Credit	
Russian Federation 6hr+	52 (3.3)	▲
‡ Lebanon	45 (3.2)	▲
‡ United States	36 (2.6)	▲
Russian Federation	32 (1.9)	▲
† Portugal	30 (1.8)	
Norway	28 (2.4)	
International Avg.	27 (0.7)	
Slovenia	20 (1.7)	▼
Sweden	18 (1.0)	▼
Italy	17 (1.6)	▼
France	13 (1.0)	▼

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

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

What is the maximum number of animals?

Indicate one of the times at which the maximum occurs.

Maximum number of animals:

$P(t) =$ 1500

One time at which maximum occurs:

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

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 π/6 (or equivalent).

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

▲ 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 M2.5.5: High International Benchmark – Example Item 5 (Continued)

Scoring Guide

Code	Response	Item: MA33232
	Correct Response	
20	$P(t) = 1500$ $t = \frac{\pi}{6}$ (or any other value of the type $\frac{\pi}{6} + 2k\pi$)	
	Partially Correct Response	
10	$P(t)$ correct only	
11	t correct only	
	Incorrect Response	
79	Incorrect (including crossed out, erased, stray marks, illegible, or off task)	
	Nonresponse	
NR	No Response	

Country	Percent of Students in Each Scoring Guide Category				
	Correct Student Responses			Incorrect Student Responses	
	20	10	11	79	NR*
Russian Federation 6hr+	52 (3.3)	8 (1.2)	2 (0.5)	11 (1.2)	28 (3.1)
‡ Lebanon	45 (3.2)	9 (1.7)	4 (2.1)	17 (2.5)	26 (2.2)
‡ United States	36 (2.6)	10 (1.3)	6 (1.2)	32 (2.5)	16 (1.7)
Russian Federation	32 (1.9)	11 (1.1)	2 (0.8)	14 (1.2)	41 (1.7)
† Portugal	30 (1.8)	12 (1.2)	3 (1.1)	26 (1.5)	30 (1.8)
Norway	28 (2.4)	21 (1.2)	2 (0.8)	23 (1.5)	27 (1.8)
Slovenia	20 (1.7)	9 (1.0)	2 (0.5)	28 (1.7)	40 (2.0)
Sweden	18 (1.0)	32 (1.6)	1 (0.2)	26 (1.1)	23 (1.5)
Italy	17 (1.6)	4 (0.6)	2 (0.6)	16 (1.5)	60 (2.1)
France	13 (1.0)	22 (1.1)	0 (0.2)	25 (1.5)	39 (1.5)

* 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.

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

Exhibit M2.6: Description of the TIMSS Advanced 2015 Advanced International Benchmark (625) of Advanced Mathematics Achievement

625 Advanced International Benchmark ●

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.

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

Exhibit M2.6.1: Advanced International Benchmark – Example Item 1

Country	Percent Full Credit	
Russian Federation 6hr+	50 (2.8)	▲
‡ Lebanon	39 (2.6)	▲
Russian Federation	35 (1.9)	▲
Italy	29 (1.6)	▲
Slovenia	26 (1.7)	▲
International Avg.	20 (0.5)	
† Portugal	13 (1.1)	▼
Norway	11 (1.2)	▼
Sweden	9 (1.1)	▼
France	8 (1.0)	▼
‡ United States	7 (1.0)	▼

Content Domain: Algebra

Cognitive Domain: Applying

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

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

$y = 10^6 ax$ and $y = \frac{x^2}{10^6}$ intersect.

Answer: $x = 0$, $x = 10^{12} a$

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 $x = 10^{12}a$.

▲ 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.

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

Exhibit M2.6.1: Advanced International Benchmark – Example Item 1 (Continued)

Scoring Guide

Code	Response	Item: MA33121
	Correct Response	
20	$x = 0$ and $x = 10^{12}a$	
	Partially Correct Response	
10	$x = 0$ correct only	
11	$x = 10^{12}a$ correct only	
	Incorrect Response	
79	Incorrect (including crossed out, erased, stray marks, illegible, or off task)	
	Nonresponse	
NR	No Response	

Country	Percent of Students in Each Scoring Guide Category				
	Correct Student Responses			Incorrect Student Responses	
	20	10	11	79	NR*
Russian Federation 6hr+	50 (2.8)	11 (1.4)	4 (0.8)	14 (2.9)	21 (2.8)
‡ Lebanon	39 (2.6)	9 (1.7)	22 (2.7)	19 (2.8)	11 (2.2)
Russian Federation	35 (1.9)	13 (1.6)	3 (0.4)	15 (1.5)	33 (1.7)
Italy	29 (1.6)	8 (0.8)	5 (0.7)	15 (1.4)	43 (2.3)
Slovenia	26 (1.7)	9 (0.9)	17 (1.7)	37 (2.1)	11 (1.2)
† Portugal	13 (1.1)	12 (0.9)	15 (1.1)	28 (1.4)	32 (1.9)
Norway	11 (1.2)	15 (1.6)	11 (1.4)	26 (2.2)	38 (2.5)
Sweden	9 (1.1)	10 (0.7)	10 (0.9)	34 (1.5)	37 (1.5)
France	8 (1.0)	11 (0.7)	11 (1.0)	29 (1.4)	41 (1.3)
‡ United States	7 (1.0)	22 (1.5)	16 (1.6)	42 (2.1)	13 (1.3)

* 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.

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

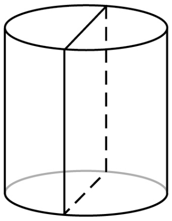
Exhibit M2.6.2: Advanced International Benchmark – Example Item 2

Country	Percent Correct	
Russian Federation 6hr+	52 (2.4)	▲
Russian Federation	45 (1.7)	▲
Slovenia	35 (1.8)	▲
‡ United States	31 (1.9)	
Sweden	31 (1.2)	
International Avg.	30 (0.6)	
Italy	29 (1.8)	
† Portugal	28 (1.6)	
Norway	28 (1.6)	
France	25 (1.3)	▼
‡ Lebanon	19 (1.7)	▼

Content Domain: Calculus

Cognitive Domain: Applying

Description: Maximizes the volume of a cylinder given a relationship between its height and diameter



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

Ⓐ 2.5 m

Ⓑ 2 m

Ⓒ 1.5 m

● 1 m

Ⓔ 0.5 m

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

▲ 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 M2.6.2: Advanced International Benchmark – Example Item 2 (Continued)

Country	Percent of Students Responding to Each Answer Option					
	A	B	C	D	E	NR*
Russian Federation 6hr+	9 (1.0)	14 (1.8)	9 (1.5)	52 (2.4)	13 (2.1)	3 (0.5)
Russian Federation	8 (0.9)	14 (1.1)	14 (1.4)	45 (1.7)	15 (1.2)	3 (0.5)
Slovenia	9 (1.1)	14 (1.0)	15 (1.2)	35 (1.8)	20 (2.0)	6 (0.9)
‡ United States	10 (1.5)	15 (1.5)	20 (1.5)	31 (1.9)	21 (2.2)	3 (0.8)
Sweden	10 (1.1)	20 (1.1)	15 (1.2)	31 (1.2)	13 (1.4)	10 (0.9)
Italy	7 (1.0)	15 (1.3)	16 (1.1)	29 (1.8)	17 (1.3)	16 (1.3)
† Portugal	6 (1.0)	12 (1.1)	15 (1.2)	28 (1.6)	29 (1.4)	9 (0.9)
Norway	10 (1.0)	18 (1.5)	16 (1.4)	28 (1.6)	19 (1.4)	9 (1.1)
France	13 (1.0)	22 (1.0)	17 (1.2)	25 (1.3)	14 (1.0)	10 (0.8)
‡ Lebanon	15 (1.9)	13 (2.0)	17 (2.1)	19 (1.7)	9 (1.5)	27 (2.9)

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

* 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 M2.6.3: Advanced International Benchmark – Example Item 3

Country	Percent Full Credit	
‡ United States	37 (2.8)	▲
Sweden	23 (1.3)	▲
Russian Federation 6hr+	22 (2.2)	▲
‡ Lebanon	20 (2.8)	
Norway	20 (2.3)	
International Avg.	16 (0.6)	
Russian Federation	16 (1.5)	
Slovenia	15 (1.2)	
France	7 (0.8)	▼
Italy	6 (1.0)	▼
† Portugal	1 (0.3)	▼

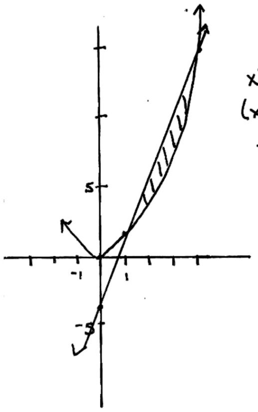
Content Domain: Calculus

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.



$x^2 = 5x - 4$

$x^2 - 5x + 4 = 0$

$(x-4)(x-1) = 0$

$x = 1, 4$

$A = \int_1^4 (5x - 4 - x^2)\,dx$

$A = \frac{5}{2}x^2 - 4x - \frac{x^3}{3} \Big|_1^4$

$A = (40 - 16 - \frac{64}{3}) - (\frac{5}{2} - 4 - \frac{1}{3})$

$A = \frac{9}{2}$

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

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.

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

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

Scoring Guide

Code	Response	Item: MA23043
	Correct Response	
20	Integrations and subtraction shown correctly to give area of $4\frac{1}{2}$, $\frac{9}{2}$, 4.5, or equivalent Note: No need to explicitly show how points of intersection of the two functions was determined	
21	Correct solution by use of calculator. Calculator use is described in examples	
	Partially Correct Response	
10	Correct method with computation error	
11	Correct method using calculator but correct answer not given	
12	$-4\frac{1}{2}$ or equivalent with correct method shown	
	Incorrect Response	
70	Calculator used—answer incorrect or explanation inadequate	
79	Other incorrect (including crossed out, erased, stray marks, illegible, or off task)	
	Nonresponse	
NR	No Response	

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

Country	Percent of Students in Each Scoring Guide Category							
	Correct Student Responses					Incorrect Student Responses		
	20	21	10	11	12	70	79	NR*
‡ United States	24 (2.1)	14 (1.6)	13 (1.3)	2 (0.5)	1 (0.3)	1 (0.3)	35 (2.5)	11 (1.7)
Sweden	16 (1.1)	6 (0.7)	6 (0.8)	0 (0.3)	1 (0.2)	3 (0.6)	36 (1.4)	32 (1.6)
Russian Federation 6hr+	22 (2.2)	0 (0.1)	8 (1.1)	0 (0.1)	1 (0.4)	0 (0.1)	38 (2.2)	32 (3.1)
‡ Lebanon	20 (2.6)	1 (0.7)	15 (2.0)	0 (0.0)	1 (0.5)	0 (0.0)	43 (2.8)	20 (3.2)
Norway	16 (2.0)	4 (0.9)	10 (1.2)	0 (0.0)	1 (0.5)	2 (0.5)	29 (1.5)	38 (2.4)
Russian Federation	16 (1.5)	0 (0.1)	5 (0.8)	0 (0.0)	0 (0.2)	0 (0.0)	34 (1.9)	45 (2.0)
Slovenia	15 (1.2)	0 (0.1)	15 (1.9)	0 (0.1)	2 (0.5)	0 (0.1)	55 (2.0)	13 (1.5)
France	5 (0.8)	1 (0.3)	2 (0.5)	0 (0.2)	1 (0.4)	2 (0.4)	40 (1.7)	47 (1.6)
Italy	6 (1.0)	0 (0.1)	8 (1.0)	0 (0.0)	1 (0.2)	0 (0.0)	32 (1.7)	54 (2.0)
† Portugal	0 (0.1)	1 (0.3)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.2)	48 (1.8)	51 (1.8)

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

Country	Percent Correct	
Russian Federation 6hr+	56 (2.7)	▲
Russian Federation	45 (1.9)	▲
Slovenia	43 (2.2)	▲
Sweden	41 (1.6)	
Norway	40 (2.2)	
† Portugal	39 (2.0)	
‡ United States	39 (2.1)	
International Avg.	39 (0.7)	
France	34 (1.6)	▼
Italy	34 (2.0)	▼
‡ Lebanon	32 (2.2)	▼

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

Ⓐ $\left|\vec{a}\right| = \left|\vec{b}\right|$

Ⓑ $\vec{a}$ and $\vec{b}$ are parallel vectors.

● $\vec{a}$ and $\vec{b}$ are perpendicular vectors.

Ⓓ $\vec{a}+\vec{b} = \vec{0}$

▲ 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.

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

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

Country	Percent of Students Responding to Each Answer Option				
	A	B	C	D	NR*
Russian Federation 6hr+	9 (1.4)	21 (2.0)	56 (2.7)	9 (1.0)	5 (1.0)
Russian Federation	11 (1.0)	27 (1.7)	45 (1.9)	11 (1.2)	5 (0.7)
Slovenia	10 (1.0)	27 (1.5)	43 (2.2)	14 (1.2)	6 (0.8)
Sweden	11 (0.9)	30 (1.3)	41 (1.6)	10 (0.9)	8 (0.7)
Norway	10 (0.9)	31 (1.8)	40 (2.2)	13 (1.2)	6 (1.0)
† Portugal	11 (1.2)	28 (1.6)	39 (2.0)	13 (1.2)	9 (0.9)
‡ United States	9 (1.1)	36 (2.2)	39 (2.1)	9 (1.2)	7 (2.2)
France	14 (1.0)	28 (1.6)	34 (1.6)	15 (1.0)	9 (0.9)
Italy	14 (1.3)	30 (1.7)	34 (2.0)	9 (1.0)	13 (1.2)
‡ Lebanon	13 (2.1)	28 (2.9)	32 (2.2)	13 (2.1)	14 (2.0)

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

* 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.

TIMSS
Advanced
2015

CHAPTER M3: ACHIEVEMENT IN CONTENT AND COGNITIVE DOMAINS

TIMSS ADVANCED 2015 INTERNATIONAL RESULTS IN ADVANCED MATHEMATICS AND PHYSICS

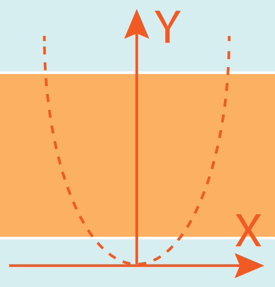
IEA
TIMSS & PIRLS
International Study Center
Lynch School of Education, Boston College

ADVANCED MATHEMATICS **TIMSS** *Advanced* **2015**

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



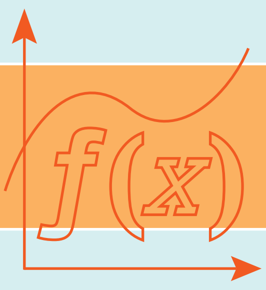
Relative Strength

4 Countries
Russian Federation, Portugal, France, and Slovenia

Relative Weakness

4 Countries
The United States, Norway, Sweden, and Italy

Calculus



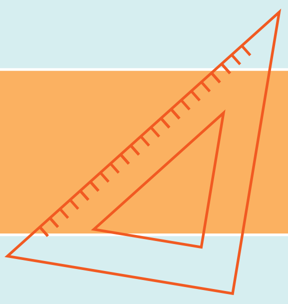
Relative Strength

5 Countries
Lebanon, the United States, Norway, Sweden, and Italy

Relative Weakness

3 Countries
Russian Federation, Portugal, and Slovenia

Geometry



Relative Strength

2 Countries
Russian Federation and Norway

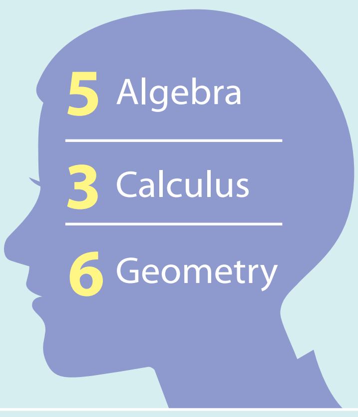
Relative Weakness

6 Countries
Lebanon, the United States, Portugal, France, Slovenia, and Italy

Differences reflected in Achievement by Gender

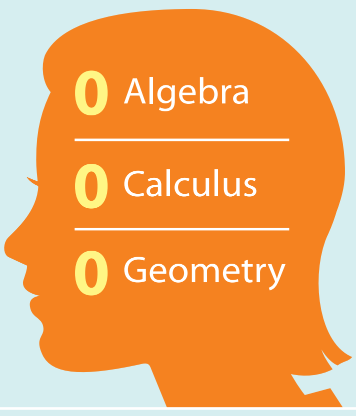
Achievement differences in content domains by gender reflect males' higher achievement in 6 countries in mathematics overall.

Number of Countries where Males had higher achievement than Females



5 Algebra
3 Calculus
6 Geometry

Number of Countries where Females had higher achievement than Males



0 Algebra
0 Calculus
0 Geometry

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

Relative Weakness

3 Countries
Russian Federation, Norway, and Sweden

Applying

Relative Strength

2 Countries
Russian Federation and Slovenia

Relative Weakness

3 Countries
The United States, Portugal, and France

Reasoning

Relative Strength

3 Countries
Portugal, Norway, and Sweden

Relative Weakness

3 Countries
Lebanon, Slovenia, and Italy

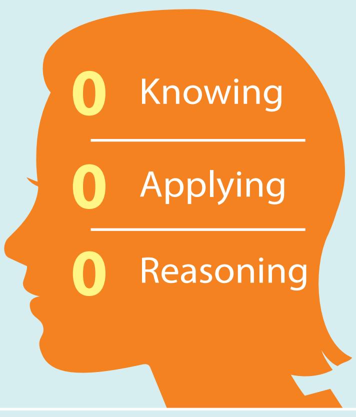
Differences reflected in Achievement by Gender

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.

Number of Countries where Males had higher achievement than Females

5 Knowing
3 Applying
6 Reasoning

Number of Countries where Females had higher achievement than Males



0 Knowing
0 Applying
0 Reasoning

SOURCE: IEA's Trends in International Mathematics and Science Study – TIMSS Advanced 2015.
http://timss2015.org/advanced/download-center/

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Exhibit M3.1: Achievement in Advanced Mathematics Content Domains

Country	Overall Advanced Mathematics Average Scale Score	Algebra (37 items)		Calculus (34 items)		Geometry (30 items)	
		Average Scale Score	Difference from Overall Advanced Mathematics Score	Average Scale Score	Difference from Overall Advanced Mathematics Score	Average Scale Score	Difference from Overall Advanced Mathematics Score
Russian Federation 6hr+	540 (7.8)	556 (9.0)	16 (3.9) ▲	513 (8.0)	-27 (2.3) ▼	560 (8.4)	20 (3.2) ▲
‡ Lebanon	532 (3.1)	525 (4.0)	-6 (3.6)	544 (3.9)	12 (2.8) ▲	526 (3.7)	-6 (2.3) ▼
‡ United States	485 (5.2)	478 (5.0)	-7 (1.7) ▼	504 (6.0)	19 (2.9) ▲	455 (5.7)	-30 (2.6) ▼
Russian Federation	485 (5.7)	495 (6.3)	10 (1.9) ▲	459 (5.9)	-26 (1.2) ▼	500 (5.8)	15 (1.0) ▲
† Portugal	482 (2.5)	495 (2.7)	12 (1.5) ▲	476 (2.6)	-6 (1.4) ▼	464 (3.2)	-18 (1.5) ▼
France	463 (3.1)	469 (2.9)	7 (1.8) ▲	466 (3.2)	3 (1.8)	441 (3.7)	-22 (1.3) ▼
Slovenia	460 (3.4)	474 (3.5)	14 (1.1) ▲	437 (4.4)	-23 (2.0) ▼	456 (4.0)	-4 (1.4) ▼
Norway	459 (4.6)	446 (4.1)	-13 (1.6) ▼	463 (5.3)	4 (1.5) ▲	473 (4.6)	14 (2.0) ▲
Sweden	431 (4.0)	422 (4.1)	-9 (1.2) ▼	438 (3.9)	7 (1.5) ▲	430 (3.7)	-1 (1.4)
Italy	422 (5.3)	414 (5.1)	-8 (2.2) ▼	433 (5.2)	11 (2.7) ▲	413 (5.7)	-9 (3.2) ▼

▲ Subscale score significantly higher than overall mathematics score

▼ Subscale score significantly lower than overall mathematics score

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.

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 M3.2: Achievement in Advanced Mathematics Content Domains by Gender

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

▲ Average significantly higher than other gender

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.

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 M3.3: Achievement in Advanced Mathematics Cognitive Domains

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

▲ Subscale score significantly higher than overall mathematics score

▼ Subscale score significantly lower than overall mathematics score

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.

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 M3.4: Achievement in Advanced Mathematics Cognitive Domains by Gender

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

▲ Average significantly higher than other gender

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.

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.

TIMSS
Advanced
2015

CHAPTER M4: HOME ENVIRONMENT AND FUTURE PLANS

TIMSS ADVANCED 2015 INTERNATIONAL RESULTS IN ADVANCED MATHEMATICS AND PHYSICS

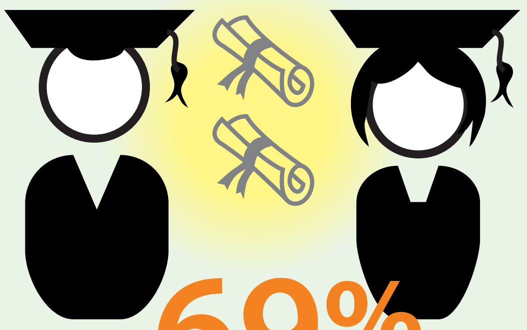
IEA
TIMSS & PIRLS
International Study Center
Lynch School of Education, Boston College

ADVANCED MATHEMATICS

TIMSS *Advanced* 2015

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.

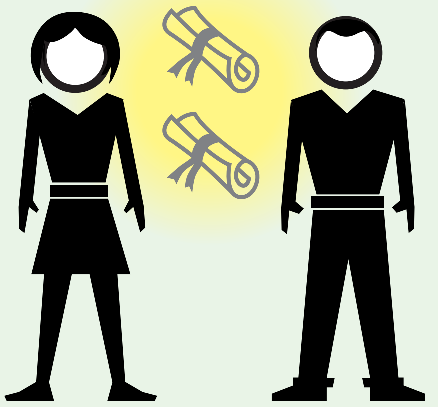


69%

of students expect to obtain an advanced degree

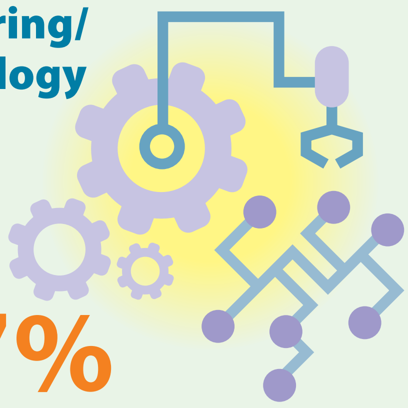
Higher percentages of the Females taking advanced mathematics than of the Males expect to obtain an advanced degree.

72% **66%**



The most popular areas of future study included:

Engineering/ Technnology



37%

Biological/ Biomedical

27%

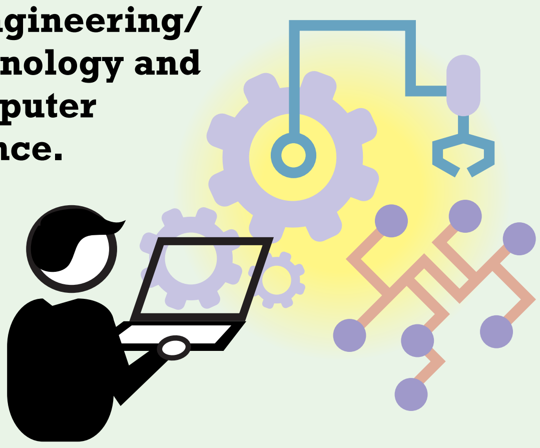
Education trailed behind (8%) as a future area of study.

Students' Plans for Future Professions

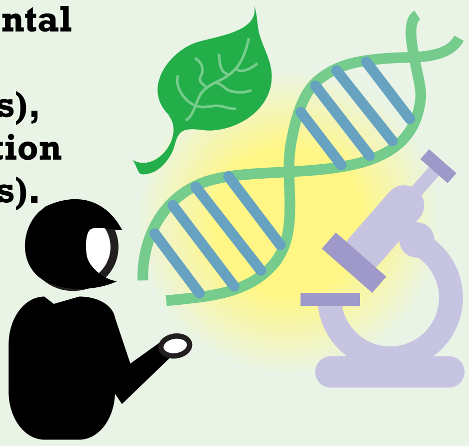
Students who studied advanced mathematics in secondary school reported considering a number of professions.

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).



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

http://timss2015.org/advanced/download-center/

IEA
TIMSS & PIRLS International Study Center
Lynch School of Education, Boston College

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.

Country	Many Resources		Some Resources		Few Resources		Average Scale Score
	Percent of Students	Average Achievement	Percent of Students	Average Achievement	Percent of Students	Average Achievement	
Norway	49 (2.3)	476 (4.1)	50 (2.1)	444 (4.9)	1 (0.2)	~ ~	11.2 (0.10)
Sweden	40 (1.5)	464 (4.7)	58 (1.4)	410 (4.4)	1 (0.2)	~ ~	10.7 (0.07)
United States	35 (1.9)	511 (6.5)	62 (1.8)	474 (5.4)	2 (0.4)	~ ~	10.5 (0.09)
Russian Federation 6hr+	30 (1.6)	567 (6.7)	70 (1.6)	529 (9.4)	0 (0.1)	~ ~	10.6 (0.06)
France	28 (1.1)	493 (3.7)	71 (1.1)	452 (3.2)	1 (0.3)	~ ~	10.2 (0.05)
Slovenia	23 (1.1)	489 (6.1)	77 (1.1)	452 (3.6)	0 (0.1)	~ ~	10.1 (0.06)
Portugal	20 (1.1)	513 (3.5)	73 (1.1)	476 (2.6)	7 (0.5)	461 (6.1)	9.3 (0.06)
Russian Federation	20 (1.0)	514 (5.2)	80 (1.0)	477 (6.2)	0 (0.1)	~ ~	10.1 (0.04)
Italy	16 (1.0)	471 (8.3)	79 (1.0)	416 (5.5)	5 (0.6)	347 (17.2)	9.3 (0.05)
Lebanon	8 (0.8)	546 (13.9)	82 (1.2)	535 (3.1)	10 (0.9)	496 (6.2)	8.7 (0.05)
International Avg.	27 (0.5)	497 (2.3)	70 (0.5)	460 (1.5)	3 (0.1)	435 (6.4)	

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.

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.

Number of books in the home:
1) 0-10
2) 11-25
3) 26-100
4) 101-200
5) More than 200

Number of home study supports:
1) None
2) Study desk/table or own room
3) Both

Highest level of education of either parent:
1) Finished some primary or lower secondary or did not go to school
2) Finished lower secondary
3) Finished upper secondary
4) Finished post-secondary education
5) Finished university or higher

Highest level of occupation of either parent:
1) Has never worked outside home for pay, general laborer, or semi-professional (skilled agricultural or fishery worker, craft or trade worker, plant or machine operator)
2) Clerical (clerk or service or sales worker)
3) Small business owner
4) Professional (corporate manager or senior official, professional, or technician or associate professional)

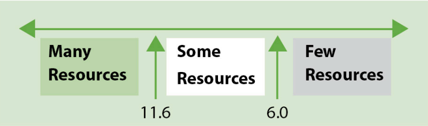


Exhibit M4.2: Students Working at a Paid Job on a Regular Basis During the School Year

Reported by Advanced Mathematics Students

Country	Time Spent Working at a Paid Job per Week							
	No Time		Less than 5 Hours		5 to10 Hours		More than 10 Hours	
	Percent of Students	Average Achievement	Percent of Students	Average Achievement	Percent of Students	Average Achievement	Percent of Students	Average Achievement
France	96 (0.3)	463 (3.1)	2 (0.2)	~ ~	1 (0.2)	~ ~	1 (0.1)	~ ~
Italy	91 (0.8)	423 (5.3)	3 (0.4)	440 (13.3)	4 (0.4)	414 (15.5)	3 (0.4)	388 (17.6)
Lebanon	92 (1.1)	536 (3.5)	2 (0.5)	~ ~	2 (0.5)	~ ~	3 (0.7)	508 (17.6)
Norway	47 (1.7)	467 (5.2)	13 (1.0)	467 (5.9)	23 (1.2)	457 (5.5)	18 (1.9)	439 (5.9)
Portugal	93 (0.5)	485 (2.5)	2 (0.3)	~ ~	3 (0.3)	467 (11.0)	3 (0.3)	443 (9.4)
Russian Federation	93 (0.4)	487 (5.7)	2 (0.2)	~ ~	2 (0.2)	~ ~	3 (0.2)	470 (9.8)
Russian Federation 6hr+	93 (0.6)	541 (7.7)	2 (0.4)	~ ~	2 (0.3)	~ ~	3 (0.4)	522 (17.2)
Slovenia	81 (0.8)	467 (3.2)	7 (0.5)	449 (8.0)	7 (0.5)	439 (8.3)	5 (0.5)	419 (8.2)
Sweden	71 (1.3)	430 (4.4)	11 (0.7)	450 (6.4)	13 (0.8)	443 (6.2)	6 (0.4)	411 (7.7)
United States	65 (1.8)	491 (6.4)	4 (0.5)	473 (15.4)	10 (1.0)	494 (9.1)	20 (1.2)	471 (7.0)
International Avg.	81 (0.4)	472 (1.5)	5 (0.2)	456 (4.7)	7 (0.2)	452 (4.0)	7 (0.3)	444 (4.0)

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.

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

Country	Always		Almost Always		Sometimes		Never	
	Percent of Students	Average Achievement	Percent of Students	Average Achievement	Percent of Students	Average Achievement	Percent of Students	Average Achievement
France	89 (0.9)	465 (2.9)	8 (0.7)	446 (7.4)	2 (0.3)	~ ~	1 (0.2)	~ ~
Italy	72 (1.4)	439 (4.9)	19 (1.2)	386 (8.2)	7 (0.7)	345 (15.1)	1 (0.3)	~ ~
Lebanon	5 (0.7)	527 (12.6)	12 (1.2)	540 (7.8)	65 (1.7)	529 (3.7)	19 (1.6)	538 (5.4)
Norway	85 (1.4)	462 (4.7)	9 (1.0)	449 (8.5)	4 (0.5)	433 (7.5)	2 (0.4)	~ ~
Portugal	91 (0.6)	483 (2.6)	7 (0.5)	478 (5.5)	2 (0.2)	~ ~	0 (0.1)	~ ~
Russian Federation	86 (1.2)	485 (5.7)	11 (0.8)	487 (9.1)	2 (0.6)	~ ~	0 (0.2)	~ ~
Russian Federation 6hr+	85 (1.2)	540 (8.4)	13 (1.0)	547 (8.5)	2 (0.3)	~ ~	0 (0.1)	~ ~
Slovenia	88 (0.7)	462 (3.6)	9 (0.7)	454 (8.0)	2 (0.3)	~ ~	1 (0.2)	~ ~
Sweden	78 (1.4)	444 (3.8)	12 (0.7)	401 (6.9)	8 (0.9)	368 (11.8)	2 (0.3)	~ ~
United States	74 (2.4)	491 (4.4)	16 (1.5)	484 (12.0)	8 (0.9)	463 (12.0)	3 (0.9)	423 (50.0)
International Avg.	74 (0.4)	473 (1.9)	12 (0.3)	458 (2.8)	11 (0.3)	428 (4.8)	3 (0.2)	481 (25.2)

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.

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

Exhibit M4.4: Students' Expectations for Further Education

Reported by Advanced Mathematics Students

Country	Doctoral Degree		Master's Degree		Bachelor's Degree		Post-Secondary Education but Not Bachelor's Degree		Upper-Secondary Education	
	Percent of Students	Average Achievement	Percent of Students	Average Achievement	Percent of Students	Average Achievement	Percent of Students	Average Achievement	Percent of Students	Average Achievement
Lebanon	58 (2.1)	538 (3.9)	35 (2.0)	530 (4.3)	4 (0.6)	515 (9.5)	2 (0.3)	~ ~	1 (0.4)	~ ~
Portugal	24 (0.9)	504 (3.2)	47 (0.9)	495 (3.0)	23 (0.8)	450 (4.1)	3 (0.3)	430 (8.2)	3 (0.4)	408 (8.2)
United States	23 (1.1)	478 (11.3)	49 (1.2)	494 (5.2)	27 (1.3)	477 (6.5)	0 (0.1)	~ ~	0 (0.1)	~ ~
France	21 (0.8)	476 (3.9)	54 (1.0)	475 (3.3)	13 (0.8)	433 (4.9)	11 (0.6)	421 (4.2)	2 (0.4)	~ ~
Slovenia	18 (1.5)	499 (6.3)	48 (1.0)	469 (3.2)	22 (1.1)	434 (5.0)	12 (0.9)	416 (6.7)	1 (0.2)	~ ~
Italy	14 (0.7)	464 (7.1)	19 (0.9)	434 (6.5)	41 (1.1)	442 (5.6)	15 (0.9)	378 (8.5)	11 (1.0)	337 (16.6)
Russian Federation 6hr+	12 (1.4)	586 (10.4)	62 (1.1)	545 (6.7)	25 (1.2)	512 (11.1)	1 (0.3)	~ ~	0 (0.1)	~ ~
Sweden	9 (0.7)	455 (8.4)	61 (1.1)	451 (4.1)	26 (1.1)	391 (4.9)	4 (0.5)	375 (9.8)	0 (0.1)	~ ~
Russian Federation	8 (0.6)	529 (9.9)	58 (1.1)	492 (5.4)	31 (1.0)	467 (7.3)	2 (0.3)	~ ~	1 (0.3)	~ ~
Norway	8 (0.8)	495 (5.6)	70 (1.7)	469 (4.8)	20 (1.5)	419 (4.7)	1 (0.4)	~ ~	1 (0.2)	~ ~
International Avg.	20 (0.4)	493 (2.4)	49 (0.4)	479 (1.5)	23 (0.4)	448 (2.0)	6 (0.2)	404 (3.4)	2 (0.1)	373 (9.2)

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

Students' Expectations for Further Education by Gender

Reported by Advanced Mathematics Students

Country	Doctoral Degree		Master's Degree		Bachelor's Degree		Post-Secondary Education but Not Bachelor's Degree		Upper-Secondary Education	
	Percent of Females	Percent of Males	Percent of Females	Percent of Males	Percent of Females	Percent of Males	Percent of Females	Percent of Males	Percent of Females	Percent of Males
Lebanon	65 (3.7) ▲	54 (2.3)	32 (3.6)	37 (2.2)	3 (0.8)	5 (0.7) ▲	0 (0.2)	2 (0.5) ▲	0 (0.2)	2 (0.6) ▲
Portugal	27 (1.3) ▲	21 (1.3)	49 (1.3) ▲	45 (1.2)	21 (1.1)	27 (1.2) ▲	1 (0.2)	4 (0.7) ▲	2 (0.4)	3 (0.6)
United States	25 (2.1)	21 (1.6)	51 (2.1)	48 (2.9)	24 (1.6)	30 (2.2) ▲	0 (0.1)	0 (0.2)	0 (0.1)	0 (0.1)
France	26 (1.2) ▲	16 (1.0)	47 (1.3)	60 (1.2) ▲	13 (1.0)	13 (1.0)	12 (1.0) ▲	9 (0.8)	1 (0.4)	2 (0.4)
Slovenia	17 (1.6)	19 (1.7)	53 (1.5) ▲	40 (1.4)	21 (1.4)	24 (1.4)	9 (1.2)	16 (1.3) ▲	0 (0.3)	1 (0.3)
Italy	13 (1.2)	14 (0.9)	26 (1.4) ▲	15 (1.0)	44 (1.6) ▲	38 (1.5)	14 (1.4)	16 (1.2)	3 (0.4)	17 (1.6) ▲
Russian Federation 6hr+	10 (1.0)	15 (2.0) ▲	64 (1.5)	60 (1.9)	26 (1.7)	24 (1.3)	1 (0.3)	1 (0.3)	0 (0.1)	0 (0.1)
Sweden	10 (1.1) ▲	7 (0.6)	63 (1.6)	59 (1.4)	25 (1.5)	27 (1.3)	2 (0.4)	6 (0.6) ▲	0 (0.1)	1 (0.2) ▲
Russian Federation	7 (0.7)	9 (0.8) ▲	59 (1.4)	57 (1.2)	31 (1.2)	30 (1.2)	2 (0.7)	2 (0.4)	1 (0.3)	1 (0.4)
Norway	8 (0.8)	8 (1.1)	75 (1.6) ▲	67 (2.1)	17 (1.5)	22 (2.0) ▲	0 (0.2)	2 (0.5) ▲	0 (0.2)	1 (0.3) ▲
International Avg.	22 (0.6) ▲	19 (0.5)	50 (0.6) ▲	47 (0.6)	22 (0.4)	24 (0.5) ▲	5 (0.3)	6 (0.3) ▲	1 (0.1)	3 (0.2) ▲

▲ Percent significantly higher than other gender

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.

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.

Country	Mathematics or Statistics		Physics		Engineering and Engineering Technologies		Computer and Information Sciences		Chemistry	
	Percent of Students	Average Achievement	Percent of Students	Average Achievement	Percent of Students	Average Achievement	Percent of Students	Average Achievement	Percent of Students	Average Achievement
France	15 (0.7)	520 (4.5)	14 (0.6)	512 (4.5)	23 (0.8)	499 (4.3)	12 (0.6)	490 (4.9)	11 (0.6)	485 (4.6)
Italy	9 (0.6)	473 (12.2)	6 (0.5)	514 (12.2)	25 (1.2)	467 (8.3)	7 (0.8)	429 (11.5)	8 (0.6)	445 (10.4)
Lebanon	23 (1.4)	529 (5.0)	18 (1.3)	531 (7.0)	75 (1.5)	539 (3.9)	12 (0.9)	530 (7.0)	5 (0.8)	525 (15.0)
Norway	31 (1.1)	491 (4.5)	33 (1.2)	494 (4.8)	68 (1.4)	466 (5.3)	23 (1.0)	466 (6.4)	15 (1.2)	477 (6.4)
Portugal	10 (0.6)	526 (4.2)	7 (0.6)	541 (6.2)	28 (1.3)	508 (3.7)	12 (0.8)	490 (7.0)	5 (0.5)	524 (6.6)
Russian Federation	28 (1.2)	529 (6.0)	28 (1.4)	520 (6.8)	27 (1.3)	511 (6.8)	24 (1.2)	519 (6.3)	9 (0.6)	498 (7.5)
Russian Federation 6hr+	41 (1.9)	575 (7.1)	36 (1.4)	572 (7.3)	34 (1.4)	562 (7.2)	32 (1.4)	573 (6.7)	7 (1.0)	539 (14.0)
Slovenia	6 (0.5)	528 (8.6)	5 (0.5)	523 (7.4)	14 (1.0)	485 (4.3)	8 (0.6)	486 (7.6)	7 (0.7)	500 (6.6)
Sweden	18 (0.9)	487 (4.9)	15 (0.9)	492 (5.9)	47 (0.9)	453 (4.3)	18 (1.1)	429 (5.8)	9 (0.5)	451 (8.0)
United States	26 (1.1)	512 (10.8)	15 (1.0)	525 (16.7)	28 (1.6)	523 (5.9)	17 (1.4)	502 (14.8)	14 (1.0)	524 (9.3)
International Avg.	18 (0.3)	511 (2.4)	16 (0.3)	517 (2.9)	37 (0.4)	494 (1.8)	15 (0.3)	482 (2.8)	9 (0.3)	492 (2.9)

Country	Biological and Biomedical Sciences		Education		Business		Other	
	Percent of Students	Average Achievement	Percent of Students	Average Achievement	Percent of Students	Average Achievement	Percent of Students	Average Achievement
France	40 (1.0)	449 (3.1)	7 (0.5)	452 (5.9)	14 (0.6)	458 (5.1)	30 (0.9)	448 (3.4)
Italy	33 (1.2)	440 (6.0)	12 (0.8)	414 (9.7)	13 (0.8)	444 (7.2)	38 (1.0)	406 (6.1)
Lebanon	5 (0.7)	535 (12.7)	2 (0.4)	~ ~	6 (0.9)	530 (14.0)	15 (1.1)	520 (5.5)
Norway	24 (0.9)	453 (5.3)	11 (0.7)	457 (5.7)	25 (1.8)	450 (5.1)	34 (1.1)	453 (4.4)
Portugal	38 (1.7)	494 (2.7)	3 (0.2)	441 (7.7)	26 (1.7)	467 (4.4)	30 (1.1)	461 (3.0)
Russian Federation	15 (0.8)	475 (8.4)	11 (0.6)	472 (9.4)	29 (0.9)	483 (6.8)	50 (1.0)	475 (5.8)
Russian Federation 6hr+	9 (0.9)	512 (19.2)	8 (0.6)	532 (10.6)	32 (1.5)	532 (7.8)	47 (1.4)	527 (8.0)
Slovenia	23 (1.2)	497 (5.7)	12 (0.8)	435 (4.4)	10 (0.8)	424 (7.1)	41 (1.3)	433 (3.8)
Sweden	32 (1.2)	424 (6.4)	6 (0.5)	433 (8.0)	16 (0.8)	416 (5.8)	32 (1.0)	411 (4.9)
United States	33 (1.2)	479 (6.1)	8 (0.6)	460 (7.9)	25 (1.4)	485 (6.0)	42 (1.5)	477 (6.0)
International Avg.	27 (0.4)	472 (2.3)	8 (0.2)	445 (2.7)	18 (0.4)	462 (2.5)	35 (0.4)	454 (1.6)

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 M4.6: 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.

Country	Engineering and Engineering Technologies		Computer and Information Sciences		Biological and Biomedical Sciences		Environmental Sciences	
	Percent of Students	Average Achievement	Percent of Students	Average Achievement	Percent of Students	Average Achievement	Percent of Students	Average Achievement
France	48 (1.0)	487 (3.4)	28 (0.9)	488 (3.7)	59 (1.0)	455 (2.9)	35 (0.9)	465 (3.5)
Italy	43 (1.4)	444 (7.1)	32 (1.5)	424 (7.9)	48 (1.2)	437 (5.6)	33 (1.2)	424 (6.8)
Lebanon	93 (0.8)	535 (3.1)	s 61 (2.1)	536 (4.2)	s 23 (1.9)	534 (7.0)	s 24 (1.6)	535 (6.2)
Norway	89 (0.7)	462 (4.9)	55 (1.5)	465 (5.6)	53 (1.3)	457 (4.7)	59 (1.4)	467 (4.6)
Portugal	43 (1.4)	497 (3.9)	37 (1.1)	485 (4.0)	49 (1.6)	491 (2.8)	28 (1.1)	474 (3.2)
Russian Federation	55 (1.5)	504 (5.9)	55 (1.4)	502 (6.0)	32 (0.9)	476 (6.7)	27 (1.0)	477 (6.5)
Russian Federation 6hr+	62 (1.6)	557 (7.2)	62 (1.5)	555 (7.3)	25 (1.5)	529 (11.6)	23 (1.1)	527 (10.7)
Slovenia	39 (1.2)	486 (4.5)	34 (1.3)	475 (4.9)	53 (1.2)	483 (5.2)	44 (1.2)	464 (4.2)
Sweden	79 (0.8)	442 (4.2)	55 (1.4)	438 (4.6)	61 (1.1)	430 (4.7)	49 (1.3)	438 (4.0)
United States	52 (1.4)	508 (7.2)	40 (1.6)	500 (8.3)	54 (1.1)	481 (6.6)	30 (1.9)	486 (9.0)
International Avg.	60 (0.4)	485 (1.7)	44 (0.5)	479 (1.9)	48 (0.4)	472 (1.8)	37 (0.4)	470 (1.9)

Country	Agriculture and Agricultural Sciences		Education		Finance/Banking		Actuarial Sciences	
	Percent of Students	Average Achievement	Percent of Students	Average Achievement	Percent of Students	Average Achievement	Percent of Students	Average Achievement
France	11 (0.6)	464 (5.2)	46 (0.9)	471 (3.3)	28 (0.9)	466 (4.7)	16 (0.6)	461 (4.2)
Italy	21 (0.9)	414 (9.3)	41 (1.3)	435 (5.5)	41 (1.1)	417 (7.0)	20 (1.0)	410 (7.7)
Lebanon	s 19 (1.7)	523 (6.2)	r 57 (2.3)	540 (4.4)	s 31 (2.3)	524 (7.7)	s 19 (2.0)	523 (7.2)
Norway	17 (1.1)	453 (4.7)	56 (1.5)	467 (4.6)	45 (2.3)	456 (4.0)	32 (1.3)	457 (5.8)
Portugal	16 (0.7)	468 (4.0)	27 (0.9)	494 (3.9)	37 (1.6)	480 (3.4)	9 (0.5)	476 (5.4)
Russian Federation	20 (0.9)	472 (7.3)	40 (0.9)	493 (6.9)	64 (1.1)	480 (6.4)	27 (0.8)	493 (6.2)
Russian Federation 6hr+	16 (1.1)	522 (11.8)	38 (1.4)	550 (9.4)	65 (1.8)	540 (7.9)	28 (1.4)	544 (10.1)
Slovenia	23 (1.1)	468 (4.7)	59 (1.2)	465 (3.9)	40 (1.2)	457 (4.1)	18 (1.0)	458 (6.5)
Sweden	18 (0.7)	425 (6.1)	46 (1.0)	448 (3.8)	48 (1.2)	426 (4.6)	24 (0.8)	448 (6.1)
United States	16 (1.3)	467 (14.8)	46 (1.4)	492 (5.2)	39 (1.6)	479 (8.8)	25 (1.3)	508 (11.1)
International Avg.	18 (0.3)	462 (2.5)	46 (0.4)	478 (1.6)	42 (0.5)	465 (2.0)	21 (0.4)	470 (2.3)

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.

( ) 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

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.

Country	Engineering and Engineering Technologies		Computer and Information Sciences		Biological and Biomedical Sciences		Environmental Sciences	
	Percent of Females	Percent of Males	Percent of Females	Percent of Males	Percent of Females	Percent of Males	Percent of Females	Percent of Males
France	32 (1.2)	63 (1.2) ▲	10 (0.7)	45 (1.3) ▲	72 (1.2) ▲	46 (1.3)	35 (1.2)	35 (1.2)
Italy	25 (1.7)	54 (1.6) ▲	13 (1.1)	43 (1.9) ▲	62 (1.6) ▲	40 (1.4)	31 (2.0)	34 (1.4)
Lebanon	89 (1.7)	95 (0.9) ▲	r 54 (3.7)	s 66 (2.4) ▲	s 25 (3.0)	s 22 (2.1)	s 24 (2.8)	s 23 (1.8)
Norway	83 (1.3)	92 (0.6) ▲	35 (1.9)	68 (1.8) ▲	71 (1.6) ▲	41 (2.0)	67 (1.9) ▲	54 (1.9)
Portugal	25 (1.3)	60 (2.0) ▲	17 (1.0)	58 (1.5) ▲	64 (2.0) ▲	33 (1.8)	34 (1.4) ▲	22 (1.5)
Russian Federation	37 (1.8)	73 (1.6) ▲	39 (1.3)	71 (1.6) ▲	40 (1.1) ▲	24 (1.1)	34 (1.4) ▲	21 (1.0)
Russian Federation 6hr+	46 (2.4)	76 (1.8) ▲	48 (2.0)	75 (1.5) ▲	29 (1.9) ▲	22 (1.5)	30 (2.0) ▲	18 (1.3)
Slovenia	24 (1.0)	61 (2.0) ▲	20 (1.4)	55 (1.7) ▲	53 (1.5)	54 (1.6)	47 (1.6) ▲	41 (1.6)
Sweden	68 (1.5)	87 (0.8) ▲	32 (1.8)	70 (1.4) ▲	78 (1.2) ▲	50 (1.5)	56 (1.9) ▲	44 (1.8)
United States	35 (2.2)	68 (1.4) ▲	25 (2.0)	54 (2.1) ▲	60 (1.9) ▲	47 (1.9)	31 (2.7)	29 (2.2)
International Avg.	46 (0.5)	73 (0.5) ▲	27 (0.6)	59 (0.6) ▲	58 (0.6) ▲	40 (0.6)	40 (0.6) ▲	34 (0.5)

Country	Agriculture and Agricultural Sciences		Education		Finance/Banking		Actuarial Sciences	
	Percent of Females	Percent of Males	Percent of Females	Percent of Males	Percent of Females	Percent of Males	Percent of Females	Percent of Males
France	12 (0.7)	10 (0.8)	49 (1.3) ▲	43 (1.3)	21 (1.1)	34 (1.2) ▲	15 (0.9)	18 (0.8) ▲
Italy	13 (1.2)	25 (1.3) ▲	46 (2.2) ▲	38 (1.5)	33 (1.7)	46 (1.3) ▲	17 (1.3)	21 (1.2) ▲
Lebanon	s 18 (2.2)	s 20 (2.0)	r 64 (2.4) ▲	r 52 (3.1)	s 30 (4.0)	s 32 (2.9)	s 17 (2.9)	s 21 (2.4)
Norway	19 (1.6) ▲	15 (1.2)	57 (1.9)	55 (1.7)	37 (2.3)	50 (2.7) ▲	31 (2.0)	33 (1.4)
Portugal	14 (0.9)	18 (1.0) ▲	28 (1.2)	25 (1.4)	37 (2.1)	38 (1.9)	9 (0.8)	8 (0.8)
Russian Federation	18 (1.2)	22 (1.0) ▲	51 (1.2) ▲	29 (1.2)	64 (1.2)	64 (1.7)	27 (0.9)	26 (1.0)
Russian Federation 6hr+	14 (1.6)	18 (1.2) ▲	48 (2.2) ▲	29 (1.7)	65 (2.0)	66 (2.1)	30 (1.7)	26 (1.6)
Slovenia	21 (1.4)	26 (1.4) ▲	63 (1.4) ▲	53 (2.1)	35 (1.4)	46 (1.7) ▲	17 (1.5)	18 (1.3)
Sweden	19 (1.2)	17 (0.9)	49 (1.5) ▲	44 (1.5)	39 (1.7)	54 (1.4) ▲	19 (1.3)	27 (1.2) ▲
United States	14 (1.4)	18 (1.9)	48 (2.1)	43 (2.0)	33 (1.5)	45 (2.8) ▲	20 (1.6)	30 (2.0) ▲
International Avg.	17 (0.5)	19 (0.4) ▲	50 (0.6) ▲	42 (0.6)	37 (0.7)	46 (0.7) ▲	19 (0.5)	22 (0.5) ▲

▲ 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.

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

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CHAPTER M5:
SCHOOL COMPOSITION

TIMSS ADVANCED 2015 INTERNATIONAL RESULTS IN ADVANCED MATHEMATICS AND PHYSICS

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ADVANCED MATHEMATICS

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Socioeconomic Composition of Schools

PERCENT OF STUDENTS **54%**

Average Achievement **482**

Attended schools with more affluent than disadvantaged students

PERCENT OF STUDENTS **26%**

Average Achievement **457**

Attended schools with neither more affluent nor more disadvantaged students

PERCENT OF STUDENTS **20%**

Average Achievement **432**

Attended schools with more disadvantaged than affluent students

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

SOURCE: IEA's Trends in International Mathematics and Science Study – TIMSS Advanced 2015.
http://timss2015.org/advanced/download-center/

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

Reported by Principals

Country	**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		**Neither More Affluent nor More Disadvantaged**		**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	
	Percent of Students	Average Achievement	Percent of Students	Average Achievement	Percent of Students	Average Achievement
France	50 (4.1)	471 (4.0)	28 (3.9)	462 (5.5)	22 (3.4)	437 (6.1)
Italy	48 (4.2)	442 (7.4)	40 (4.8)	423 (11.0)	12 (3.4)	331 (17.7)
Lebanon	34 (5.1)	554 (7.1)	29 (4.6)	529 (8.4)	37 (3.1)	515 (4.0)
Norway r	77 (5.5)	468 (6.1)	22 (5.5)	447 (6.5)	1 (0.9)	~ ~
Portugal r	18 (3.3)	490 (6.5)	36 (3.5)	479 (4.5)	46 (4.1)	476 (4.6)
Russian Federation	80 (3.2)	492 (6.1)	15 (2.5)	454 (15.6)	5 (1.4)	442 (40.2)
Russian Federation 6hr+	91 (2.4)	546 (8.2)	8 (2.3)	507 (29.7)	1 (0.7)	~ ~
Slovenia	64 (5.0)	474 (5.0)	24 (4.9)	438 (8.1)	12 (2.2)	427 (11.9)
Sweden r	80 (3.7)	442 (4.1)	13 (2.6)	379 (12.9)	7 (2.7)	374 (13.6)
United States	34 (4.6)	509 (10.8)	28 (4.2)	498 (8.6)	38 (3.9)	458 (9.4)
International Avg.	54 (1.4)	482 (2.2)	26 (1.4)	457 (3.2)	20 (1.0)	432 (6.1)

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.

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 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

Exhibit M5.2: Schools with Students Having the Language of the Test as Their Native Language

Reported by Principals

Country	School Has More than 90% of Students with Language of Test as Their Native Language		School Has 51-90% of Students with Language of Test as Their Native Language		School Has 50% or Less of Students with Language of Test as Their Native Language	
	Percent of Students	Average Achievement	Percent of Students	Average Achievement	Percent of Students	Average Achievement
France	88 (3.1)	462 (3.1)	11 (3.1)	451 (14.3)	1 (0.6)	~ ~
Italy	83 (3.2)	426 (5.6)	17 (3.1)	402 (17.7)	1 (0.7)	~ ~
Lebanon	11 (3.6)	533 (9.0)	12 (2.7)	511 (7.7)	76 (4.3)	534 (4.3)
Norway r	72 (8.0)	466 (6.2)	28 (8.0)	452 (11.4)	0 (0.0)	~ ~
Portugal	92 (2.0)	482 (2.6)	5 (1.2)	468 (9.3)	4 (1.7)	504 (11.2)
Russian Federation	82 (2.8)	485 (6.0)	12 (2.2)	482 (19.4)	5 (1.3)	488 (31.7)
Russian Federation 6hr+	91 (3.5)	541 (8.2)	6 (3.2)	516 (71.0)	3 (1.5)	549 (12.7)
Slovenia	88 (3.8)	462 (3.8)	12 (3.8)	443 (12.5)	0 (0.0)	~ ~
Sweden	31 (5.2)	450 (5.9)	58 (6.2)	424 (6.0)	11 (4.0)	414 (19.7)
United States	54 (4.3)	502 (5.5)	32 (3.7)	485 (8.4)	14 (3.8)	425 (18.1)
International Avg.	67 (1.4)	474 (1.9)	21 (1.4)	458 (4.2)	13 (0.8)	473 (8.6)

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.

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.

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CHAPTER M6:
SCHOOL CLIMATE

TIMSS ADVANCED 2015 INTERNATIONAL RESULTS IN ADVANCED MATHEMATICS AND PHYSICS

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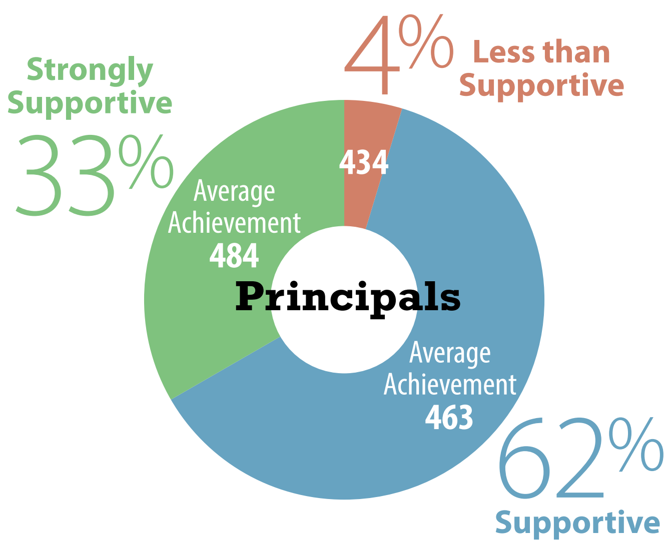
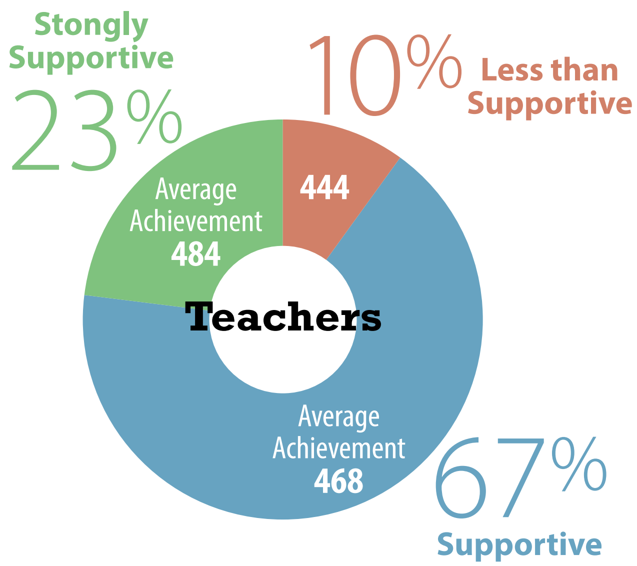
Lynch School of Education, Boston College

Schools Have Positive Environments

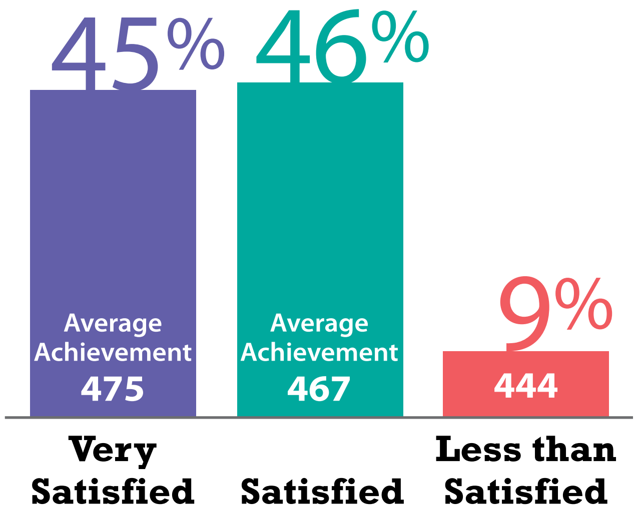
Generally, students taking advanced mathematics courses are in positive school environments, and the more positive the school environment the higher the average achievement.



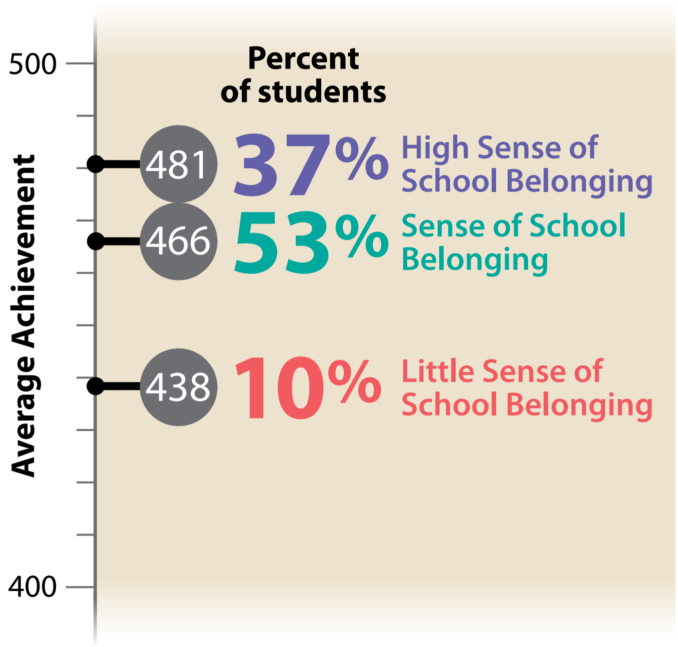


Principals and teachers agree that high percentages of TIMSS Advanced students attend schools that support advanced mathematics education, although the principals have more positive attitudes than the teachers.

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.



SOURCE: IEA's Trends in International Mathematics and Science Study – TIMSS Advanced 2015.
http://timss2015.org/advanced/download-center/

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Exhibit M6.1: Programs to Encourage Students to Study Advanced Mathematics

Reported by National Research Coordinators

Country	School Partnerships with Industry	School Collaborations with Universities	Contests/ Competitions in Advanced Mathematics
France	○	●	●
Italy	●	●	●
Lebanon	○	○	○
Norway	○	●	●
Portugal	○	●	●
Russian Federation	●	●	●
Slovenia	○	○	●
Sweden	●	●	●
United States	●	●	●

● 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.

Country	Strongly Supportive		Supportive		Less than Supportive		Average Scale Score
	Percent of Students	Average Achievement	Percent of Students	Average Achievement	Percent of Students	Average Achievement	
Russian Federation 6hr+	86 (2.4)	544 (8.6)	14 (2.4)	513 (18.1)	0 (0.0)	~ ~	12.3 (0.13)
Russian Federation	73 (3.2)	494 (7.5)	27 (3.2)	460 (11.2)	0 (0.0)	~ ~	11.8 (0.13)
Norway r	62 (7.2)	474 (6.7)	38 (7.2)	442 (5.3)	0 (0.3)	~ ~	11.3 (0.24)
United States r	47 (5.2)	495 (7.9)	51 (5.2)	481 (8.5)	3 (1.1)	435 (20.9)	10.6 (0.15)
Lebanon	39 (2.5)	536 (4.8)	60 (2.6)	531 (4.0)	2 (0.3)	~ ~	10.6 (0.10)
Portugal	35 (3.7)	483 (3.4)	61 (4.0)	484 (3.3)	4 (1.6)	470 (11.0)	10.2 (0.12)
Italy	21 (4.2)	437 (13.6)	72 (4.6)	417 (8.1)	6 (2.5)	413 (26.9)	9.5 (0.17)
France	8 (2.3)	479 (11.0)	84 (3.4)	460 (3.2)	8 (2.5)	456 (10.0)	8.7 (0.14)
Slovenia	7 (4.4)	505 (44.9)	89 (5.2)	458 (5.2)	4 (2.8)	410 (46.0)	8.9 (0.14)
Sweden	6 (3.0)	456 (13.6)	80 (4.3)	431 (4.6)	13 (3.1)	419 (13.8)	8.6 (0.14)
International Avg.	33 (1.4)	484 (5.8)	62 (1.5)	463 (2.2)	4 (0.6)	434 (10.1)	

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.

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?

	Agree a lot	Agree a little	Disagree a little	Disagree a lot
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) The school has initiatives to promote student interest in advanced mathematics and physics (e.g., student clubs, competitions)	○	○	○	○
5) The school has partnership initiatives 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	○	○	○	○

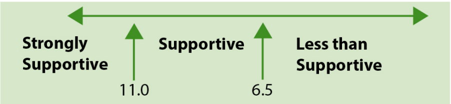


Exhibit M6.3: School Supports Advanced Mathematics and Physics Education – Teacher Version

Reported by Advanced Mathematics 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 7.4, 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.

Country	Strongly Supportive		Supportive		Less than Supportive		Average Scale Score
	Percent of Students	Average Achievement	Percent of Students	Average Achievement	Percent of Students	Average Achievement	
Russian Federation 6hr+	62 (4.4)	549 (6.9)	38 (4.4)	525 (18.4)	0 (0.0)	~ ~	12.1 (0.15)
Russian Federation	52 (2.5)	503 (8.6)	48 (2.5)	464 (7.9)	1 (0.5)	~ ~	11.5 (0.11)
Lebanon	46 (3.2)	533 (4.1)	52 (3.3)	532 (5.0)	1 (0.2)	~ ~	11.5 (0.10)
United States r	40 (4.0)	487 (11.4)	56 (3.9)	487 (5.5)	4 (1.1)	433 (25.3)	10.9 (0.17)
Norway	28 (6.5)	476 (6.4)	70 (7.1)	456 (5.8)	3 (1.5)	463 (31.0)	10.6 (0.17)
Portugal	24 (3.1)	486 (5.0)	72 (3.5)	482 (3.0)	5 (1.5)	475 (10.1)	10.3 (0.12)
Italy	6 (1.7)	465 (30.4)	69 (3.3)	427 (6.6)	25 (3.2)	406 (14.5)	8.8 (0.13)
France	4 (1.2)	479 (12.0)	87 (2.1)	461 (3.2)	9 (1.7)	459 (6.0)	9.2 (0.08)
Sweden	3 (1.1)	442 (10.8)	77 (3.2)	435 (4.5)	20 (3.3)	436 (8.8)	8.8 (0.11)
Slovenia	2 (0.1)	~ ~	77 (2.7)	466 (4.6)	22 (2.7)	434 (7.4)	8.4 (0.08)
International Avg.	23 (1.1)	484 (4.8)	67 (1.2)	468 (1.8)	10 (0.7)	444 (6.5)	

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.

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?

	Agree a lot	Agree a little	Disagree a little	Disagree a lot
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	○	○	○	○

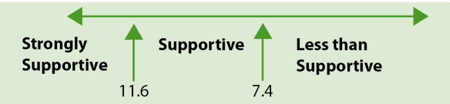


Exhibit M6.4: Teacher Job Satisfaction

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.

Country	Very Satisfied		Satisfied		Less than Satisfied		Average Scale Score
	Percent of Students	Average Achievement	Percent of Students	Average Achievement	Percent of Students	Average Achievement	
Lebanon	79 (3.5)	534 (3.7)	19 (3.5)	529 (6.8)	2 (0.9)	~ ~	11.4 (0.08)
United States r	63 (3.8)	481 (8.0)	32 (3.5)	489 (7.3)	5 (1.3)	493 (14.1)	10.8 (0.15)
Norway	60 (4.8)	473 (6.0)	36 (4.7)	446 (5.6)	4 (1.8)	423 (11.1)	10.6 (0.18)
Russian Federation 6hr+	54 (4.8)	540 (11.7)	44 (4.6)	543 (11.3)	3 (1.2)	556 (59.5)	10.5 (0.13)
Russian Federation	42 (2.9)	505 (7.3)	55 (3.0)	471 (8.4)	3 (1.0)	415 (26.7)	10.1 (0.11)
France	36 (2.9)	465 (4.5)	50 (2.8)	459 (4.3)	14 (2.3)	459 (7.3)	9.6 (0.14)
Portugal	34 (3.3)	486 (4.6)	55 (3.5)	481 (3.8)	12 (2.2)	477 (6.0)	9.6 (0.13)
Slovenia	31 (4.4)	476 (6.4)	56 (4.9)	452 (7.3)	13 (3.2)	453 (11.3)	9.5 (0.18)
Sweden	29 (3.5)	436 (6.4)	60 (4.2)	437 (5.8)	11 (2.3)	423 (9.0)	9.4 (0.14)
Italy	28 (3.1)	417 (11.2)	52 (3.4)	435 (9.1)	20 (2.9)	408 (11.1)	9.1 (0.16)
International Avg.	45 (1.2)	475 (2.3)	46 (1.3)	467 (2.2)	9 (0.7)	444 (4.8)	

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.

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?

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

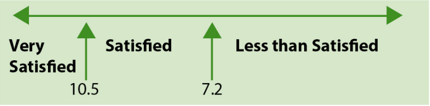


Exhibit M6.5: Students' Sense of School Belonging

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 **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**.

Country	High Sense of School Belonging		Sense of School Belonging		Little Sense of School Belonging		Average Scale Score
	Percent of Students	Average Achievement	Percent of Students	Average Achievement	Percent of Students	Average Achievement	
Norway	59 (1.7)	468 (4.6)	38 (1.6)	450 (4.9)	3 (0.4)	420 (13.3)	11.0 (0.08)
Sweden	54 (1.4)	446 (4.1)	41 (1.3)	421 (5.0)	5 (0.6)	366 (9.2)	10.7 (0.06)
Russian Federation	49 (1.6)	494 (6.4)	43 (1.3)	480 (5.9)	8 (0.5)	450 (10.5)	10.6 (0.08)
Russian Federation 6hr+	49 (2.1)	547 (8.5)	43 (1.8)	537 (7.5)	8 (0.8)	517 (15.3)	10.6 (0.11)
United States	46 (2.0)	492 (6.9)	47 (1.8)	485 (5.3)	7 (0.7)	452 (7.6)	10.4 (0.09)
Lebanon	43 (2.1)	542 (4.1)	48 (1.9)	528 (4.3)	9 (1.0)	526 (8.5)	10.2 (0.08)
Portugal	38 (1.3)	489 (3.9)	55 (1.1)	480 (2.8)	7 (0.5)	466 (5.3)	10.1 (0.05)
France	20 (1.2)	479 (4.4)	73 (1.0)	463 (3.0)	7 (0.7)	421 (7.2)	9.4 (0.05)
Italy	16 (1.1)	424 (11.9)	61 (1.2)	427 (5.4)	23 (1.2)	408 (8.7)	8.9 (0.05)
Slovenia	11 (0.9)	493 (6.4)	69 (0.9)	464 (4.0)	20 (0.9)	430 (5.0)	8.8 (0.05)
International Avg.	37 (0.5)	481 (2.1)	53 (0.5)	466 (1.5)	10 (0.3)	438 (2.9)	

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

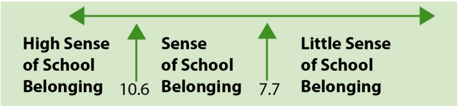
The Russian Federation 6hr+ results are for a subset of the Russian Federation students. This subset of students are in an Intensive stream that have at least 6 hours of mathematics lessons per week.

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.

	Agree a lot	Agree a little	Disagree a little	Disagree a lot
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	○	○	○	○



TIMSS
Advanced
2015

CHAPTER M7:
SCHOOL SAFETY

TIMSS ADVANCED 2015 INTERNATIONAL RESULTS IN
ADVANCED MATHEMATICS AND PHYSICS

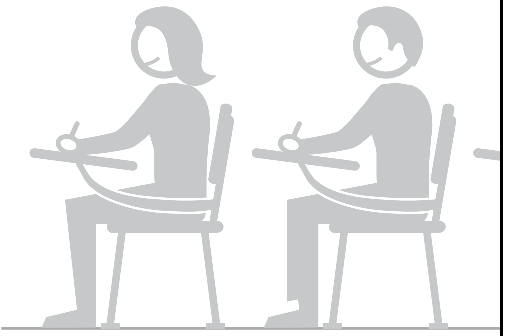
IEA
TIMSS & PIRLS
International Study Center
Lynch School of Education, Boston College

ADVANCED MATHEMATICS

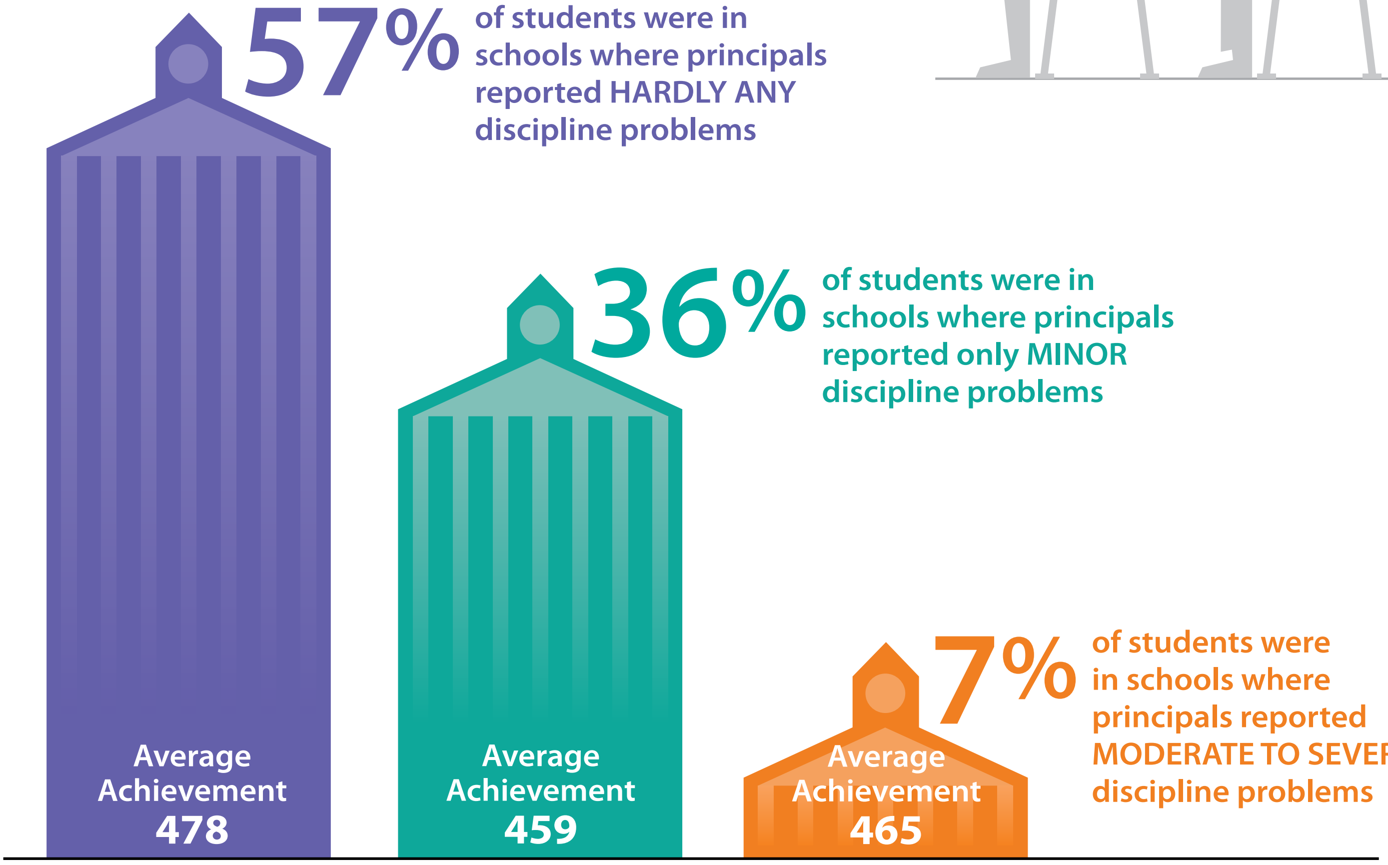
TIMSS *Advanced* 2015

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

Average Achievement **478**

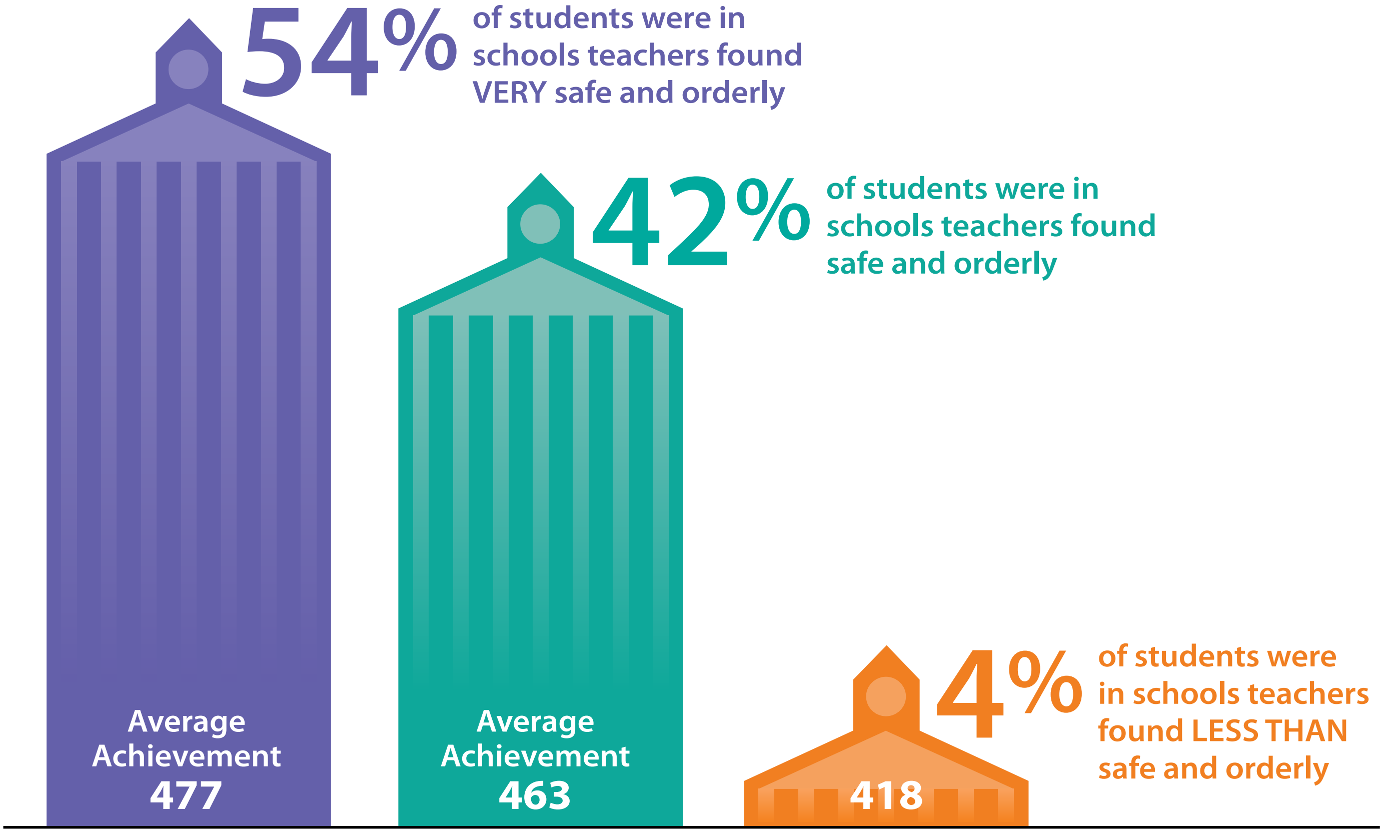
36% of students were in schools where principals reported only MINOR discipline problems

Average Achievement **459**

7% of students were in schools where principals reported MODERATE TO SEVERE discipline problems

Average Achievement **465**

Teachers' Reports



54% of students were in schools teachers found VERY safe and orderly

Average Achievement **477**

42% of students were in schools teachers found safe and orderly

Average Achievement **463**

4% of students were in schools teachers found LESS THAN safe and orderly

418

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

http://timss2015.org/advanced/download-center/

IEA

TIMSS & PIRLS
International Study Center
Lynch School of Education, Boston College

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**.

Country	Hardly Any Problems		Minor Problems		Moderate to Severe Problems		Average Scale Score
	Percent of Students	Average Achievement	Percent of Students	Average Achievement	Percent of Students	Average Achievement	
Russian Federation	85 (2.2)	486 (6.2)	15 (2.2)	474 (14.4)	0 (0.0)	~ ~	11.0 (0.08)
Russian Federation 6hr+	82 (3.5)	538 (9.0)	18 (3.5)	548 (15.7)	0 (0.0)	~ ~	11.0 (0.15)
Norway r	66 (8.0)	467 (7.1)	33 (8.0)	453 (6.5)	1 (0.7)	~ ~	10.5 (0.40)
France	65 (4.7)	464 (3.6)	31 (4.5)	455 (6.5)	4 (1.7)	457 (14.5)	10.4 (0.18)
Slovenia	65 (4.7)	469 (5.5)	34 (4.7)	444 (8.3)	1 (0.8)	~ ~	10.3 (0.10)
Portugal	57 (3.9)	483 (3.6)	38 (3.9)	482 (4.8)	6 (1.9)	474 (9.0)	10.2 (0.15)
United States	55 (4.4)	494 (6.2)	43 (4.4)	478 (9.7)	1 (0.7)	~ ~	10.1 (0.14)
Lebanon	48 (3.6)	540 (5.4)	26 (4.8)	522 (4.6)	26 (3.4)	526 (6.0)	9.2 (0.18)
Italy	39 (4.6)	451 (10.4)	39 (4.5)	401 (10.7)	22 (3.5)	403 (18.4)	9.0 (0.20)
Sweden	34 (4.6)	447 (5.8)	65 (4.7)	424 (6.5)	2 (1.0)	~ ~	9.4 (0.11)
International Avg.	57 (1.6)	478 (2.1)	36 (1.6)	459 (2.8)	7 (0.6)	465 (6.4)	

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.

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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.

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?

	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	○	○	○	○

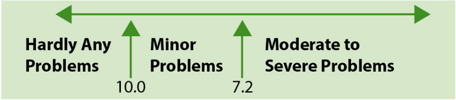


Exhibit M7.2: Safe and Orderly School – Teachers' Reports

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.

Country	Very Safe and Orderly		Safe and Orderly		Less than Safe and Orderly		Average Scale Score
	Percent of Students	Average Achievement	Percent of Students	Average Achievement	Percent of Students	Average Achievement	
Russian Federation 6hr+	78 (4.2)	552 (7.4)	22 (4.2)	499 (19.3)	0 (0.0)	~ ~	10.9 (0.13)
Russian Federation	75 (3.2)	495 (7.0)	24 (3.2)	451 (12.2)	1 (0.6)	~ ~	10.9 (0.13)
Norway	74 (5.1)	465 (5.0)	25 (5.0)	450 (6.8)	1 (1.3)	~ ~	10.8 (0.18)
United States r	71 (3.8)	486 (7.4)	26 (3.5)	491 (8.9)	3 (0.9)	408 (20.2)	10.8 (0.19)
Lebanon	67 (4.6)	535 (3.7)	31 (4.7)	526 (7.7)	2 (0.2)	~ ~	10.7 (0.12)
Portugal	52 (3.4)	484 (4.0)	41 (3.7)	481 (3.5)	6 (1.4)	478 (10.7)	9.7 (0.11)
Sweden	44 (4.3)	446 (4.9)	53 (4.3)	427 (6.2)	3 (1.1)	412 (11.1)	9.5 (0.13)
Italy	43 (3.3)	428 (8.0)	51 (3.2)	429 (8.3)	6 (1.8)	355 (27.9)	9.4 (0.14)
France	34 (3.1)	473 (5.6)	61 (3.0)	458 (3.3)	5 (1.4)	426 (13.6)	9.3 (0.15)
Slovenia	27 (3.4)	482 (8.4)	67 (3.1)	454 (4.0)	6 (2.8)	428 (13.4)	8.9 (0.17)
International Avg.	54 (1.3)	477 (2.1)	42 (1.3)	463 (2.4)	4 (0.5)	418 (7.1)	

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.

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.

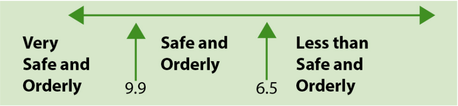
( ) Standard errors appear in parentheses. Because of rounding some results may appear inconsistent.

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.

	Agree a lot	Agree a little	Disagree a little	Disagree a lot
1) This school is located in a safe neighborhood ----------	○	○	○	○
2) I feel safe at this school ---------------------------------------	○	○	○	○
3) This school's security policies and practices are sufficient---	○	○	○	○
4) The students behave in an orderly manner -------------	○	○	○	○
5) The students are respectful of the teachers ------------	○	○	○	○
6) The students respect school property---------------------	○	○	○	○
7) This school has clear rules about student conduct---	○	○	○	○
8) This school's rules are enforced in a fair and consistent manner---	○	○	○	○



TIMSS
Advanced
2015

CHAPTER M8: TEACHERS’ AND PRINCIPALS’ PREPARATION

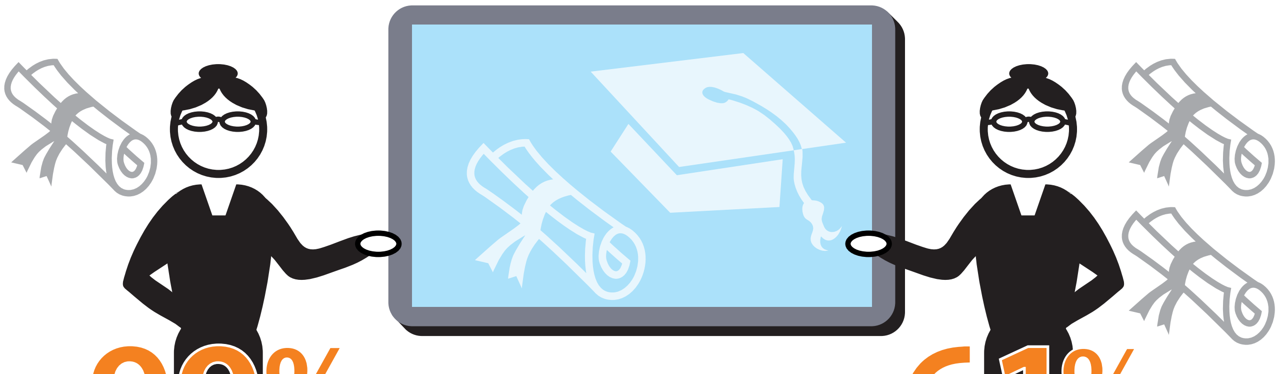
TIMSS ADVANCED 2015 INTERNATIONAL RESULTS IN ADVANCED MATHEMATICS AND PHYSICS

IEA
TIMSS & PIRLS
International Study Center
Lynch School of Education, Boston College

ADVANCED MATHEMATICS TIMSS Advanced 2015

Students Have Well Qualified Teachers and Principals

Mathematics teachers of TIMSS Advanced students reported high levels of education and considerable experience.



99%

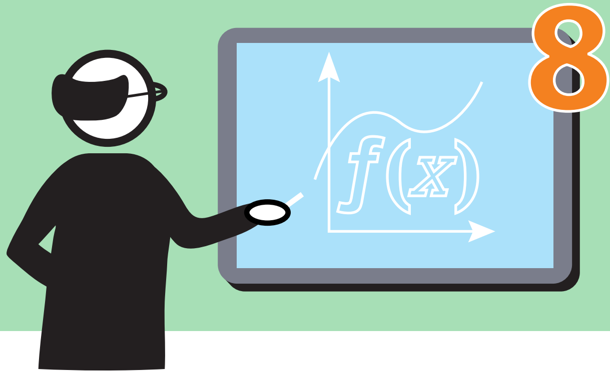
of students were taught by mathematics teachers with at least a Bachelor's degree

61%

of students were taught by mathematics teachers with a Master's or Doctorate degree

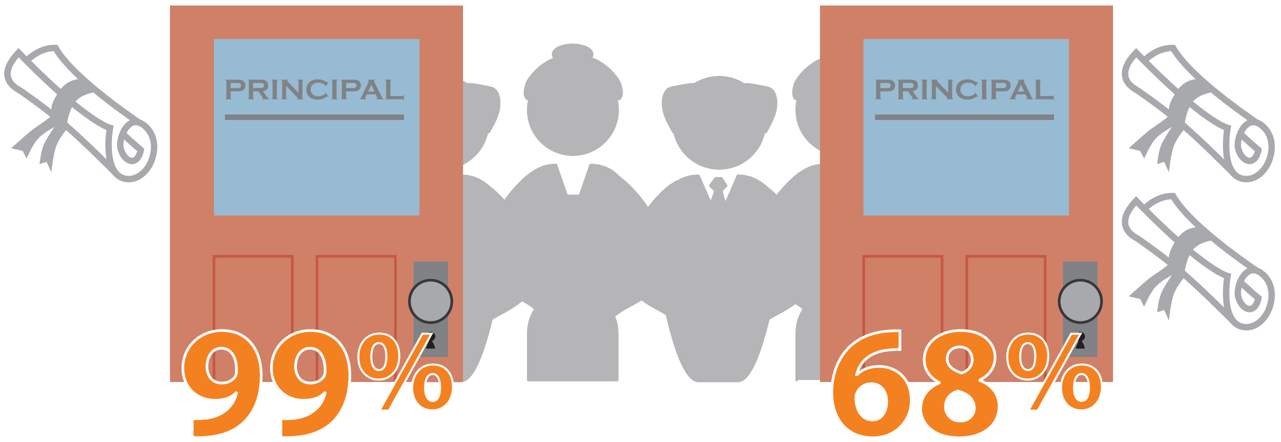
On average, students were taught by mathematics teachers with 14 years of experience teaching advanced mathematics.

The TIMSS Advanced countries have special requirements for teaching advanced mathematics, so it may be a concern that:



81% **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.



99%

of students had principals with at least a Bachelor's degree

68%

of students had principals with a Master's or Doctorate degree

On average, principals had 11 years of experience.

SOURCE: IEA's Trends in International Mathematics and Science Study – TIMSS Advanced 2015.
http://timss2015.org/advanced/download-center/

IEA TIMSS & PIRLS International Study Center
Lynch School of Education, Boston College

Exhibit M8.1: National Requirements for Being an Advanced Mathematics Teacher in the Final Year of School

Reported by National Research Coordinators

Country	Requirements
France	Teachers must be qualified to teach secondary school. Secondary school teachers must hold a master's degree and pass the competitive national examination.
Italy	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).
Lebanon	Teachers must hold a bachelor's degree in mathematics, as well as a teaching diploma.
Norway	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.
Portugal	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.
Russian Federation	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.
Slovenia	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.
Sweden	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.
United States	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.

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

Exhibit M8.2: Advanced Mathematics Teachers' Formal Education*

Reported by Advanced Mathematics Teachers

Country	Completed Postgraduate University Degree**		Completed Bachelor's Degree or Equivalent but Not a Postgraduate Degree		Did Not Complete Bachelor's Degree	
	Percent of Students	Average Achievement	Percent of Students	Average Achievement	Percent of Students	Average Achievement
France	75 (2.9)	462 (3.3)	25 (2.9)	460 (4.7)	0 (0.0)	~ ~
Italy	11 (2.0)	388 (18.2)	87 (2.2)	428 (6.4)	2 (0.9)	~ ~
Lebanon	59 (4.1)	529 (3.6)	34 (4.2)	542 (7.3)	7 (1.5)	524 (12.6)
Norway	77 (3.2)	464 (4.7)	22 (3.2)	452 (9.4)	0 (0.0)	~ ~
Portugal	20 (2.8)	483 (5.4)	78 (2.9)	482 (2.9)	2 (0.8)	~ ~
Russian Federation	71 (3.3)	483 (8.0)	29 (3.3)	485 (12.0)	0 (0.0)	~ ~
Russian Federation 6hr+	81 (2.7)	547 (9.2)	19 (2.7)	513 (13.4)	0 (0.0)	~ ~
Slovenia	99 (0.8)	460 (3.5)	1 (0.8)	~ ~	0 (0.0)	~ ~
Sweden	67 (3.5)	436 (4.8)	32 (3.4)	437 (7.2)	2 (0.6)	~ ~
United States r	73 (4.3)	493 (5.4)	27 (4.3)	464 (13.2)	0 (0.0)	~ ~
International Avg.	61 (1.1)	466 (2.6)	37 (1.1)	469 (3.0)	1 (0.2)	524 (12.6)

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

Country	Major in Mathematics and Mathematics Education		Major in Mathematics but No Major in Mathematics Education		Major in Mathematics Education but No Major in Mathematics		All Other Majors	
	Percent of Students	Average Achievement	Percent of Students	Average Achievement	Percent of Students	Average Achievement	Percent of Students	Average Achievement
France	32 (2.7)	465 (4.1)	68 (2.7)	460 (3.9)	0 (0.4)	~ ~	0 (0.2)	~ ~
Italy	49 (4.1)	417 (10.9)	41 (3.8)	444 (8.7)	1 (0.6)	~ ~	9 (1.9)	379 (17.6)
Lebanon	61 (4.1)	534 (4.6)	33 (2.5)	538 (5.1)	1 (0.6)	~ ~	5 (4.2)	514 (14.0)
Norway	18 (3.5)	466 (11.4)	80 (3.7)	461 (4.0)	0 (0.0)	~ ~	2 (1.3)	~ ~
Portugal	76 (3.1)	480 (3.4)	19 (2.6)	489 (5.3)	3 (1.2)	496 (8.1)	2 (1.0)	~ ~
Russian Federation	60 (3.8)	492 (7.7)	39 (3.8)	468 (7.7)	0 (0.0)	~ ~	1 (0.5)	~ ~
Russian Federation 6hr+	69 (5.1)	555 (8.3)	30 (5.0)	505 (16.6)	0 (0.0)	~ ~	1 (0.5)	~ ~
Slovenia	56 (4.3)	465 (4.7)	29 (3.5)	452 (8.4)	13 (2.6)	458 (7.1)	2 (0.6)	~ ~
Sweden	71 (3.7)	440 (4.8)	20 (3.0)	426 (7.2)	7 (2.0)	437 (9.5)	2 (0.9)	~ ~
United States r	58 (3.2)	478 (8.2)	22 (2.7)	500 (8.6)	11 (1.9)	497 (13.6)	9 (1.0)	482 (8.7)
International Avg.	53 (1.2)	471 (2.4)	39 (1.1)	471 (2.3)	4 (0.5)	472 (4.9)	4 (0.6)	458 (8.0)

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.

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

Country	Percent of Students by Teacher Characteristics							Average Number of Years Teaching	
	Gender		Age						
	Female	Male	29 Years or Under	30-39 Years	40-49 Years	50-59 Years	60 Years or Older	Teaching Altogether	Teaching Mathematics at the Advanced Level
France	40 (3.2)	60 (3.2)	4 (1.2)	17 (2.3)	43 (3.2)	30 (2.7)	6 (1.4)	23 (0.5)	9 (0.4)
Italy	67 (3.6)	33 (3.6)	0 (0.0)	2 (0.7)	31 (3.4)	50 (3.7)	17 (2.6)	25 (0.5)	17 (0.6)
Lebanon	18 (1.7)	82 (1.7)	4 (1.4)	21 (2.3)	29 (4.9)	23 (3.7)	23 (2.3)	25 (0.6)	20 (0.7)
Norway	25 (4.5)	75 (4.5)	3 (1.5)	24 (4.9)	25 (3.3)	20 (3.1)	29 (5.9)	20 (1.6)	13 (1.3)
Portugal	75 (2.8)	25 (2.8)	0 (0.0)	12 (2.6)	44 (3.4)	39 (3.3)	6 (1.6)	25 (0.5)	10 (0.4)
Russian Federation	96 (1.2)	4 (1.2)	1 (0.7)	7 (1.5)	35 (3.4)	39 (3.2)	17 (2.8)	28 (0.6)	9 (0.5)
Russian Federation 6hr+	91 (2.1)	9 (2.1)	2 (1.1)	5 (1.6)	39 (4.4)	41 (4.8)	14 (2.9)	28 (0.7)	14 (0.7)
Slovenia	75 (3.1)	25 (3.1)	1 (0.8)	24 (3.8)	35 (3.9)	34 (4.1)	6 (1.4)	22 (0.8)	18 (0.5)
Sweden	30 (4.4)	70 (4.4)	4 (1.7)	20 (3.0)	30 (4.1)	21 (3.4)	24 (2.6)	18 (1.0)	13 (0.9)
United States	r 44 (4.0)	56 (4.0)	r 7 (2.2)	21 (2.7)	37 (3.1)	19 (2.2)	15 (3.6)	r 20 (0.9)	r 13 (0.8)
International Avg.	52 (1.1)	48 (1.1)	3 (0.4)	17 (1.0)	34 (1.2)	31 (1.1)	16 (1.0)	23 (0.3)	14 (0.2)

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 M8.5: 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.

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

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*

Reported by Principals

Country		Percent of Students by Principal Educational Level		
		Completed Postgraduate University Degree**	Completed Bachelor's Degree or Equivalent but Not a Postgraduate Degree	Did Not Complete Bachelor's Degree
France		73 (4.0)	25 (4.0)	1 (1.1)
Italy		27 (4.5)	69 (4.4)	4 (2.0)
Lebanon		71 (4.3)	27 (4.2)	3 (0.5)
Norway	r	70 (6.1)	30 (6.1)	0 (0.0)
Portugal		38 (4.0)	62 (4.0)	0 (0.0)
Russian Federation		85 (2.5)	15 (2.5)	0 (0.0)
Russian Federation 6hr+		91 (3.8)	9 (3.8)	0 (0.0)
Slovenia		100 (0.0)	0 (0.0)	0 (0.0)
Sweden		49 (5.1)	47 (5.1)	4 (1.5)
United States		99 (0.7)	1 (0.7)	0 (0.0)
International Avg.		68 (1.3)	31 (1.3)	1 (0.3)

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.

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

Country		Percent of Students by Principal Years of Experience as a Principal				Average Years of Experience as a Principal
		20 Years or More	At Least 10 but Less than 20 Years	At Least 5 but Less than 10 Years	Less than 5 Years	
France		14 (2.7)	31 (4.1)	27 (3.9)	28 (4.4)	10 (0.7)
Italy		17 (3.6)	28 (4.5)	40 (4.9)	15 (3.4)	11 (0.7)
Lebanon		33 (5.1)	20 (2.7)	26 (3.5)	21 (3.0)	14 (0.9)
Norway	r	37 (9.0)	33 (8.1)	22 (5.4)	9 (4.0)	16 (1.7)
Portugal		17 (2.6)	33 (3.4)	27 (3.4)	22 (3.3)	11 (0.6)
Russian Federation		20 (2.5)	31 (3.6)	30 (3.1)	18 (1.8)	12 (0.5)
Russian Federation 6hr+		25 (3.9)	35 (4.8)	26 (5.4)	14 (2.6)	14 (0.9)
Slovenia		12 (3.6)	33 (3.6)	28 (2.5)	27 (2.1)	11 (0.6)
Sweden		5 (2.5)	29 (3.8)	42 (4.6)	24 (4.1)	9 (0.5)
United States	r	10 (2.7)	30 (4.6)	29 (4.3)	32 (5.1)	9 (0.7)
International Avg.		18 (1.4)	30 (1.5)	30 (1.4)	22 (1.2)	11 (0.3)

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.

TIMSS
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CHAPTER M9: CLASSROOM INSTRUCTION

TIMSS ADVANCED 2015 INTERNATIONAL RESULTS IN ADVANCED MATHEMATICS AND PHYSICS

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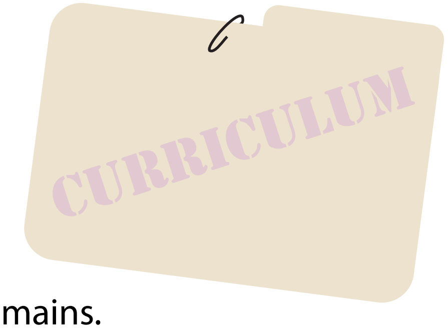
Instruction in Advanced Mathematics Classes

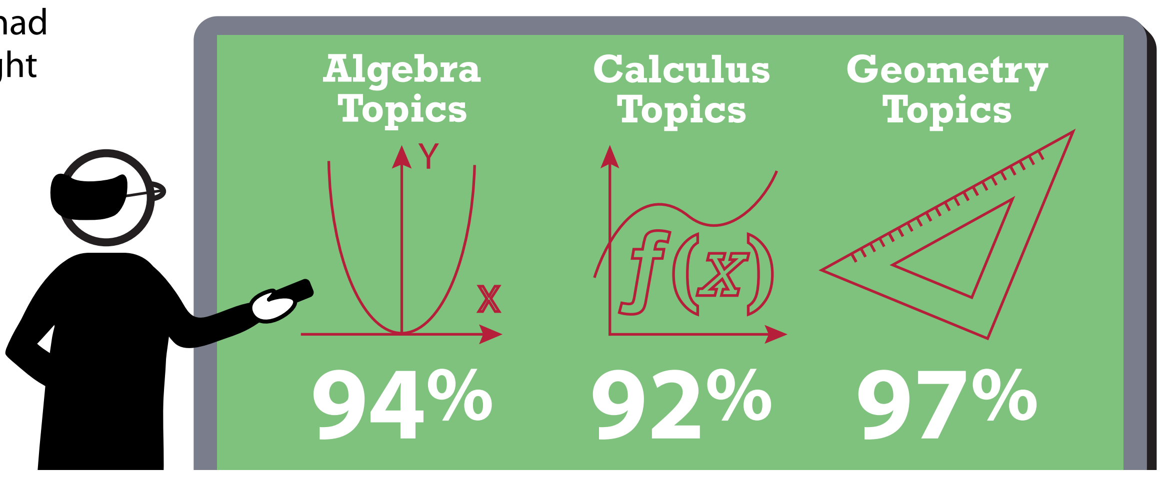
Curriculum

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%

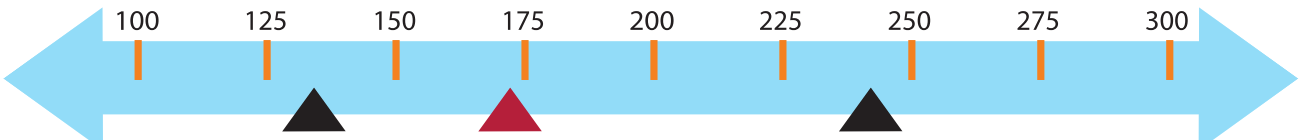
Calculus Topics 92%

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.



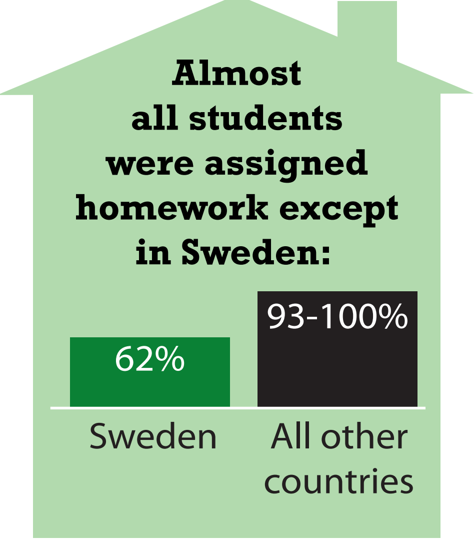
130-131 Hours Italy/ Slovenia

171 Hours International Average

242 Hours Lebanon

Students also studied outside of school:

Almost all students were assigned homework except in Sweden:

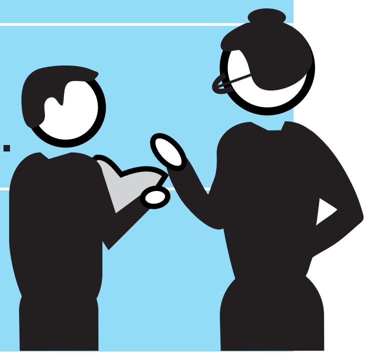


Large percentages of Advanced Mathematics students reported attending extra tutoring outside of school to improve their achievement.

3/5 **attended tutoring in Portugal and the Russian Federation.**

1/3 **attended tutoring in France, Italy, and Slovenia.**

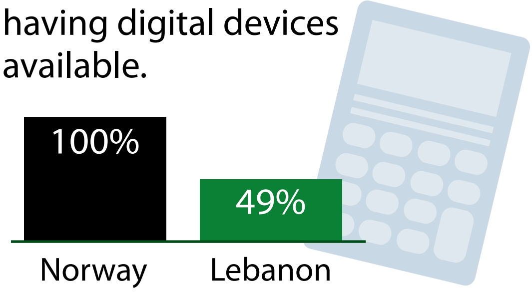
On average, students attending extra tutoring had lower achievement.



Technology

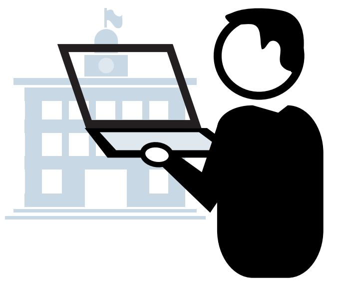
There is a continuing debate about the role of technology in education, and more particularly in mathematics classes.

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



Teachers have students use their digital devices primarily to draw graphs of functions (68%) and solve equations (63%).

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



Find information about mathematics concepts or solve problems

68-70%

Access course materials and do homework

50-54%

SOURCE: IEA's Trends in International Mathematics and Science Study – TIMSS Advanced 2015.
http://timss2015.org/advanced/download-center/

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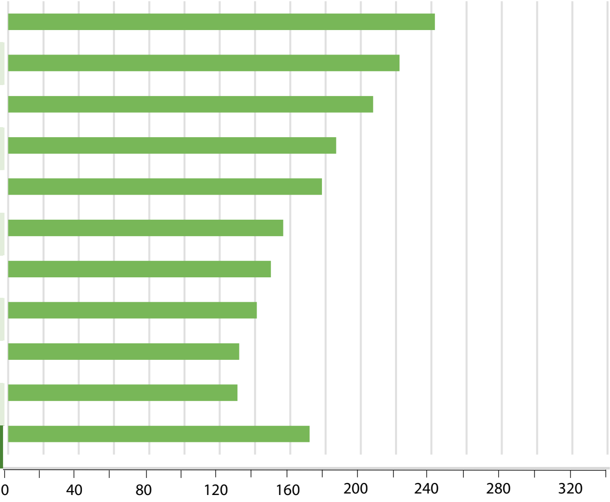
Exhibit M9.1: Instructional Time Spent on Advanced Mathematics

Reported by Principals and Advanced Mathematics Teachers

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



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.

$$\textbf{Total Instructional Hours per Year} = \text{Principal Reports of School Days per Year} \times \text{Principal Reports of Instructional Hours per Day}$$

$$\textbf{Hours per Year for Advanced Mathematics Instruction} = \frac{\text{Teacher Reports of Weekly Advanced Mathematics Instructional Hours}}{\text{Principal Reports of School Days per Week}} \times \text{Principal Reports of School Days per Year}$$

Exhibit M9.2: Types of Homework Assignments

Reported by Advanced Mathematics Teachers

Country	Mathematics Homework Assigned to Class			Percent of Students Whose Teachers "Sometimes" or "Always or Almost Always" Assign Each Type of Homework					
	Percent of Students	Average Achievement							
	Yes	Yes	No	Doing Problem/ Question Sets	Reading the Textbook	Memorizing Formulas and Procedures	Gathering, Analyzing, and Reporting Data	Finding Applications of the Content Covered	Working on Projects
France	100 (0.0)	461 (3.1)	~ ~	100 (0.3)	42 (3.1)	90 (1.9)	68 (2.6)	43 (3.3)	20 (2.3)
Italy	98 (0.9)	424 (5.7)	~ ~	98 (1.0)	80 (3.0)	71 (2.8)	58 (3.3)	73 (3.2)	27 (2.8)
Lebanon	93 (1.9)	531 (3.2)	543 (13.8)	93 (1.9)	79 (2.4)	84 (2.2)	83 (2.7)	84 (2.4)	56 (4.8)
Norway	94 (2.4)	461 (4.7)	477 (18.2)	93 (2.6)	73 (4.4)	69 (4.5)	19 (3.5)	29 (4.4)	5 (2.1)
Portugal	96 (1.6)	484 (2.6)	468 (11.3)	94 (1.9)	63 (3.3)	54 (3.8)	44 (4.1)	58 (3.6)	13 (2.0)
Russian Federation	100 (0.0)	484 (5.8)	~ ~	100 (0.0)	95 (1.5)	96 (1.3)	89 (2.0)	93 (1.5)	73 (3.3)
Russian Federation 6hr+	100 (0.0)	540 (8.1)	~ ~	100 (0.0)	92 (1.7)	91 (2.7)	84 (2.5)	89 (2.7)	72 (4.3)
Slovenia	97 (1.0)	460 (3.7)	465 (18.0)	97 (1.0)	38 (3.0)	76 (3.1)	33 (2.3)	29 (3.5)	21 (2.5)
Sweden	62 (4.4)	431 (5.4)	441 (6.2)	60 (4.4)	38 (3.4)	22 (3.0)	15 (2.9)	24 (3.3)	18 (2.5)
United States	r 98 (1.4)	485 (5.8)	~ ~	r 98 (1.4)	r 58 (3.5)	r 78 (2.5)	r 52 (4.1)	r 65 (4.1)	r 63 (3.6)
International Avg.	93 (0.7)	469 (1.5)	479 (6.4)	92 (0.7)	63 (1.1)	71 (1.0)	51 (1.1)	55 (1.1)	33 (1.0)

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

Country	Students Did Not Attend Extra Tutoring		Students Attended Extra Tutoring		Reasons for Attending Extra Tutoring (Students Could Indicate More than One)					
					To Excel in Class		To Keep Up in Class		To Do Well on an Examination	
	Percent of Students	Average Achievement	Percent of Students	Average Achievement	Percent of Students	Average Achievement	Percent of Students	Average Achievement	Percent of Students	Average Achievement
France	65 (1.0)	476 (3.2)	35 (1.0)	438 (3.6)	10 (0.6)	468 (5.2)	23 (0.9)	426 (3.5)	28 (0.8)	436 (3.5)
Italy	67 (1.2)	434 (5.7)	33 (1.2)	397 (6.4)	5 (0.4)	414 (11.0)	23 (0.9)	383 (6.4)	18 (0.9)	402 (6.9)
Lebanon	84 (1.4)	540 (3.0)	16 (1.4)	494 (5.5)	7 (0.8)	501 (9.3)	5 (0.6)	472 (8.4)	10 (1.1)	486 (6.0)
Norway	93 (0.8)	462 (4.6)	7 (0.8)	428 (7.8)	4 (0.8)	432 (10.7)	4 (0.5)	409 (10.6)	5 (0.6)	429 (8.7)
Portugal	39 (1.5)	491 (3.4)	61 (1.5)	477 (2.6)	38 (1.3)	484 (3.3)	46 (1.4)	466 (2.8)	54 (1.6)	478 (2.7)
Russian Federation	33 (1.3)	491 (7.3)	67 (1.3)	482 (5.5)	23 (1.1)	488 (6.6)	18 (0.9)	461 (8.1)	64 (1.4)	481 (5.4)
Russian Federation 6hr+	38 (2.8)	553 (8.6)	62 (2.8)	533 (8.7)	21 (1.8)	533 (11.5)	15 (1.4)	500 (11.4)	60 (2.7)	532 (9.0)
Slovenia	70 (1.2)	481 (3.3)	30 (1.2)	414 (5.1)	11 (0.9)	424 (7.9)	17 (0.8)	396 (5.8)	25 (1.1)	410 (5.1)
Sweden	89 (0.7)	438 (4.0)	11 (0.7)	379 (7.5)	6 (0.4)	397 (7.1)	5 (0.4)	347 (9.4)	9 (0.6)	371 (7.1)
United States	88 (0.9)	489 (5.4)	12 (0.9)	462 (7.6)	8 (0.7)	463 (10.9)	9 (0.7)	448 (7.9)	10 (0.8)	462 (8.8)
International Avg.	70 (0.4)	478 (1.5)	30 (0.4)	441 (2.0)	12 (0.3)	452 (2.8)	17 (0.3)	423 (2.5)	25 (0.3)	439 (2.1)

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.

Exhibit M9.4: Examinations with Consequences for Students in Advanced Mathematics Programs (Tracks)

Reported by National Research Coordinators

Country	Examinations with Consequences for Individual Students	Grades at Which Examinations with Consequences for Individual Students are Given	Format of Examinations with Consequences for Individual Students	Comments
France	●	Grade 12	Written and/or oral examinations	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.
Italy	●	Grades 8 and 13	Written and oral examinations	Final examinations for technical and vocational secondary schools (Grade 13) also give students an opportunity to find a job.
Lebanon	●	Grade 12	Written examinations	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.
Norway	●	Grades 12 and 13	Written or oral examinations	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.
Portugal	●	Grades 9 and 12	Written examinations	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.
Russian Federation	●	Grade 11	Written examinations	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.
Slovenia	●	End of upper-secondary education	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.	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.
Sweden	○	n/a	n/a	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.
United States	○	n/a	n/a	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.

● Yes
○ No

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

Exhibit M9.5: Characteristics and Methods Used to Evaluate the Advanced Mathematics Curriculum

Reported by National Research Coordinators

Country	National Curriculum	Year Introduced	Being Revised	Methods Used to Evaluate the Implementation of the Advanced Mathematics Curriculum			
				Visits by Inspectors	Research Programs	School Self-Evaluation	National or Regional Assessments
France	●	2011	○	●	○	○	●
Italy	●	2010	○	○	○	●	●
Lebanon	●	2001	○	●	○	●	●
Norway	●	2006	○	○	○	○	●
Portugal	●	2003	●	○	○	●	●
Russian Federation	●	2004	●	○	●	●	●
Slovenia	●	2008	○	○	●	●	●
Sweden	●	2011	○	●	●	●	●
United States	○	Varies by school and by course	●	Varies by state	●	●	○

● 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

Reported by National Research Coordinators

Country	All Advanced Mathematics (19 topics)	Algebra (8 topics)	Calculus (7 topics)	Geometry (4 topics)
France	18	8	6	4
Italy	19	8	7	4
Lebanon	19	8	7	4
Norway	18	7	7	4
Portugal	18	8	6	4
Russian Federation	16	8	4	4
Russian Federation 6hr+	19	8	7	4
Slovenia	19	8	7	4
Sweden	17	8	5	4
United States	19	8	7	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.

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

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

Exhibit M9.7: Percentages of Students Taught* the TIMSS Advanced Topics in Algebra, Calculus, and Geometry

Algebra Topics

Reported by Advanced Mathematics Teachers

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

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

* 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^{th} 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

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

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

* 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

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

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

* 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

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

* 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 Trends in International Mathematics and Science Study – TIMSS Advanced 2015

Exhibit M9.9: National Policies Regarding the Use of Technology in Advanced Mathematics Instruction and Assessment

Reported by National Research Coordinators

Country	Description of National Policies for Technology Use in Advanced Mathematics Instruction	Description of National Policies for Technology Use in Advanced Mathematics Assessment
France	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.	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.
Italy	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.	Same
Lebanon	No policy	No policy
Norway	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.	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.
Portugal	Some subjects (such as normal and binomial distributions) are always taught with graphing calculators.	Some advanced mathematics examinations require the use of a graphing calculator.
Russian Federation	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.	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.
Slovenia	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.	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.
Sweden	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.	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.
United States	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.	Policies vary by state, but some programs (such as AP and IB) have their own specifications about what kinds of calculators are permissible.

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

Exhibit M9.10: Availability of Digital Devices in Advanced Mathematics Lessons

Reported by Advanced Mathematics Teachers

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

Country		Digital Devices Available for Students to Use in Advanced Mathematics Lessons		
		Percent of Students	Average Achievement	
		Yes	Yes	No
France		86 (2.2)	460 (3.3)	470 (6.6)
Italy		58 (3.6)	430 (7.4)	417 (10.4)
Lebanon		49 (3.3)	543 (5.2)	521 (3.5)
Norway		100 (0.0)	462 (4.5)	~ ~
Portugal		78 (3.1)	485 (3.0)	477 (5.6)
Russian Federation		64 (4.1)	486 (7.2)	480 (8.0)
Russian Federation 6hr+		68 (4.5)	542 (6.7)	536 (20.6)
Slovenia		75 (2.3)	458 (4.2)	465 (6.4)
Sweden		97 (1.5)	435 (4.2)	445 (8.3)
United States	r	92 (1.6)	485 (6.0)	485 (13.6)
International Avg.		78 (0.9)	472 (1.7)	470 (2.9)

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.

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 M9.11: Profiles of Uses of Digital Devices at Least Monthly in Advanced Mathematics Lessons

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.

International Avg.

France

Italy

Lebanon

Norway

Portugal

Russian Federation

Russian Federation 6hr+

Slovenia

Sweden

United States

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

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.

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

Country	Percent of Students Whose Teachers Have Them Use Digital Devices at Least Monthly							
	Read the Textbook or Course Materials	Look Up Ideas and Information	Process and Analyze Data	Draw Graphs of Functions	Solve Equations	Manipulate Algebraic Expressions	Conduct Modeling and Simulations	Perform Numerical Integration
France	28 (2.9)	48 (3.0)	72 (2.9)	82 (2.4)	72 (2.6)	67 (2.9)	69 (3.2)	64 (3.3)
Italy	31 (2.9)	41 (3.9)	45 (4.0)	44 (3.9)	30 (4.1)	27 (3.7)	31 (3.7)	26 (3.9)
Lebanon	26 (3.8)	35 (3.4)	37 (3.5)	34 (2.9)	45 (3.2)	39 (3.4)	31 (3.0)	42 (3.3)
Norway	48 (6.0)	59 (5.0)	89 (3.5)	99 (1.1)	95 (2.2)	88 (3.0)	92 (3.3)	83 (3.3)
Portugal	30 (4.1)	35 (3.6)	59 (3.9)	77 (3.1)	73 (3.3)	50 (3.3)	72 (3.1)	0 (0.1)
Russian Federation	55 (4.0)	61 (4.1)	50 (3.6)	40 (3.8)	39 (4.0)	38 (3.9)	34 (3.2)	25 (3.8)
Russian Federation 6hr+	60 (5.2)	65 (4.5)	54 (4.2)	44 (4.6)	35 (4.4)	37 (4.4)	38 (4.5)	25 (4.6)
Slovenia	22 (2.5)	41 (3.7)	31 (2.2)	51 (3.7)	39 (3.2)	26 (2.9)	34 (4.5)	17 (2.4)
Sweden	33 (3.3)	61 (3.5)	75 (3.1)	94 (2.0)	87 (2.8)	36 (4.0)	80 (2.8)	89 (2.4)
United States	r 34 (4.2)	r 65 (4.3)	r 75 (3.2)	r 90 (1.8)	r 84 (2.3)	r 71 (3.8)	r 72 (3.3)	r 84 (3.6)
International Avg.	34 (1.3)	50 (1.3)	59 (1.1)	68 (1.0)	63 (1.0)	49 (1.2)	57 (1.1)	48 (1.0)

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.

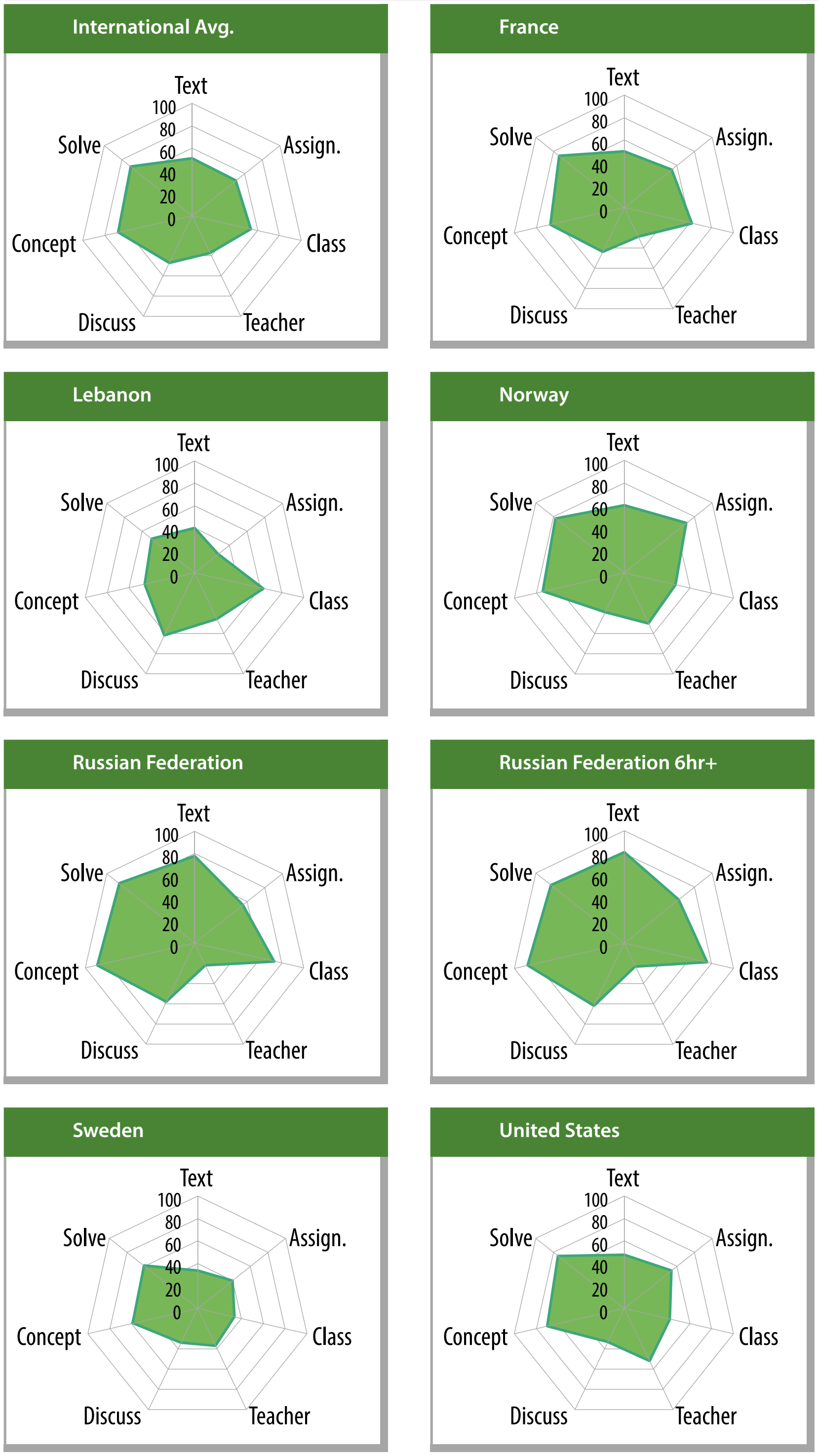
( ) Standard errors appear in parentheses. Because of rounding some results may appear inconsistent.

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

Exhibit M9.13: Profiles of Student Use of the Internet for Advanced Mathematics Schoolwork

Reported by Advanced Mathematics 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 advanced mathematics schoolwork.



The axis labels correspond with these ways that students use the Internet for advanced mathematics schoolwork:

Text	Access the Textbook or Other Course Materials
Assign.	Access Assignments Posted Online by the Teacher
Class	Collaborate with Classmates on Mathematics Assignments or Projects
Teacher	Communicate with the Teacher
Discuss	Discuss Mathematics Topics with Other Students
Concept	Find Information, Articles, or Tutorials to Aid in Understanding Mathematics Concepts
Solve	Find Information, Articles, or Tutorials to Aid in Solving Mathematics Problems

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

Exhibit M9.14: Percentages of Students Who Use the Internet for Advanced Mathematics Schoolwork

Reported by Advanced Mathematics Students

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

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.

TIMSS
Advanced
2015

CHAPTER M10: STUDENT ENGAGEMENT AND ATTITUDES

TIMSS ADVANCED 2015 INTERNATIONAL RESULTS IN ADVANCED MATHEMATICS AND PHYSICS

IEA
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International Study Center
Lynch School of Education, Boston College

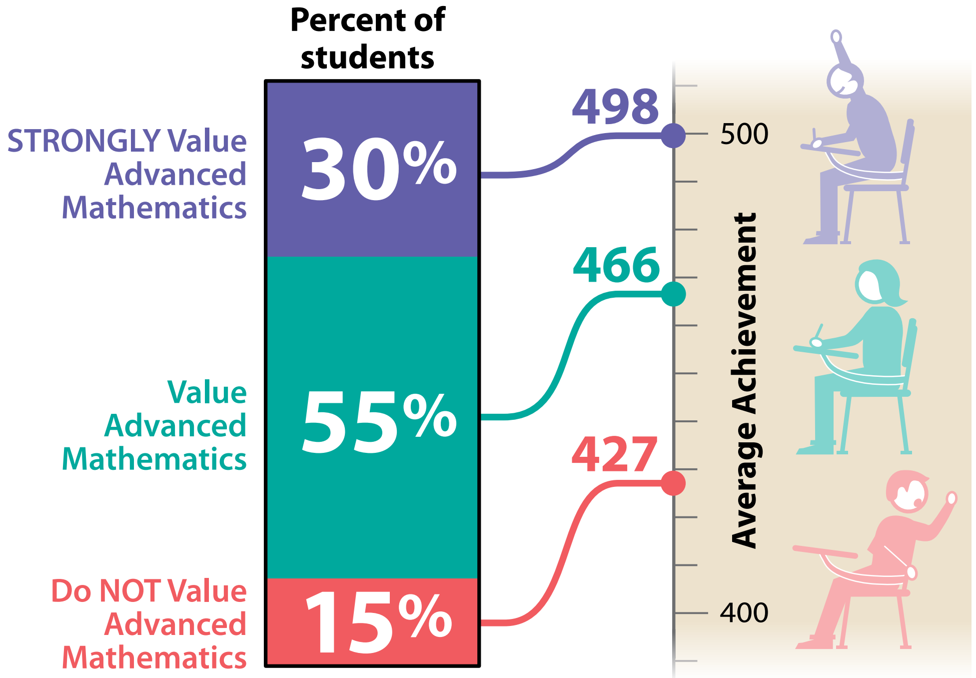
ADVANCED MATHEMATICS

TIMSS Advanced 2015

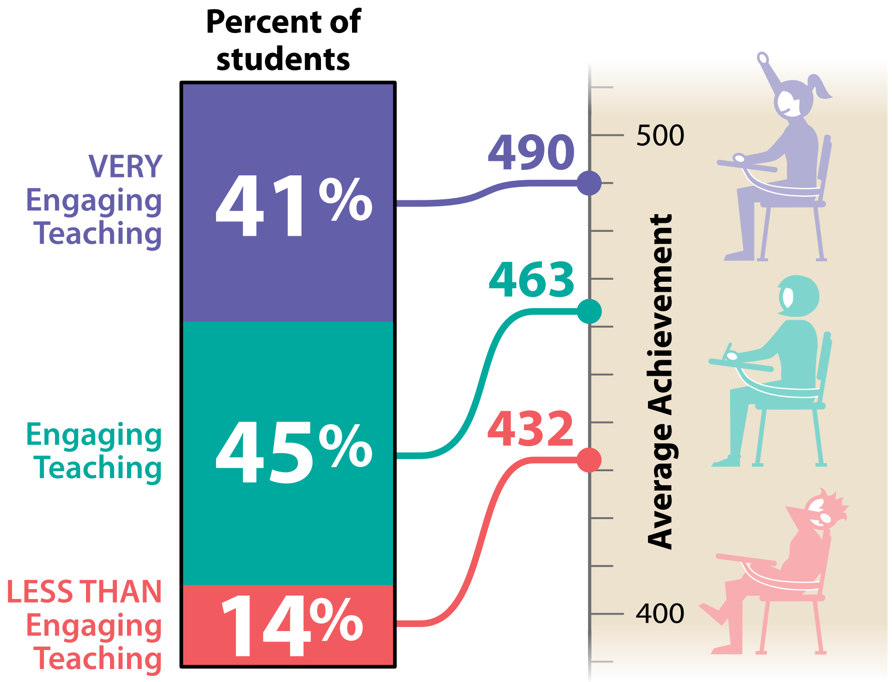
Students' Attitudes Toward Advanced Mathematics

Most students in advanced mathematics courses had positive attitudes toward mathematics and more positive attitudes were associated with higher achievement.

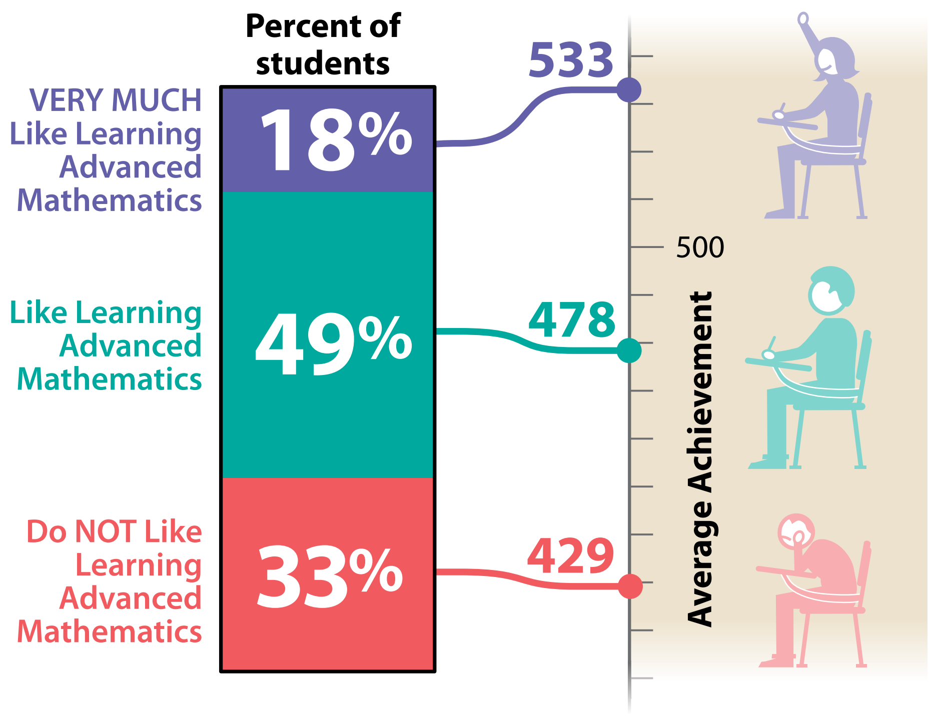
Most students (85%) STRONGLY value or value advanced mathematics.



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.



SOURCE: IEA's Trends in International Mathematics and Science Study – TIMSS Advanced 2015.
http://timss2015.org/advanced/download-center/

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International Study Center
Lynch School of Education, Boston College

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.

Country	Very Engaging Teaching		Engaging Teaching		Less than Engaging Teaching		Average Scale Score
	Percent of Students	Average Achievement	Percent of Students	Average Achievement	Percent of Students	Average Achievement	
Lebanon	67 (1.9)	539 (3.3)	28 (1.7)	519 (5.0)	5 (0.6)	525 (13.0)	11.2 (0.08)
Russian Federation 6hr+	60 (2.3)	553 (8.4)	35 (2.0)	523 (8.8)	4 (0.6)	499 (12.4)	10.9 (0.11)
Russian Federation	54 (2.1)	509 (6.2)	38 (1.5)	464 (5.9)	7 (0.9)	413 (12.9)	10.6 (0.09)
United States	54 (1.8)	503 (5.9)	35 (1.4)	473 (8.4)	11 (1.1)	446 (10.5)	10.5 (0.09)
Norway	44 (2.3)	477 (4.9)	47 (1.3)	450 (4.5)	9 (1.2)	422 (6.7)	10.1 (0.09)
Portugal	42 (1.8)	498 (2.9)	44 (1.4)	480 (2.7)	14 (1.3)	446 (5.4)	10.1 (0.09)
France	35 (1.5)	481 (3.5)	57 (1.3)	458 (3.3)	9 (0.8)	421 (5.9)	9.9 (0.06)
Sweden	27 (1.6)	471 (5.0)	51 (1.3)	428 (4.2)	22 (1.6)	391 (6.2)	9.4 (0.09)
Italy	25 (1.4)	429 (8.0)	52 (1.2)	427 (6.3)	24 (1.8)	403 (7.4)	9.2 (0.09)
Slovenia	18 (1.0)	500 (6.4)	57 (1.5)	464 (3.9)	25 (1.6)	425 (3.6)	9.0 (0.05)
International Avg.	41 (0.6)	490 (1.8)	45 (0.5)	463 (1.7)	14 (0.4)	432 (2.9)	

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.

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?

	Agree a lot	Agree a little	Disagree a little	Disagree a lot
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	○	○	○	○

Very Engaging Teaching ↑ 10.4 Engaging Teaching ↑ 7.9 Less than Engaging Teaching

Exhibit M10.1: Students' Views on Engaging Teaching in Advanced Mathematics Lessons (Continued)

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

Reported by Advanced Mathematics Students

Country	Very Engaging Teaching		Engaging Teaching		Less than Engaging Teaching	
	Percent of Students	Average Achievement	Percent of Students	Average Achievement	Percent of Students	Average Achievement
Lebanon						
Females	69 (3.4)	539 (5.2)	28 (3.4)	523 (8.5)	4 (0.9)	492 (21.0)
Males	66 (2.0)	538 (4.4)	28 (1.9)	517 (6.2)	5 (0.9)	538 (14.5)
Russian Federation 6hr+						
Females	61 (2.7)	543 (9.9)	35 (2.3)	512 (9.7)	5 (0.9)	482 (17.1)
Males	60 (2.5)	562 (8.1)	36 (2.3)	532 (9.8)	4 (0.6)	515 (13.2)
Russian Federation						
Females	54 (2.9)	503 (7.0)	39 (2.2)	460 (7.0)	7 (1.1)	409 (13.2)
Males	54 (1.9)	514 (6.8)	38 (1.5)	469 (6.5)	8 (0.9)	416 (15.3)
United States						
Females	55 (1.7)	486 (7.1)	34 (1.4)	459 (6.7)	12 (1.2)	428 (12.3)
Males	53 (2.7)	519 (6.0)	37 (2.6)	485 (13.8)	10 (1.3)	465 (13.1)
Norway						
Females	42 (2.9)	471 (5.2)	47 (2.2)	448 (6.0)	11 (1.5)	411 (8.9)
Males	45 (2.4)	480 (5.7)	47 (1.5)	452 (5.4)	8 (1.4)	432 (8.0)
Portugal						
Females	45 (2.2)	496 (3.5)	43 (1.7)	474 (3.8)	12 (1.5)	454 (5.7)
Males	39 (1.9)	499 (4.0)	45 (1.7)	486 (3.2)	16 (1.5)	439 (8.3)
France						
Females	36 (1.9)	465 (3.8)	55 (1.7)	443 (3.5)	9 (1.0)	416 (7.1)
Males	33 (1.7)	496 (4.3)	58 (1.5)	471 (3.8)	8 (1.0)	425 (7.4)
Sweden						
Females	26 (1.9)	466 (5.9)	50 (2.0)	423 (6.0)	24 (2.0)	382 (8.2)
Males	27 (1.9)	474 (6.4)	53 (1.5)	431 (4.2)	20 (1.6)	399 (7.1)
Italy						
Females	25 (1.9)	434 (13.5)	50 (1.8)	431 (6.6)	26 (2.2)	414 (7.9)
Males	25 (1.7)	426 (8.7)	53 (1.3)	425 (7.9)	22 (1.9)	395 (9.2)
Slovenia						
Females	16 (1.1)	485 (6.6)	57 (1.7)	454 (4.3)	27 (2.0)	420 (4.0)
Males	22 (1.5)	516 (8.8)	57 (1.9)	478 (5.2)	21 (1.9)	435 (6.3)
International Avg.						
Females	41 (0.8)	483 (2.3)	44 (0.7)	457 (2.0)	15 (0.5)	425 (3.6)
Males	41 (0.7)	496 (2.1)	46 (0.6)	468 (2.3)	13 (0.5)	438 (3.5)

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.

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 M10.2: Students Like Learning Advanced Mathematics

Reported by Advanced Mathematics Students

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**.

Country	Very Much Like Learning Advanced Mathematics		Like Learning Advanced Mathematics		Do Not Like Learning Advanced Mathematics		Average Scale Score
	Percent of Students	Average Achievement	Percent of Students	Average Achievement	Percent of Students	Average Achievement	
Lebanon	39 (1.8)	553 (4.1)	55 (1.9)	520 (4.4)	6 (0.9)	511 (8.0)	11.5 (0.07)
Russian Federation 6hr+	28 (2.3)	587 (7.9)	49 (1.4)	539 (7.2)	23 (1.6)	484 (11.7)	10.6 (0.11)
Norway	24 (1.2)	509 (5.1)	55 (1.0)	454 (4.5)	21 (1.1)	416 (5.6)	10.5 (0.06)
United States	19 (1.5)	542 (7.2)	50 (1.6)	490 (7.2)	31 (1.4)	445 (6.1)	10.0 (0.07)
Russian Federation	19 (1.2)	549 (6.3)	49 (1.0)	490 (5.9)	32 (1.7)	437 (6.9)	10.1 (0.08)
Portugal	19 (1.0)	537 (3.1)	49 (1.0)	490 (2.7)	33 (1.0)	441 (3.1)	10.0 (0.05)
Sweden	16 (0.8)	518 (4.6)	50 (0.8)	443 (4.2)	35 (0.9)	377 (5.1)	9.9 (0.05)
France	11 (0.6)	529 (4.9)	56 (0.9)	473 (3.0)	33 (1.1)	422 (3.4)	9.8 (0.04)
Italy	9 (0.6)	499 (6.5)	47 (1.0)	441 (5.6)	44 (1.2)	387 (6.8)	9.4 (0.04)
Slovenia	4 (0.5)	559 (8.8)	35 (1.3)	504 (3.3)	61 (1.4)	429 (3.6)	8.7 (0.05)
International Avg.	18 (0.4)	533 (1.9)	49 (0.4)	478 (1.6)	33 (0.4)	429 (1.9)	

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?

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

* Reverse coded

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

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

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

Students Like Learning Advanced Mathematics by Gender

Reported by Advanced Mathematics Students

Country	Very Much Like Learning Advanced Mathematics		Like Learning Advanced Mathematics		Do Not Like Learning Advanced Mathematics	
	Percent of Students	Average Achievement	Percent of Students	Average Achievement	Percent of Students	Average Achievement
Lebanon						
Females	44 (3.0)	547 (7.0)	51 (2.8)	525 (6.5)	5 (1.4)	506 (19.7)
Males	36 (1.9)	557 (4.7)	57 (2.0)	518 (5.1)	7 (1.2)	513 (9.3)
Russian Federation 6hr+						
Females	25 (2.7)	576 (9.5)	49 (1.6)	534 (8.8)	26 (2.6)	477 (14.2)
Males	31 (2.6)	595 (9.0)	49 (2.1)	543 (6.8)	20 (1.4)	492 (10.7)
Norway						
Females	24 (1.9)	497 (5.8)	56 (1.8)	451 (5.8)	20 (1.4)	408 (7.7)
Males	25 (1.6)	516 (5.7)	54 (1.6)	456 (4.6)	21 (1.4)	420 (6.3)
United States						
Females	17 (2.0)	528 (9.2)	45 (2.1)	477 (6.4)	38 (1.9)	437 (6.5)
Males	22 (1.9)	552 (9.1)	54 (1.9)	500 (9.8)	24 (1.6)	457 (8.0)
Russian Federation						
Females	16 (1.0)	544 (6.6)	48 (1.6)	487 (6.6)	36 (2.1)	441 (7.2)
Males	22 (1.6)	553 (7.5)	50 (1.2)	492 (6.3)	28 (1.8)	432 (8.0)
Portugal						
Females	18 (1.3)	531 (3.9)	48 (1.4)	491 (3.4)	34 (1.5)	443 (3.5)
Males	19 (1.3)	543 (4.4)	50 (1.2)	488 (3.3)	31 (1.1)	439 (5.1)
Sweden						
Females	14 (0.8)	506 (7.7)	48 (1.3)	438 (4.6)	38 (1.4)	376 (6.8)
Males	17 (1.1)	525 (4.9)	51 (1.1)	446 (5.1)	33 (1.3)	377 (6.1)
France						
Females	10 (0.7)	509 (5.8)	54 (1.3)	460 (3.3)	36 (1.3)	416 (4.0)
Males	13 (0.8)	543 (5.8)	58 (1.2)	484 (3.3)	30 (1.3)	429 (4.0)
Italy						
Females	9 (1.0)	492 (10.7)	46 (2.0)	450 (7.2)	44 (2.1)	390 (8.0)
Males	9 (0.6)	503 (8.2)	47 (1.0)	435 (6.5)	44 (1.2)	384 (8.5)
Slovenia						
Females	3 (0.5)	545 (12.4)	31 (1.5)	499 (3.9)	66 (1.5)	422 (4.3)
Males	6 (0.9)	570 (9.4)	42 (1.8)	509 (5.6)	53 (2.0)	441 (4.8)
International Avg.						
Females	17 (0.5)	522 (2.7)	47 (0.6)	475 (1.8)	35 (0.6)	427 (2.9)
Males	19 (0.5)	540 (2.3)	51 (0.5)	481 (1.9)	30 (0.5)	433 (2.3)

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.

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 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**.

Country	Strongly Value Advanced Mathematics		Value Advanced Mathematics		Do Not Value Advanced Mathematics		Average Scale Score
	Percent of Students	Average Achievement	Percent of Students	Average Achievement	Percent of Students	Average Achievement	
United States	54 (1.6)	506 (7.1)	43 (1.3)	463 (5.6)	3 (0.5)	448 (13.6)	11.3 (0.07)
Lebanon	47 (1.5)	547 (4.2)	50 (1.5)	522 (3.8)	3 (0.7)	492 (13.3)	11.1 (0.06)
Portugal	41 (1.4)	509 (2.8)	51 (1.2)	469 (3.1)	8 (0.6)	432 (4.9)	10.5 (0.05)
Norway	40 (1.2)	475 (5.1)	56 (1.2)	452 (5.0)	5 (0.6)	418 (7.3)	10.6 (0.05)
Russian Federation 6hr+	36 (2.2)	567 (7.1)	51 (1.4)	537 (7.2)	12 (1.4)	473 (17.5)	10.3 (0.12)
Russian Federation	26 (1.4)	525 (6.3)	56 (0.6)	482 (5.7)	18 (1.1)	433 (7.5)	9.8 (0.08)
Sweden	26 (0.9)	461 (5.1)	64 (1.0)	426 (4.5)	10 (0.6)	391 (6.9)	10.0 (0.04)
Italy	18 (0.9)	457 (7.1)	59 (1.0)	428 (5.9)	24 (1.0)	383 (7.7)	9.3 (0.05)
France	15 (0.7)	503 (4.8)	69 (0.8)	464 (2.8)	16 (0.8)	419 (4.1)	9.4 (0.04)
Slovenia	2 (0.3)	~ ~	50 (1.6)	486 (4.0)	48 (1.6)	430 (3.7)	8.2 (0.04)
International Avg.	30 (0.4)	498 (1.9)	55 (0.4)	466 (1.5)	15 (0.3)	427 (2.8)	

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.

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.

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

	Agree a lot	Agree a little	Disagree a little	Disagree a lot
1) Learning mathematics will help me get ahead in the world	○	○	○	○
2) It is important to do well in my mathematics class	○	○	○	○
3) The mathematics I am studying is not useful for my future*	○	○	○	○
4) My parents are pleased that I am taking advanced mathematics	○	○	○	○
5) Doing well in mathematics will help me get into the university of my choice	○	○	○	○
6) Learning advanced mathematics does not seem to be a worthwhile exercise*	○	○	○	○
7) My parents think that it is important that I do well in my mathematics class	○	○	○	○
8) I like telling people I am studying advanced mathematics	○	○	○	○
9) Learning advanced mathematics will give me more job opportunities	○	○	○	○

*Reverse coded

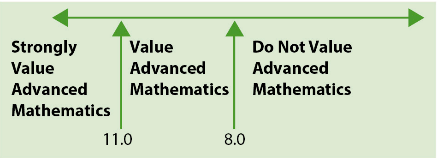

Exhibit M10.3: Students Value Advanced Mathematics (Continued)

Students Value Advanced Mathematics by Gender

Reported by Advanced Mathematics Students

Country	Strongly Value Advanced Mathematics		Value Advanced Mathematics		Do Not Value Advanced Mathematics	
	Percent of Students	Average Achievement	Percent of Students	Average Achievement	Percent of Students	Average Achievement
United States						
Females	52 (1.8)	492 (6.7)	45 (1.7)	447 (5.3)	3 (0.6)	441 (20.3)
Males	55 (2.4)	519 (9.5)	41 (1.9)	481 (8.1)	4 (1.0)	454 (17.4)
Lebanon						
Females	52 (2.6)	543 (5.8)	46 (2.5)	525 (6.5)	2 (0.6)	~ ~
Males	44 (2.1)	550 (5.3)	53 (2.3)	521 (4.8)	3 (0.9)	487 (13.4)
Portugal						
Females	38 (1.6)	508 (3.6)	54 (1.5)	469 (3.6)	8 (0.6)	437 (5.2)
Males	43 (1.8)	510 (3.7)	49 (1.6)	469 (4.4)	8 (0.9)	427 (7.6)
Norway						
Females	36 (1.8)	465 (5.7)	59 (1.8)	450 (6.6)	5 (0.8)	409 (12.2)
Males	42 (1.3)	480 (6.4)	53 (1.4)	453 (5.2)	5 (0.7)	423 (7.6)
Russian Federation 6hr+						
Females	33 (2.6)	560 (8.4)	53 (1.5)	527 (8.0)	14 (2.2)	465 (22.5)
Males	39 (2.2)	572 (7.6)	50 (1.7)	546 (7.4)	11 (1.0)	481 (15.2)
Russian Federation						
Females	23 (1.3)	520 (7.5)	57 (0.9)	480 (6.2)	20 (1.3)	435 (8.3)
Males	30 (1.6)	529 (7.0)	54 (0.9)	485 (6.2)	16 (1.2)	430 (8.6)
Sweden						
Females	25 (1.2)	448 (6.5)	65 (1.3)	420 (5.3)	10 (0.8)	392 (10.8)
Males	27 (1.3)	469 (6.0)	64 (1.4)	430 (5.5)	9 (0.8)	390 (9.5)
Italy						
Females	16 (1.4)	461 (12.6)	61 (1.5)	432 (6.7)	24 (1.6)	394 (11.4)
Males	19 (1.0)	456 (8.1)	57 (1.6)	425 (7.8)	24 (1.3)	376 (8.5)
France						
Females	12 (0.8)	486 (5.1)	70 (1.2)	452 (3.3)	18 (1.0)	416 (5.0)
Males	17 (0.9)	513 (5.8)	68 (1.1)	476 (3.2)	14 (1.1)	424 (4.9)
Slovenia						
Females	2 (0.4)	~ ~	44 (1.6)	476 (3.8)	54 (1.6)	425 (4.6)
Males	3 (0.5)	557 (12.1)	58 (2.4)	497 (5.4)	40 (2.5)	442 (5.4)
International Avg.						
Females	28 (0.5)	490 (2.5)	56 (0.5)	461 (1.8)	16 (0.4)	418 (3.8)
Males	31 (0.5)	509 (2.5)	55 (0.6)	471 (1.9)	14 (0.4)	428 (3.3)

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.

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.

TIMSS
Advanced
2015

CHAPTER M11: DESCRIPTION OF ADVANCED MATHEMATICS PROGRAMS AND CURRICULUM

TIMSS ADVANCED 2015 INTERNATIONAL RESULTS IN ADVANCED MATHEMATICS AND PHYSICS

IEA
TIMSS & PIRLS
International Study Center
Lynch School of Education, Boston College

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.

Content Area	Topics
Analysis	Quadratic functions: solving quadratic equations, sign of a quadratic function Sequences: arithmetic and geometric sequences, induction, finite or infinite limits, bounded sequences Function limits: finite or infinite limits, limits of a sum, product, quotient or composite functions, asymptotes Continuity on an interval, including the Intermediate Value Theorem 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

Content Area	Topics
Analysis (Continued)	Sine and cosine functions Exponential functions Natural logarithms 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
Geometry	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 Euclidean vectors, including the characterization of a line and a plane, scalar product, coordinates, equation of a plane Trigonometry, including trigonometric functions defined on the unit circle, radian, the sine and cosine of supplementary and complementary angles
Probability and Statistics	Descriptive statistics, including variance, standard deviation Conditional probability, independence Probability density functions, including discrete and continuous random variables, probability distributions (normal, Bernoulli, binomial, uniform, exponential), variance, standard deviation Confidence intervals Sampling, confidence interval for a proportion

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 underling 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.

Grade	Topics
Grades 9 and 10	Arithmetic: integer, rational and real numbers; algebra, polynomials, algebraic equations of first and second-degree, inequalities, simultaneous equations Functions: Linear functions $f(x) = ax + b$, quadratic functions $f(x) = ax^2 + bx + c$, $f(x) = \|x\|$, and $f(x) = a/x$ Euclidean geometry and Cartesian plane geometry: geometric transformations in the plane, circles, circumference, and π (pi), introduction to trigonometric functions and to vectors Descriptive statistics: average values, variance, standard deviation Classic probability, probability theorems
Grades 11 and 12	Analytic geometry Conics Spatial geometry: planes, lines, polyhedra, pyramids, solids of rotation (cylinder, cone, sphere), areas and volumes of elementary solids Trigonometry: triangles, law of sines and law of cosines law Trigonometric functions: trigonometric equations and inequalities Exponential functions: exponential equations and inequalities Logarithmic functions, e (base of natural logarithms), logarithmic equations and inequalities Arithmetic and geometric sequences and series Mathematical induction Complex numbers: algebraic, geometric and trigonometric forms and representations; sums, products, and quotients; complex solutions of quadratic equations Combinatorics Statistics: regression and correlation Conditional probability, Bayes' theorem
Grade 13	Limit of a series Functions Limits: finite or infinite limits, limits of sums, products, quotients or composite functions, asymptotes Continuity on an interval Differentiation: numerical derivatives; the derivatives of common functions; derivatives of sums, products, quotients, and composite functions; applications of derivatives; the relationship between differentiability and continuity; the fundamental theorems of differential calculus; maxima and minima Integration: integration on an interval, the relationship between the definite integral and the area under a curve, the antiderivative of a function, applications of definite integrals Differential equations and applications, particularly in physics Analytic spatial geometry: coordinates, equations of planes, lines, spheres Probability: discrete and continuous random variables, probability distributions (Bernoulli, Poisson, normal), variance, standard deviation

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.

Domain	Competencies
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.

Content Area	Topics
Geometry (R1 and R2)	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
Algebra (R1 and R2)	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
Functions (R1 and R2)	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;

Content Area	Topics
Functions (R1 and R2) (Continued)	modeling periodic phenomena; definite and indefinite integrals; integration by substitution, by parts, and by partial fractions with linear denominators; interpretations of definite integrals in practical applications, and calculation of areas of plane regions and volumes of solids of revolution; mathematical modeling based on observed data
Combinatorics and Probability (R1 only)	Independence and conditional probability; Bayes' theorem for two events; ordered samples with and without replacement; unordered samples without replacement; applications to calculation of probabilities
Differential Equations (R2 only)	Modeling practical situations by differential equations; interpretation of solutions; linear first order and separable differential equations; second order homogenous differential equations; the use of Newton's second law and second order differential equations to describe free oscillations by periodic functions; application of digital tools to draw vector diagrams and integral curves

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.

Main Subject	Topics
Probability and Combinatorics	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 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 Combinatorics: enumerative combinatorics; permutations and combinations; Pascal's Triangle and Newton's Binomial expansion; the Binomial Theorem; applications of probability calculations
Introduction to Differential Calculus II	Exponential and logarithmic functions: analytical and graphical properties of exponential and logarithmic functions; rules for exponents and logarithms; modeling with exponential and logarithmic functions 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 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
Trigonometry and Complex Numbers	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 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

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.

Content Areas in Algebra and Calculus	
Grade 10	
Polynomials	Transformation of polynomials, factorization; division of polynomials; Horner's method; roots of polynomials; Bezout's theorem; converting irrational expressions
Graphs of Functions	Complex functions; conversion of graphs; graphs of linear-fractional functions, asymptotes; graphs of functions which include a sign of a module (e.g., $y=\frac{2x-6}{\lvert 3-x\rvert}$ or $y=\sin\lvert x\rvert$) ; reciprocal functions and their graphs
Introduction to Calculus	Numerical sequences, limits of sequences, limits of functions, theorems on limits of functions; properties and continuity of elementary functions
Derivatives and their Applications	Geometric and physical meaning of the derivative, continuity and differentiability of functions, derivatives of sums, products, quotients, composites and exponential functions; second derivatives and higher order derivatives; application of derivatives to study functions; Lagrange's theorem and its consequences; drawing graphs of functions

Content Areas in Algebra and Calculus	
Trigonometric Functions	Trigonometric functions of numeric argument (sine, cosine, tangent and cotangent); trigonometric identities and their consequences; reduction formulas; identical transformation of trigonometric expressions; periodicity of trigonometric functions; properties, graphs, and derivatives of trigonometric functions
Grade 11	
Integral and Differential Equations	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
Exponential and Logarithmic Functions	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
Complex Numbers	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
Elements of Combinatorics	Methods of mathematical induction; proofs of identities; factorials; the basic formulae of combinatorics; combinations and permutations; Binomial Theorem, Dirichlet's Principle
Elements of the Theory of Probability and Mathematical Statistics	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
Equations, Inequalities, Systems	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

Content Areas in Geometry	
Grade 10	
Axioms of Solid Geometry	
Parallel Lines and Planes	Mutual arrangement of lines and planes in space; theorems of parallelism of lines and planes
Perpendicularity of Lines and Planes	Theorems of dependences between parallelism and perpendicularity of lines and planes, the Theorem of the Three Perpendiculars; angles between straight lines and a plane
Coordinates and Vectors in a Space	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
Vectors in a Space	Decomposition of vectors into three non-coplanar vectors; scalar products; applications of coordinates and vectors to solve problems

Content Areas in Geometry	
Grade 11	
Polyhedrons	Concepts of polyhedrons, prisms, rectangular parallelepipeds, and pyramids; areas of faces and surfaces; sections; regular polyhedrons; dihedral angles
Solids of Revolution	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
Volumes of Bodies	Volumes of polyhedrons (prisms, pyramids) and solids of revolution (cylinder, cone, sphere, part of the sphere)
The Surface Areas of Solids of Revolution	Areas of spheres, surface areas of cylinders and cones

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.

Content Area	Topics
Sets and Logic	Basics of logic; sets
Numbers	Number sets with whole, rational, real, and complex numbers (mathematical induction and the polar form of complex numbers are optional topics)
Algebraic Expressions	Equations and inequalities and their methods of solution (parametric equations are optional); powers and roots
Geometry	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)
Functions	Limits, continuity, inverse and composite functions; linear functions; solving systems of linear equations; quadratic, exponential, rational, logarithmic and trigonometric functions; conic sections
Sequences and Series	
Calculus	Differential calculations; integrals; applications of integrals
Probability and Statistics	Combinatorics

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.

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

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.

TIMSS
Advanced
2015

ADVANCED MATHEMATICS APPENDICES

TIMSS ADVANCED 2015 INTERNATIONAL RESULTS IN ADVANCED MATHEMATICS AND PHYSICS

IEA
TIMSS & PIRLS
International Study Center
Lynch School of Education, Boston College

Exhibit MA.1: Countries Participating in the TIMSS Advanced 2015 Advanced Mathematics Assessment and in Earlier TIMSS Advanced Assessments

Country	2015	2008	1995
France	●		●
Italy	●	●	●
Lebanon	●	●	
Norway	●	●	
Portugal	●		
Russian Federation	●	●	●
Slovenia	●	●	●
Sweden	●	●	●
United States	●		●

● 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

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

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

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

Country	International Target Population Coverage	Exclusions from National Target Population		
		School-Level Exclusions	Within-Sample Exclusions	Overall Exclusions
France	100%	4.6%	0.1%	4.7%
Italy	100%	0.5%	0.7%	1.1%
Lebanon	100%	1.3%	0.0%	1.3%
Norway	100%	1.4%	0.0%	1.4%
Portugal	100%	0.0%	0.3%	0.3%
Russian Federation	100%	0.2%	0.1%	0.3%
Russian Federation 6hr+	100%	1.0%	0.1%	1.1%
Slovenia	100%	0.3%	2.2%	2.5%
Sweden	100%	1.6%	0.1%	1.7%
United States	100%	0.0%	0.1%	0.1%

[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

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

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

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

** France: Estimate derived by dividing the population of 15–19-year-olds by 5 for the single year estimate. Data retrieved from INSEE (National Institute of Statistics and Economic Studies), Estimations de Population (résultats provisoires à fin 2015); http://www.insee.fr/fr/themes/detail.asp?reg_id=99&ref_id=estim-pop.

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.

Lebanon: Value is the total population of 18-year olds in Lebanon in 2015. Data retrieved from http://databank.worldbank.org/data/reports.aspx?source=health-nutrition-and-population-statistics:-population-estimates-and-projections&Type=TABLE&preview=on.

Norway: Estimate derived by dividing the population of 15–19-year-olds by 5 for the single year estimate. Data retrieved from https://stats.oecd.org/Index.aspx?DataSetCode=POP_PROJ.

Portugal: Estimate derived by dividing the 2014 population of 15–19-year-olds by 5 for the single year estimate. Data retrieved from INE (Instituto Nacional de Estatística) Annual Estimates of Resident Population;
http://www.pordata.pt/en/Portugal/Resident+population+total+and+by+age+group-10.

Russian Federation: Estimate derived by dividing the population of 15–19-year-olds by 5 for the single year estimate. Data retrieved from The Demographic Yearbook of Russia, 2015; http://www.gks.ru/wps/wcm/connect/rosstat_main/rosstat/ru/statistics/publications/catalog/doc_1137674209312.

Slovenia: Value is the total population of 18-year olds in Slovenia as of July 1st 2015. Data retrieved from the Statistical Office of the Republic of Slovenia; http://pxweb.stat.si.

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/BefolkningR1860/table/tableViewLayout1/?rxid=06695d79-5fa1-41d1-81c1-3ae51dcd09b7.

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/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 Mathematics 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 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

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

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

Appendix MC.4: Student Sample Sizes - Advanced Mathematics

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

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

Country	School Participation		Class Participation	Student Participation	Overall Participation	
	Before Replacement	After Replacement			Before Replacement	After Replacement
France	99%	99%	100%	96%	95%	95%
Italy	88%	94%	99%	97%	85%	90%
‡ Lebanon	70%	70%	100%	98%	68%	68%
Norway	100%	100%	100%	93%	93%	93%
† Portugal	80%	87%	98%	93%	73%	80%
Russian Federation	100%	100%	100%	98%	98%	98%
Russian Federation 6hr+	100%	100%	100%	98%	98%	98%
Slovenia	89%	89%	96%	87%	75%	75%
Sweden	99%	99%	99%	90%	88%	88%
‡ United States	72%	76%	100%	87%	63%	66%

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

Country	Years of Formal Schooling*			Average Age at Time of Testing			Overall Exclusion Rates**			Advanced Mathematics Coverage Index***			Overall Participation Rates		
	2015	2008	1995	2015	2008	1995	2015	2008	1995	2015	2008	1995	2015	2008	1995
France	12		12	18.0		18.2	4.7%		1.0%	21.5%		19.9%	95%		77%
Italy	13	13	13	18.9	19.0	19.1	1.1%	0.5%	3.8%	24.5%	19.7%	14.1%	90%	95%	68%
Lebanon	12	12		17.8	17.9		1.3%	1.3%		3.9%	5.9%		68%	83%	
Norway	13	13		18.7	18.8		1.4%	1.0%		10.6%	10.9%		93%	83%	
Russian Federation 6hr+	11	10/11	10	17.7	17.0	16.9	1.1%	0.0%	2.0%	1.9%	1.4%	2.0%	98%	98%	96%
Slovenia	13	12	12	18.8	18.8	18.9	2.5%	1.3%	6.0%	34.4%	40.5%	75.4%	75%	81%	42%
Sweden	12	12	12	18.8	18.8	18.9	1.7%	1.7%	0.2%	14.1%	12.8%	16.2%	88%	84%	89%
United States	12		12	18.1		18.0	0.1%		3.7%	11.4%		6.4%	66%		71%

* 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

Country	Overall Advanced Mathematics	Advanced Mathematics Content Domains			Advanced Mathematics Cognitive Domains		
		Algebra	Calculus	Geometry	Knowing	Applying	Reasoning
France	36 (0.5)	41 (0.6)	34 (0.6)	32 (0.5)	49 (0.6)	31 (0.5)	30 (0.6)
Italy	31 (0.7)	33 (0.8)	32 (0.8)	29 (0.7)	42 (0.9)	29 (0.7)	25 (0.7)
Lebanon	50 (0.7)	52 (0.8)	51 (0.7)	47 (0.9)	64 (0.7)	45 (0.8)	44 (0.9)
Norway	37 (0.9)	37 (0.9)	35 (0.9)	38 (0.9)	46 (0.9)	33 (0.9)	33 (0.9)
Portugal	40 (0.5)	47 (0.6)	35 (0.5)	37 (0.5)	49 (0.5)	35 (0.5)	36 (0.7)
Russian Federation	43 (1.1)	48 (1.2)	36 (1.0)	45 (1.1)	52 (1.1)	41 (1.2)	37 (1.0)
Russian Federation 6hr+	54 (1.7)	61 (1.7)	46 (1.6)	57 (1.9)	63 (1.5)	52 (1.7)	50 (1.8)
Slovenia	37 (0.6)	43 (0.8)	30 (0.7)	37 (0.6)	49 (0.8)	34 (0.6)	28 (0.7)
Sweden	33 (0.6)	34 (0.7)	33 (0.6)	31 (0.6)	40 (0.7)	30 (0.6)	29 (0.6)
United States	43 (1.0)	45 (1.0)	46 (1.2)	37 (0.9)	54 (1.1)	39 (0.9)	38 (1.0)
International Avg.	39 (0.3)	42 (0.3)	37 (0.3)	37 (0.3)	49 (0.3)	35 (0.3)	33 (0.3)

( ) 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.

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[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.[2] 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.[3]

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 judged appropriate 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.

Country	Average Percent Correct on All Items	Lebanon	Russian Federation	United States	Portugal	Norway	Slovenia	France	Sweden	Italy
Lebanon	50 (0.7)	51	49	50	51	50	50	50	51	51
Russian Federation	43 (1.1)	44	44	43	44	43	43	43	42	43
United States	43 (1.0)	43	41	43	43	43	43	42	42	43
Portugal	40 (0.5)	39	40	40	42	40	39	40	40	40
Norway	37 (0.9)	37	37	37	37	37	37	37	36	36
Slovenia	37 (0.6)	37	37	37	37	36	37	37	36	36
France	36 (0.5)	36	36	36	36	36	36	36	35	36
Sweden	33 (0.6)	33	33	33	33	33	33	32	32	33
Italy	31 (0.7)	32	30	32	32	32	31	31	31	32
International Avg.	39 (0.3)	39	38	39	39	39	39	39	38	39
Number of Items (Score Points) Identified*	120	112	91	119	111	118	119	109	111	117

* 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.

( ) 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

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 advanced mathematics 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 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

Exhibit ME.2: Standard Errors 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.

Country	Average Percent Correct on All Items	Lebanon	Russian Federation	United States	Portugal	Norway	Slovenia	France	Sweden	Italy
Lebanon	50 (0.7)	0.7	0.8	0.7	0.7	0.7	0.7	0.7	0.7	0.7
Russian Federation	43 (1.1)	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1
United States	43 (1.0)	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Portugal	40 (0.5)	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Norway	37 (0.9)	0.9	0.9	0.9	0.9	0.9	0.9	0.8	0.9	0.8
Slovenia	37 (0.6)	0.6	0.7	0.6	0.7	0.6	0.6	0.6	0.6	0.6
France	36 (0.5)	0.5	0.6	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Sweden	33 (0.6)	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6
Italy	31 (0.7)	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
International Avg.	39 (0.3)	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Number of Items (Score Points) Identified*	120	112	91	119	111	118	119	109	111	117

* 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.

( ) 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

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.

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[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

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

( ) 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 MF.2: Standard Deviations of Achievement in Advanced Mathematics

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

( ) 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 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

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TIMSS
Advanced
2015

CHAPTER P1: STUDENT ACHIEVEMENT

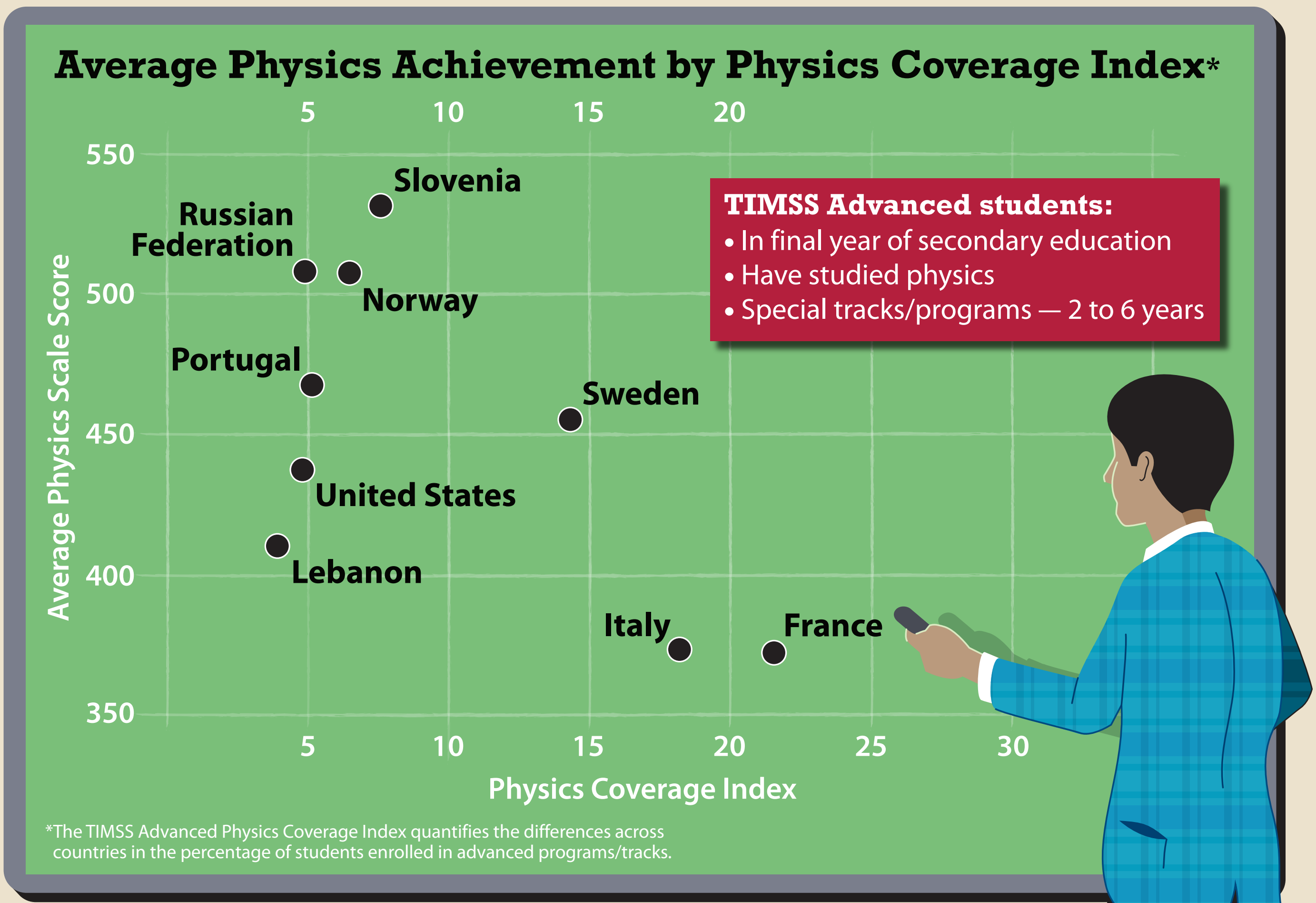
TIMSS ADVANCED 2015 INTERNATIONAL RESULTS IN ADVANCED MATHEMATICS AND PHYSICS

IEA
TIMSS & PIRLS
International Study Center
Lynch School of Education, Boston College

PHYSICS TIMSS *Advanced* 2015

International Achievement in Physics

Average Physics Achievement by Physics Coverage Index*



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

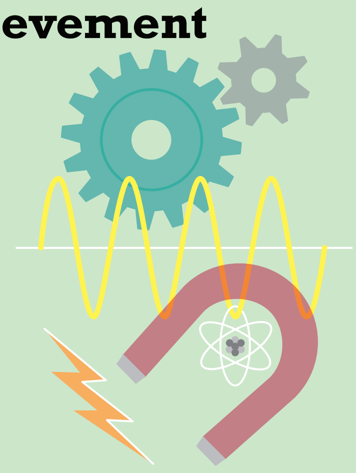
*The TIMSS Advanced Physics Coverage Index quantifies the differences across countries in the percentage of students enrolled in advanced programs/tracks.

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.

More Males enrolled

9 Countries
France, Italy, Russian Federation, Sweden, the United States, Lebanon, Slovenia, Norway, Portugal

0 Countries

More Females enrolled

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

Males higher achievement

8 Countries
France, Italy, Russian Federation, Sweden, the United States, Slovenia, Norway, Portugal

0 Countries

Females higher achievement

SOURCE: IEA's Trends in International Mathematics and Science Study – TIMSS Advanced 2015.
http://timss2015.org/advanced/download-center/

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International Study Center
Lynch School of Education, Boston College

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

Reported by National Research Coordinators

Country	Description of How the Programs (Tracks) Fit into the Overall Curriculum	Number of Years Students are Taught in These Programs (Tracks)	Number of Hours of Physics Instruction in Final Year	Criteria for Admission to These Programs (Tracks)	Prerequisites for Admission to These Programs (Tracks)
France	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.	2 years	74	Students' skills and attitudes towards science, their grades in mathematics and science, and teachers' and principals' opinions and reports all contribute.	No prerequisites
Italy	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.	5 years	86	There are no specific criteria for admission.	No prerequisites
Lebanon	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.	6 years	166	There are no specific criteria for admission; all students take physics.	No prerequisites
Norway	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.	2 years	140	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.	No prerequisites to enroll in Physics 1
Portugal	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.	3 years	98	Admission to the physics course at Grade 12 requires successfully completing the 2-year physics and chemistry course in Grades 10 and 11.	2-year physics and chemistry course in Grades 10 and 11
Russian Federation	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.	2 years	90	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.	No prerequisites

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

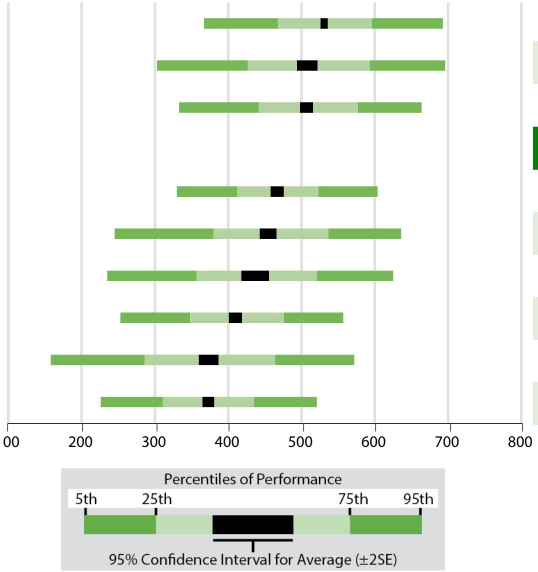
Exhibit P1.1: Structural Characteristics of the Physics Programs (Tracks) (Continued)

Country	Description of How the Programs (Tracks) Fit into the Overall Curriculum	Number of Years Students are Taught in These Programs (Tracks)	Number of Hours of Physics Instruction per Year	Criteria for Admission to These Programs (Tracks)	Prerequisites for Admission to These Programs (Tracks)
Slovenia	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.	4 years	105	Completion of elementary schooling.	No prerequisites
Sweden	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.	3 years	Varying, but approximately 110 on average	Completion of 9-year compulsory school with passing grades in Swedish, English, mathematics, biology, physics, chemistry, and at least six other subjects.	No prerequisites
United States	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) Program 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.	Varies by school and by course	Varies by school and by course	Varies by district and by school	Varies by school and by course

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

Exhibit P1.2: Distribution of Physics Achievement

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



▲ Country average significantly higher than TIMSS scale centerpoint

▼ Country average significantly lower than TIMSS scale centerpoint

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

* 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*

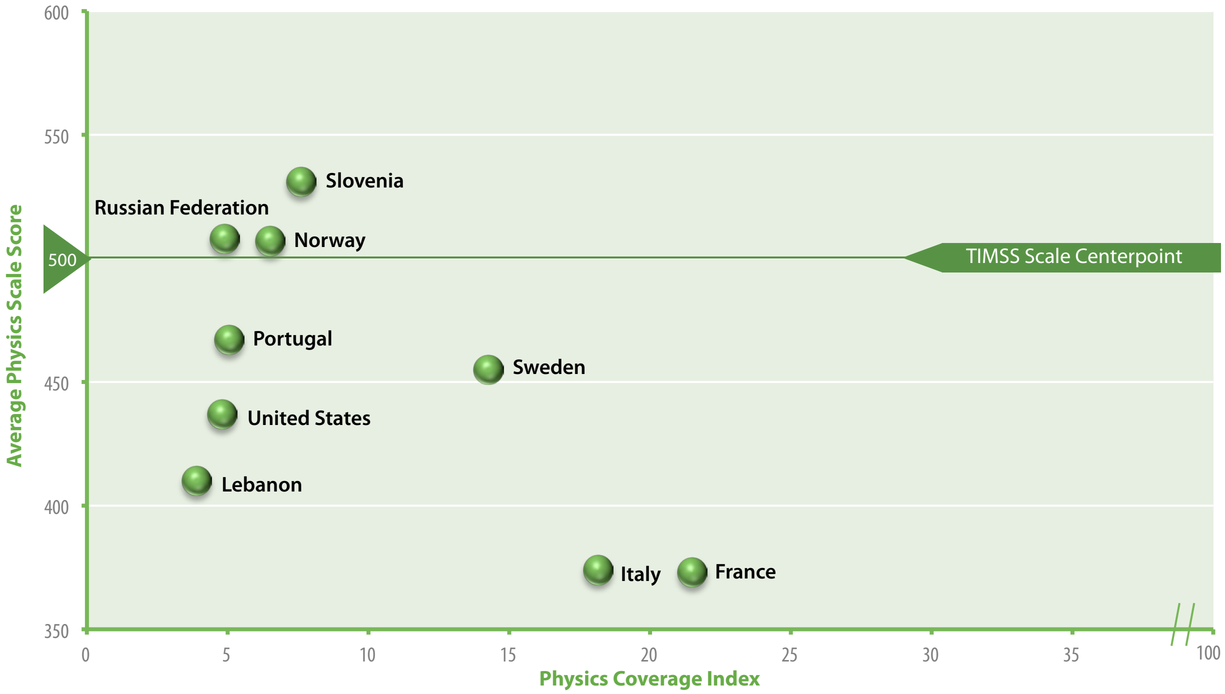


Exhibit P1.3: Multiple Comparisons of Average Physics Achievement

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.

Country	Average Scale Score	Slovenia	Russian Federation	Norway	Portugal	Sweden	United States	Lebanon	Italy	France
Slovenia	531 (2.5)		▲	▲	▲	▲	▲	▲	▲	▲
Russian Federation	508 (7.1)	▼			▲	▲	▲	▲	▲	▲
Norway	507 (4.6)	▼			▲	▲	▲	▲	▲	▲
Portugal	467 (4.6)	▼	▼	▼			▲	▲	▲	▲
Sweden	455 (5.9)	▼	▼	▼				▲	▲	▲
United States	437 (9.7)	▼	▼	▼	▼			▲	▲	▲
Lebanon	410 (4.5)	▼	▼	▼	▼	▼	▼		▲	▲
Italy	374 (6.9)	▼	▼	▼	▼	▼	▼	▼		
France	373 (4.0)	▼	▼	▼	▼	▼	▼	▼		

▲ Average achievement significantly higher than comparison country

▼ Average achievement significantly lower than comparison country

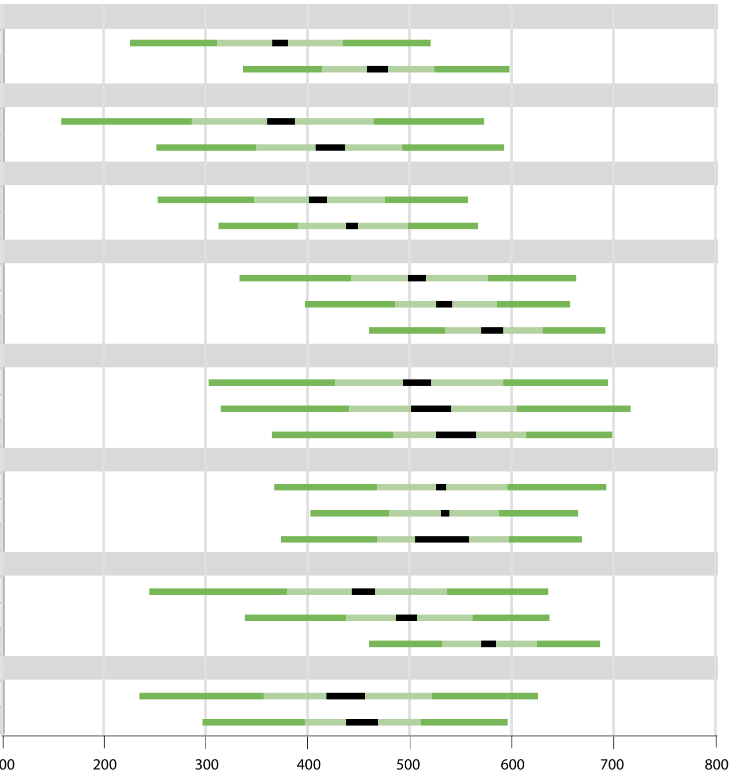
Significance tests were not adjusted for multiple comparisons. Five percent of the comparisons would be statistically significant by chance alone.
( ) Standard errors appear in parentheses. Because of rounding some results may appear inconsistent.

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

Exhibit P1.4: Differences in Physics Achievement Across Assessment Years

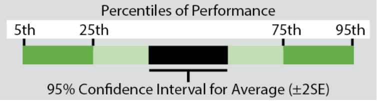
Instructions: Read across the row to determine if the performance in the row year is significantly higher (▲) or significantly lower (▼) than the performance in the column year.

Country	Physics Coverage Index*	Average Scale Score	Differences Between Years	
			2008	1995
France				
2015	21.5%	373 (4.0)		-96 ▼
1995	19.9%	469 (5.3)		
Italy				
2015	18.2%	374 (6.9)	-48 ▼	
2008	3.8%	422 (7.4)		
Lebanon				
‡ 2015	3.9%	410 (4.5)	-33 ▼	
2008	5.9%	444 (3.0)		
Norway				
2015	6.5%	507 (4.6)	-27 ▼	-74 ▼
2008	6.8%	534 (4.1)		-47 ▼
‡ 1995	8.4%	581 (5.5)		
Russian Federation				
2015	4.9%	508 (7.1)	-14	-38 ▼
2008	2.6%	521 (10.1)		-24
1995	1.5%	546 (10.1)		
Slovenia				
2015	7.6%	531 (2.5)	-4	-1
‡ 2008	7.5%	535 (2.2)		3
‡ 1995	38.6%	532 (13.5)		
Sweden				
2015	14.3%	455 (5.9)	-42 ▼	-123 ▼
2008	11.0%	497 (5.3)		-81 ▼
1995	16.3%	578 (3.7)		
United States				
‡ 2015	4.8%	437 (9.7)		-16
‡ 1995	2.7%	454 (8.1)		



▲ More recent year significantly higher

▼ More recent year significantly lower



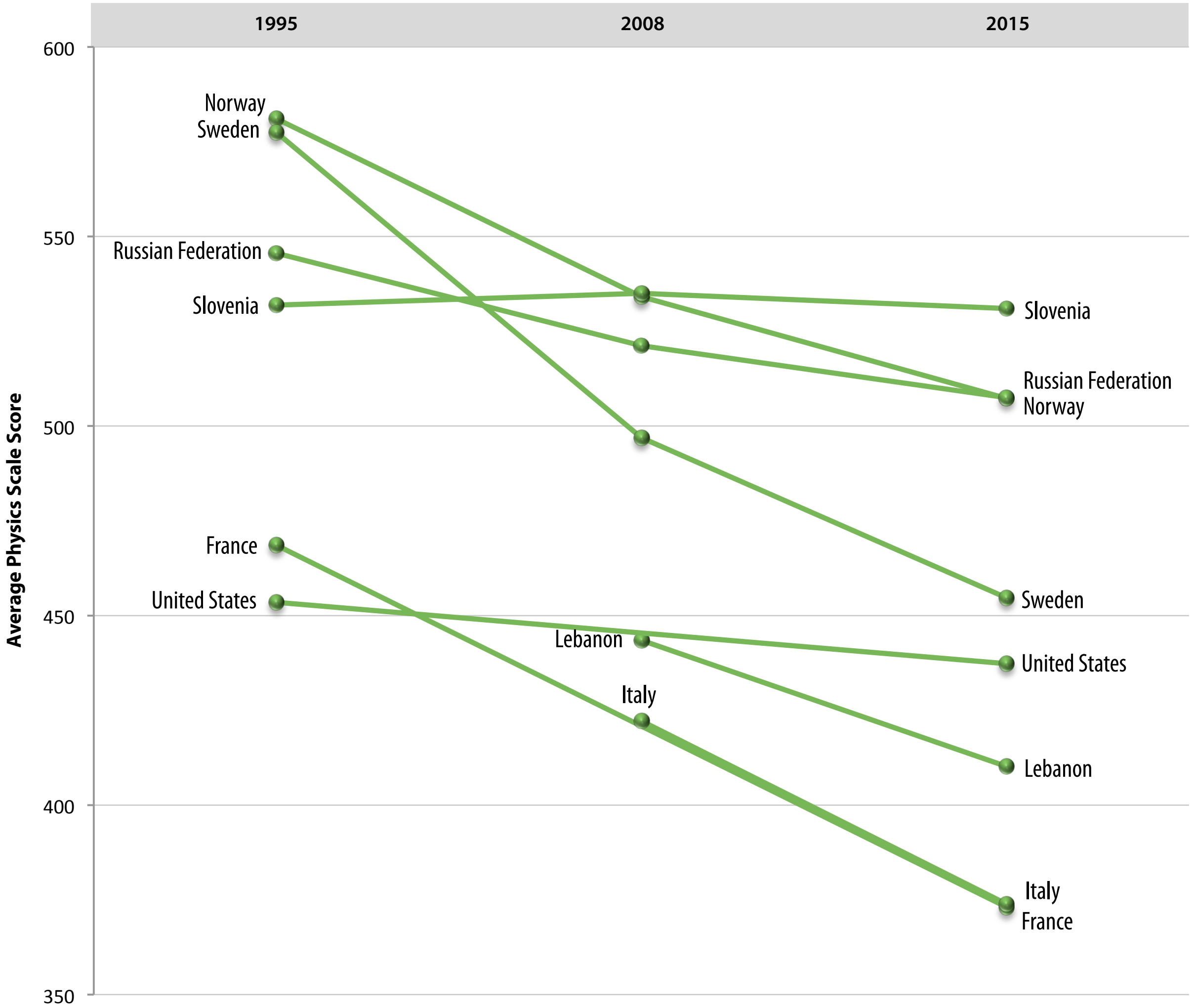
SOURCE: IEA's Trends in International Mathematics and Science Study – TIMSS Advanced 2015

* 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 P1.4: Differences in Physics Achievement Across Assessment Years (Continued)



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

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 Physical Science

Country	Achievement Difference from TIMSS Scale Centerpoint (500)	
Russian Federation	52 (5.6)	▲
United States	35 (3.1)	▲
Slovenia	28 (2.3)	▲
Italy	20 (3.6)	▲
Sweden	9 (3.2)	▲
Norway (4)	-39 (3.5)	▼
France	◊ ◊	
Lebanon	◊ ◊	

2011 - TIMSS Fourth Grade Physical Science

Country	Achievement Difference from TIMSS Scale Centerpoint (500)	
Russian Federation	48 (4.0)	▲
United States	44 (2.0)	▲
Sweden	28 (2.5)	▲
Slovenia	24 (3.1)	▲
Italy	9 (3.1)	▲
Norway (4)	-18 (3.4)	▼
France	◊ ◊	
Lebanon	◊ ◊	

2015 - TIMSS Fourth Grade Physical Science

Country	Achievement Difference from TIMSS Scale Centerpoint (500)	
Russian Federation	67 (3.6)	▲
Slovenia	46 (2.4)	▲
United States	37 (2.6)	▲
Sweden	34 (3.6)	▲
Italy	13 (2.9)	▲
France	-18 (2.7)	▼
Norway (4)	-25 (2.8)	▼
Lebanon	◊ ◊	

2007 - TIMSS Eighth Grade Physics

Country	Achievement Difference from TIMSS Scale Centerpoint (500)	
Slovenia	28 (2.4)	▲
Russian Federation	21 (4.3)	▲
Sweden	7 (3.0)	▲
United States	3 (3.0)	
Italy	-11 (3.5)	▼
Norway (8)	-26 (3.4)	▼
Lebanon	-76 (5.7)	▼
France	◊ ◊	

2011 - TIMSS Eighth Grade Physics

Country	Achievement Difference from TIMSS Scale Centerpoint (500)	
Russian Federation	47 (3.6)	▲
Slovenia	32 (2.8)	▲
United States	13 (2.5)	▲
Sweden	-2 (3.2)	
Italy	-10 (2.8)	▼
Norway (8)	-19 (3.4)	▼
Lebanon	-95 (5.4)	▼
France	◊ ◊	

2015 - TIMSS Eighth Grade Physics

Country	Achievement Difference from TIMSS Scale Centerpoint (500)	
Russian Federation	48 (4.2)	▲
Slovenia	45 (2.9)	▲
Sweden	24 (3.7)	▲
United States	16 (2.9)	▲
Italy	-4 (2.5)	
Norway (8)	-17 (2.6)	▼
Lebanon	-88 (6.6)	▼
France	◊ ◊	

2008 - TIMSS Advanced Physics

Country	Achievement Difference from TIMSS Scale Centerpoint (500)	
Slovenia	35 (2.2)	▲
Norway	34 (4.1)	▲
Russian Federation	21 (10.1)	▲
Sweden	-3 (5.3)	
Lebanon	-56 (3.0)	▼
Italy	-78 (7.4)	▼
France	◊ ◊	
United States	◊ ◊	

2015 - TIMSS Advanced Physics

Country	Achievement Difference from TIMSS Scale Centerpoint (500)	
Slovenia	31 (2.5)	▲
Russian Federation	8 (7.1)	
Norway	7 (4.6)	
Sweden	-45 (5.9)	▼
United States	-63 (9.7)	▼
Lebanon	-90 (4.5)	▼
Italy	-126 (6.9)	▼
France	-127 (4.0)	▼

▲ Country average significantly higher than the centerpoint of the TIMSS scale

▼ Country average significantly lower than the centerpoint of the TIMSS scale

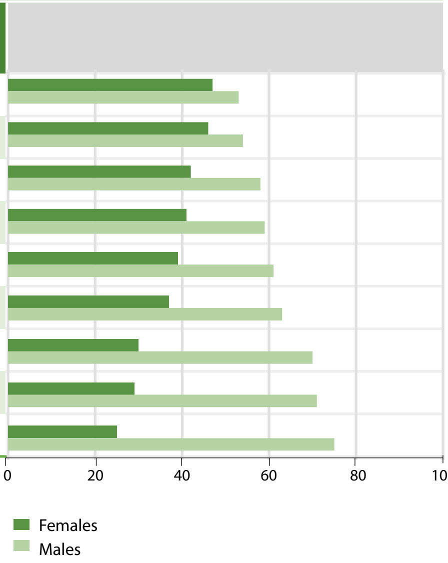
The United States adjusted the 1995 sample to correspond with the course-taking definitions used in 2015, and the 1995 results were recomputed.
A diamond (◊) indicates the country did not participate in this year's assessment.
( ) Standard errors appear in parentheses. Because of rounding some results may appear inconsistent.
* TIMSS 2007 data from: *TIMSS 2007 International Science Report*
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*

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

Exhibit P1.6: Physics Participation and Average Achievement by Gender

Participation in Physics by Gender

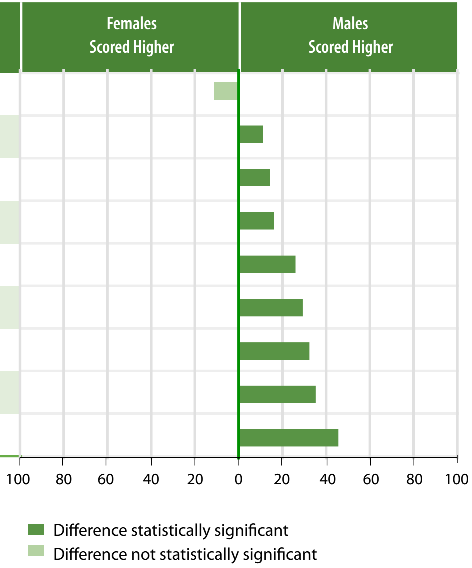
Country	Percent of Students Females	 Males
France	47 (0.9)	53 (0.9)
Italy	46 (1.1)	54 (1.1)
Russian Federation	42 (1.2)	58 (1.2)
Sweden	41 (1.4)	59 (1.4)
‡ United States	39 (1.6)	61 (1.6)
‡ Lebanon	37 (1.5)	63 (1.5)
Slovenia	30 (1.7)	70 (1.7)
Norway	29 (1.2)	71 (1.2)
Portugal	25 (1.9)	75 (1.9)



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

Average Physics Achievement by Gender

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



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

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.

Country	Females				Males			
	Percent of Students	Average Scale Score	Differences Between Years		Percent of Students	Average Scale Score	Differences Between Years	
			2008	1995			2008	1995
France								
2015	47 (0.9)	354 (4.2)		-95 ▼	53 (0.9)	390 (4.6)		-92 ▼
1995	39 (2.0)	449 (7.0)			61 (2.0)	481 (5.9)		
Italy								
2015	46 (1.1)	356 (7.3)	-50 ▼		54 (1.1)	389 (8.4)	-44 ▼	
2008	40 (2.4)	407 (10.4)			60 (2.4)	432 (7.4)		
Lebanon								
‡ 2015	37 (1.5)	417 (5.2)	-34 ▼		63 (1.5)	406 (6.4)	-34 ▼	
2008	29 (1.3)	451 (4.5)			71 (1.3)	440 (3.8)		
Norway								
2015	29 (1.2)	489 (6.0)	-28 ▼	-64 ▼	71 (1.2)	515 (4.8)	-26 ▼	-76 ▼
2008	29 (1.7)	517 (5.7)		-36 ▼	71 (1.7)	541 (4.1)		-50 ▼
‡ 1995	26 (1.8)	553 (8.7)			74 (1.8)	591 (5.4)		
Russian Federation								
2015	42 (1.2)	498 (7.9)	0	-9	58 (1.2)	514 (7.3)	-26 ▼	-63 ▼
2008	45 (1.3)	498 (10.4)		-9	55 (1.3)	540 (10.2)		-37 ▼
1995	46 (2.0)	507 (14.1)			54 (2.0)	578 (8.0)		
Slovenia								
2015	30 (1.7)	510 (6.5)	-25 ▼	32	70 (1.7)	540 (3.7)	5	-10
‡ 2008	27 (1.2)	535 (5.0)		57 ▲	73 (1.2)	535 (2.9)		-15
‡ 1995	28 (3.7)	479 (16.8)			72 (3.7)	550 (13.3)		
Sweden								
2015	41 (1.4)	448 (6.1)	-43 ▼	-103 ▼	59 (1.4)	459 (6.6)	-41 ▼	-131 ▼
2008	35 (2.4)	491 (6.0)		-60 ▼	65 (2.4)	500 (6.1)		-90 ▼
1995	33 (3.4)	551 (5.6)			67 (3.4)	590 (3.7)		
United States								
‡ 2015	39 (1.6)	409 (11.9)		-6	61 (1.6)	455 (9.3)		-27
‡ 1995	43 (4.7)	415 (8.6)			57 (4.7)	482 (10.2)		

▲ More recent year significantly higher

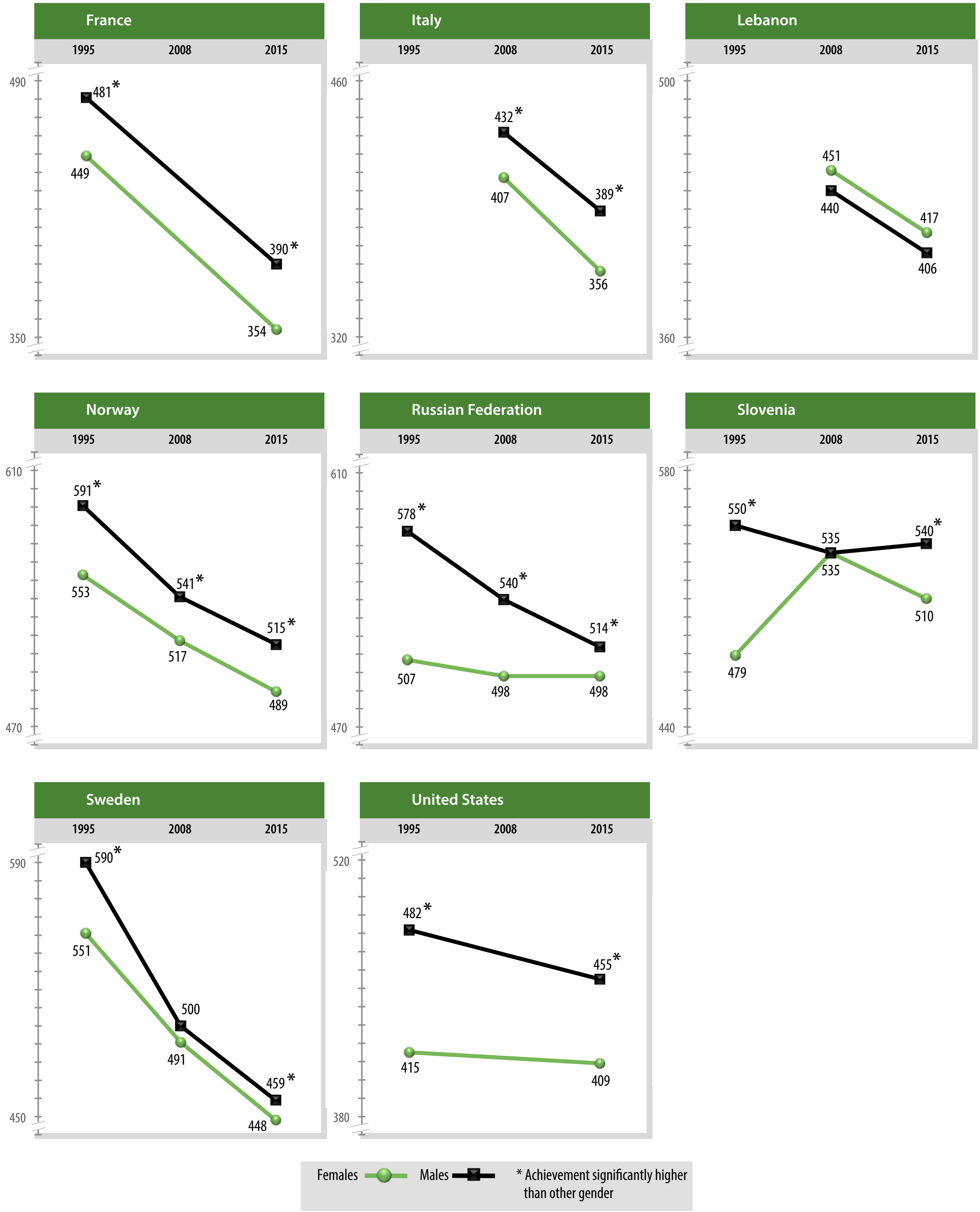
▼ More recent year significantly lower

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.

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

Exhibit P1.7: Differences in Physics Achievement by Gender Across Assessment Years (Continued)

Trends in Physics Achievement by Gender



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

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.

TIMSS
Advanced
2015

CHAPTER P2: PERFORMANCE AT INTERNATIONAL BENCHMARKS

TIMSS ADVANCED 2015 INTERNATIONAL RESULTS IN ADVANCED MATHEMATICS AND PHYSICS

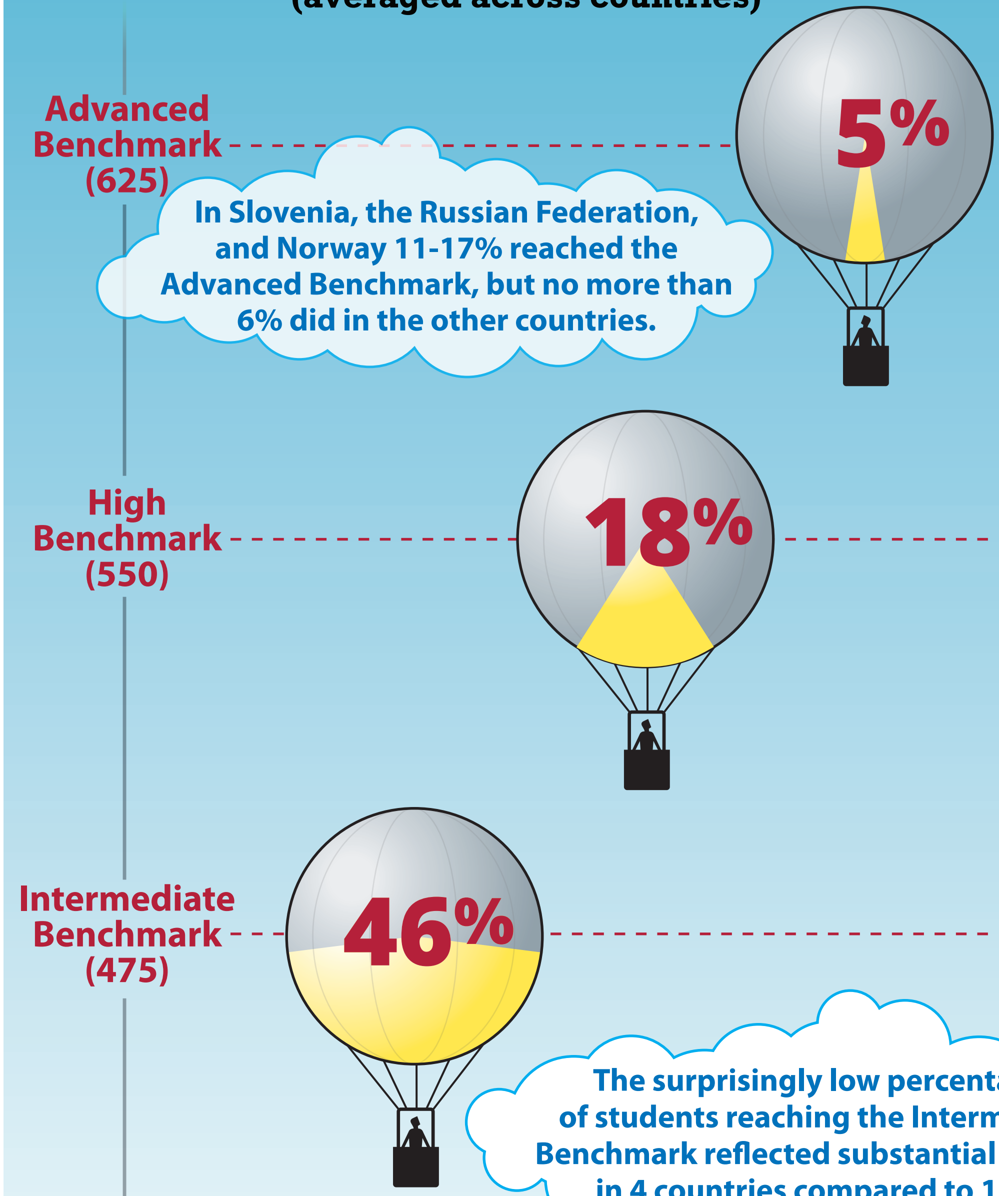
IEA
TIMSS & PIRLS
International Study Center
Lynch School of Education, Boston College

PHYSICS **TIMSS** *Advanced* **2015**

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)

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)

Students apply basic laws of physics in solving problems in a variety of situations.

Intermediate Benchmark (475)

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.

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

http://timss2015.org/advanced/download-center/

IEA
TIMSS & PIRLS International Study Center
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Exhibit P2.1: Descriptions of the TIMSS Advanced 2015 International Benchmarks of Physics Achievement

625 Advanced International Benchmark ●

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.

550 High International Benchmark ○

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.

475 Intermediate International Benchmark 🟢

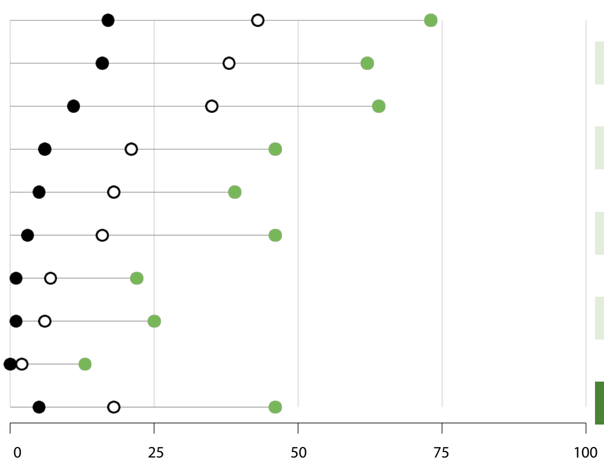
Students demonstrate some basic knowledge of the physics underlying a range of phenomena. They use their knowledge of forces and motion to solve problems, apply knowledge of heat and temperature to energy transfers, and of conservation laws to everyday and abstract contexts. They show knowledge of electric 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.

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

Exhibit P2.2: Performance at the International Benchmarks of Physics Achievement

Percentages of Students Reaching International Benchmarks

● Advanced
○ High
● Intermediate



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

* 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.

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

Exhibit P2.3: Percentages of Students Reaching the International Benchmarks of Physics Achievement Across Assessment Years

Country	Advanced International Benchmark (625)			High International Benchmark (550)			Intermediate International Benchmark (475)		
	Percent of Students			Percent of Students			Percent of Students		
	2015	2008	1995	2015	2008	1995	2015	2008	1995
Slovenia	17	12 ▲	15	43	44	45	73	77	73
Russian Federation	16	19	21	38	42	53 ▼	62	66	77 ▼
Norway	11	11	28 ▼	35	43 ▼	68 ▼	64	79 ▼	93 ▼
Sweden	6	7	25 ▼	21	30 ▼	66 ▼	46	62 ▼	92 ▼
United States	5		3	18		13	39		41
Italy	1	2		7	11 ▼		22	31 ▼	
Lebanon	1	0		6	8		25	36 ▼	
France	0		2 ▼	2		16 ▼	13		48 ▼

▲ 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.

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

Exhibit P2.4: Description of the TIMSS Advanced 2015 Intermediate International Benchmark (475) of Physics Achievement

475 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.

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

Exhibit P2.4.1: Intermediate International Benchmark – Example Item 1

Country	Percent Correct	
Slovenia	64 (2.5)	▲
Sweden	61 (1.6)	▲
Portugal	60 (2.3)	
‡ Lebanon	60 (3.8)	
‡ United States	60 (2.0)	
Norway	58 (1.8)	
International Avg.	57 (0.8)	
France	57 (1.6)	
Italy	51 (1.7)	▼
Russian Federation	45 (2.6)	▼

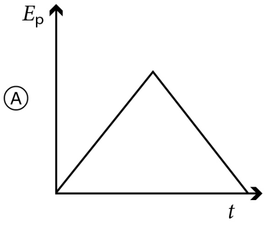
Content Domain: Mechanics & Thermodynamics

Cognitive Domain: Applying

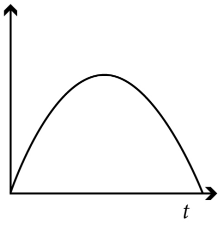
Description: Selects the graph that best represents the potential energy of a ball rolling up and down an inclined plane

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?

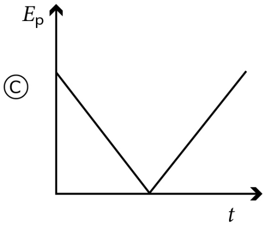
Ⓐ



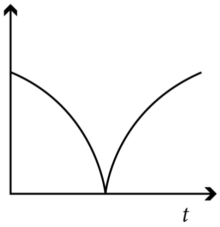
●



Ⓒ



Ⓓ



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

▲ 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 P2.4.1: Intermediate International Benchmark – Example Item 1 (Continued)

Country	Percent of Students Responding to Each Answer Option				
	A	B	C	D	NR*
Slovenia	27 (2.6)	64 (2.5)	5 (1.0)	4 (1.0)	0 (0.0)
Sweden	19 (1.3)	61 (1.6)	6 (0.8)	14 (1.0)	1 (0.3)
Portugal	33 (2.1)	60 (2.3)	4 (1.0)	2 (0.6)	0 (0.2)
‡ Lebanon	33 (3.1)	60 (3.8)	3 (1.2)	3 (1.2)	1 (0.4)
‡ United States	27 (2.2)	60 (2.0)	6 (1.2)	6 (1.1)	2 (0.3)
Norway	33 (1.6)	58 (1.8)	5 (0.8)	4 (0.7)	1 (0.3)
France	23 (1.4)	57 (1.6)	9 (0.8)	12 (1.0)	0 (0.1)
Italy	31 (1.9)	51 (1.7)	7 (0.8)	9 (0.8)	3 (0.7)
Russian Federation	44 (2.5)	45 (2.6)	6 (1.0)	4 (1.0)	0 (0.2)

* 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.

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

Exhibit P2.4.2: Intermediate International Benchmark – Example Item 2

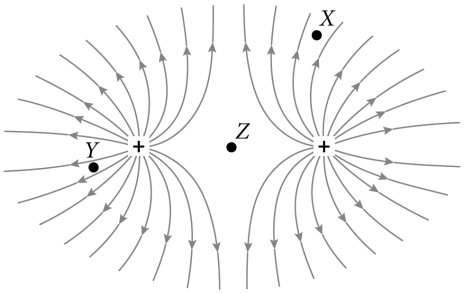
Country	Percent Full Credit	
Portugal	77 (2.2)	▲
France	76 (1.2)	▲
Norway	75 (1.5)	▲
Russian Federation	73 (2.0)	▲
‡ United States	68 (2.3)	
International Avg.	68 (0.8)	
Slovenia	67 (3.1)	
Italy	66 (1.9)	
Sweden	66 (1.3)	
‡ Lebanon	41 (3.8)	▼

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

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.

Point *X*	Point *Y*	Point *Z*
Ⓐ ↖	Ⓐ ↖	Ⓐ ↖
● ↗	Ⓑ ↗	Ⓑ ↗
Ⓒ ↙	● ↙	Ⓒ ↙
Ⓓ ↘	Ⓓ ↘	Ⓓ ↘
Ⓔ no force	Ⓔ no force	● no force

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 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

Exhibit P2.4.2: Intermediate International Benchmark – Example Item 2 (Continued)

Point X

Country	Percent of Students Responding to Each Answer Option					
	A	B	C	D	E	NR*
Portugal	5 (1.1)	82 (1.7)	10 (1.4)	2 (0.5)	1 (0.5)	1 (0.4)
Norway	5 (0.7)	81 (1.4)	10 (1.0)	3 (0.6)	1 (0.3)	2 (0.4)
France	4 (0.6)	80 (1.1)	10 (1.0)	4 (0.6)	1 (0.2)	2 (0.5)
Russian Federation	6 (0.7)	78 (1.9)	10 (1.1)	2 (0.5)	1 (0.5)	3 (0.5)
‡ United States	5 (0.9)	76 (1.9)	12 (1.4)	3 (0.7)	2 (0.6)	2 (0.9)
Sweden	7 (0.8)	74 (1.3)	11 (1.2)	5 (0.6)	1 (0.3)	3 (0.6)
Slovenia	10 (1.7)	73 (2.4)	11 (1.7)	2 (0.7)	3 (0.9)	1 (0.5)
Italy	6 (0.9)	73 (1.7)	10 (0.9)	3 (0.7)	1 (0.4)	7 (0.8)
‡ Lebanon	6 (1.1)	44 (3.8)	9 (1.4)	3 (1.0)	1 (0.4)	37 (3.9)

Point Y

Country	Percent of Students Responding to Each Answer Option					
	A	B	C	D	E	NR*
Portugal	1 (0.5)	10 (1.6)	82 (2.0)	0 (0.3)	4 (1.0)	3 (0.8)
France	2 (0.4)	13 (0.9)	82 (1.0)	1 (0.2)	1 (0.3)	2 (0.4)
Norway	3 (0.7)	8 (0.9)	81 (1.5)	3 (0.7)	2 (0.5)	2 (0.5)
Russian Federation	3 (0.7)	8 (1.1)	79 (1.7)	2 (0.4)	2 (0.6)	5 (0.7)
Slovenia	4 (0.9)	8 (1.5)	77 (2.9)	2 (0.9)	4 (1.1)	5 (1.0)
‡ United States	4 (1.3)	10 (1.5)	74 (2.1)	2 (0.7)	3 (1.0)	7 (1.4)
Italy	5 (0.9)	12 (1.1)	72 (1.7)	2 (0.4)	2 (0.4)	8 (0.8)
Sweden	4 (0.6)	10 (1.0)	71 (1.4)	4 (0.7)	5 (0.7)	6 (0.7)
‡ Lebanon	2 (0.6)	11 (1.4)	47 (4.0)	1 (0.6)	1 (0.5)	38 (3.9)

Point Z

Country	Percent of Students Responding to Each Answer Option					
	A	B	C	D	E	NR*
France	1 (0.3)	1 (0.3)	1 (0.3)	1 (0.3)	94 (0.7)	2 (0.4)
Norway	1 (0.3)	1 (0.3)	0 (0.2)	0 (0.1)	93 (0.7)	4 (0.7)
Portugal	1 (0.4)	3 (0.8)	1 (0.4)	1 (0.5)	92 (1.2)	2 (0.8)
Sweden	1 (0.2)	3 (0.5)	2 (0.5)	0 (0.2)	90 (0.7)	3 (0.4)
Russian Federation	1 (0.3)	3 (0.7)	1 (0.3)	2 (0.4)	89 (1.3)	4 (0.6)
Slovenia	2 (0.8)	3 (1.0)	1 (0.5)	1 (0.6)	87 (2.3)	5 (1.1)
Italy	1 (0.4)	1 (0.3)	1 (0.3)	2 (0.5)	86 (1.2)	8 (0.9)
‡ United States	1 (0.4)	3 (1.2)	2 (0.9)	1 (0.3)	85 (2.3)	8 (1.9)
‡ Lebanon	1 (0.4)	1 (0.4)	0 (0.3)	1 (0.4)	60 (3.8)	37 (3.9)

* 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

Exhibit P2.4.3: Intermediate International Benchmark – Example Item 3

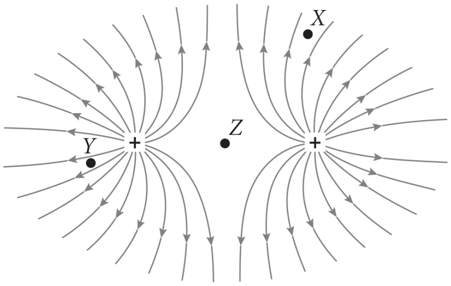
Country	Percent Full Credit	
Portugal	69 (2.8)	▲
Slovenia	58 (2.7)	▲
France	54 (2.0)	▲
International Avg.	50 (0.8)	
‡ Lebanon	50 (3.2)	
Russian Federation	50 (2.3)	
Norway	47 (1.7)	▼
Sweden	46 (1.4)	▼
‡ United States	43 (3.4)	▼
Italy	35 (1.9)	▼

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.

Point *X*	Point *Y*	Point *Z*
Ⓐ ↖	Ⓐ ↖	Ⓐ ↖
Ⓑ ↗	Ⓑ ↗	Ⓑ ↗
Ⓒ ↙	Ⓒ ↙	Ⓒ ↙
Ⓓ ↘	Ⓓ ↘	Ⓓ ↘
Ⓔ no force	Ⓔ no force	Ⓔ no force

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.

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

▲ 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 P2.4.3: Intermediate International Benchmark – Example Item 3 (Continued)

Scoring Guide

Code	Response	Item: PA33102B
	Correct Response	
10	**Z, X, Y** **OR** **Y, X, Z with a clear indication that Y is the strongest.**	
	Incorrect Response	
79	Incorrect (including crossed out, erased, stray marks, illegible, or off task)	
	Nonresponse	
NR	Blank	

Country	Percent of Students in Each Scoring Guide Category		
	Correct Student Response	Incorrect Student Responses	
	10	79	NR*
Portugal	69 (2.8)	30 (2.8)	1 (0.5)
Slovenia	58 (2.7)	39 (2.6)	3 (1.0)
France	54 (2.0)	41 (1.8)	5 (0.7)
‡ Lebanon	50 (3.2)	31 (2.3)	19 (2.3)
Russian Federation	50 (2.3)	39 (2.1)	11 (1.2)
Norway	47 (1.7)	42 (1.6)	12 (1.1)
Sweden	46 (1.4)	49 (1.5)	5 (0.7)
‡ United States	43 (3.4)	54 (4.0)	3 (1.0)
Italy	35 (1.9)	46 (2.1)	19 (1.8)

* 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

Exhibit P2.4.4: Intermediate International Benchmark – Example Item 4

Country	Percent Full Credit
Portugal	73 (2.5) ▲
Slovenia	72 (2.4) ▲
Russian Federation	64 (3.0) ▲
Norway	59 (1.9)
‡ Lebanon	59 (3.0)
International Avg.	58 (0.9)
Sweden	53 (2.2) ▼
‡ United States	53 (3.9)
France	47 (1.6) ▼
Italy	43 (2.3) ▼

Content Domain: Wave Phenomena & Atomic/Nuclear Physics

Cognitive Domain: Applying

Description: Calculates the wavelength of a sound wave above water

A marine animal makes a sound with a frequency of 1.00×10^2 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 m

The answer shown illustrates the type of response that would receive full credit (1 point). To receive 1 point, students reported the wavelength in meters.

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

▲ 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 P2.4.4: Intermediate International Benchmark – Example Item 4 (Continued)

Scoring Guide

Code	Response	Item: PA33005
☐	**Correct Response**	
10	**Answer: 3.43 (3.4 is also acceptable.)**	
☐	**Incorrect Response**	
79	Incorrect (including crossed out, erased, stray marks, illegible, or off task)	
☐	**Nonresponse**	
NR	Blank	

Country	Percent of Students in Each Scoring Guide Category		
	Correct Student Response	Incorrect Student Responses	
	10	79	NR*
Portugal	73 (2.5)	16 (2.0)	12 (2.0)
Slovenia	72 (2.4)	20 (2.1)	8 (1.5)
Russian Federation	64 (3.0)	17 (1.6)	19 (2.4)
Norway	59 (1.9)	24 (1.6)	17 (1.4)
‡ Lebanon	59 (3.0)	19 (2.8)	22 (2.3)
Sweden	53 (2.2)	28 (1.7)	19 (1.6)
‡ United States	53 (3.9)	35 (3.8)	12 (1.3)
France	47 (1.6)	30 (1.3)	23 (1.5)
Italy	43 (2.3)	20 (1.6)	37 (2.2)

* 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

Exhibit P2.4.5: Intermediate International Benchmark – Example Item 5

Country	Percent Full Credit	
Russian Federation	71 (1.9)	▲
Norway	63 (2.2)	▲
‡ Lebanon	61 (3.3)	▲
Slovenia	55 (2.9)	▲
Sweden	48 (1.9)	
International Avg.	46 (0.8)	
‡ United States	35 (3.5)	▼
Portugal	35 (2.1)	▼
France	22 (1.2)	▼
Italy	20 (1.6)	▼

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.

Isotope	Number of Protons	Number of Neutrons
^{4}He	2	2
^{14}C	6	8
^{14}N	7	7

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.

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

▲ 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 P2.4.5: Intermediate International Benchmark – Example Item 5 (Continued)

Scoring Guide

<table>
<tr><th>Code</th><th>Response</th><th>Item: PA23088</th></tr>
<tr><td></td><td colspan="2">Correct Response</td></tr>
<tr><td>10</td><td colspan="2">All six numbers correct:
<table>
<tr><th>Isotope</th><th>Number of protons</th><th>Number of neutrons</th></tr>
<tr><td>^{4}He</td><td>2</td><td>2</td></tr>
<tr><td>^{14}C</td><td>6</td><td>8</td></tr>
<tr><td>^{14}N</td><td>7</td><td>7</td></tr>
</table>
</td></tr>
<tr><td></td><td colspan="2">Incorrect Response</td></tr>
<tr><td>70</td><td colspan="2">All protons correct, all neutrons wrong</td></tr>
<tr><td>71</td><td colspan="2">Any five numbers correct</td></tr>
<tr><td>79</td><td colspan="2">Other incorrect (including crossed out, erased, stray marks, illegible, or off task)</td></tr>
<tr><td></td><td colspan="2">Nonresponse</td></tr>
<tr><td>NR</td><td colspan="2">Blank</td></tr>
</table>

Country	Percent of Students in Each Scoring Guide Category				
	Correct Student Response	Incorrect Student Responses			
	10	70	71	79	NR*
Russian Federation	71 (1.9)	2 (0.5)	3 (0.7)	16 (1.6)	8 (1.2)
Norway	63 (2.2)	5 (0.9)	1 (0.5)	27 (1.8)	4 (0.7)
‡ Lebanon	61 (3.3)	2 (0.7)	2 (0.7)	23 (2.2)	13 (2.5)
Slovenia	55 (2.9)	3 (0.8)	1 (0.7)	31 (2.5)	10 (1.4)
Sweden	48 (1.9)	4 (0.6)	2 (0.4)	38 (1.9)	8 (0.9)
‡ United States	35 (3.5)	9 (1.4)	2 (1.1)	44 (2.3)	9 (1.1)
Portugal	35 (2.1)	6 (1.2)	4 (1.0)	40 (2.4)	14 (2.0)
France	22 (1.2)	6 (0.6)	2 (0.4)	57 (1.7)	13 (1.3)
Italy	20 (1.6)	7 (0.9)	1 (0.2)	31 (1.7)	41 (2.2)

* 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

Exhibit P2.5: Description of the TIMSS Advanced 2015 High International Benchmark (550) of Physics Achievement

550 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.

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

Exhibit P2.5.1: High International Benchmark – Example Item 1

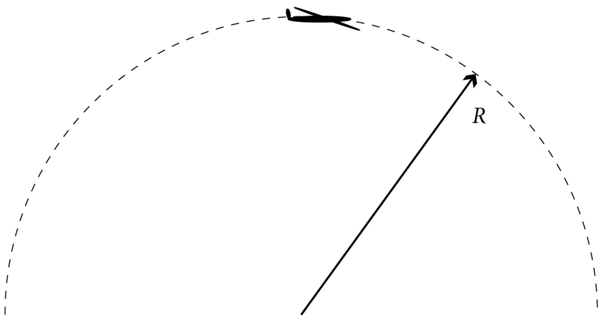
Country	Percent Correct	
Russian Federation	74 (1.7)	▲
Norway	68 (2.0)	▲
Slovenia	59 (2.7)	▲
Portugal	55 (2.5)	▲
International Avg.	49 (0.8)	
‡ United States	43 (3.2)	▼
Italy	39 (2.0)	▼
Sweden	38 (2.3)	▼
‡ Lebanon	34 (2.7)	▼
France	28 (1.5)	▼

Content Domain: Mechanics & Thermodynamics

Cognitive Domain: Reasoning

Description: Derives an expression for the speed at the top of the trajectory of an object moving in a vertical circular path

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?

Ⓐ gR

● $\sqrt{gR}$

Ⓒ $\dfrac{g}{R}$

Ⓓ $\sqrt{\dfrac{g}{R}}$

Ⓔ $2gR$

▲ 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.

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

Exhibit P2.5.1: High International Benchmark – Example Item 1 (Continued)

Country	Percent of Students Responding to Each Answer Option					
	A	B	C	D	E	NR*
Russian Federation	8 (0.9)	74 (1.7)	4 (0.6)	6 (0.7)	6 (0.8)	1 (0.3)
Norway	5 (0.8)	68 (2.0)	3 (0.5)	12 (1.3)	10 (1.1)	2 (0.5)
Slovenia	9 (1.7)	59 (2.7)	7 (1.2)	15 (1.7)	9 (1.5)	0 (0.3)
Portugal	3 (1.0)	55 (2.5)	4 (0.9)	26 (2.4)	10 (1.5)	2 (0.5)
‡ United States	12 (1.4)	43 (3.2)	11 (1.4)	19 (2.1)	13 (1.5)	1 (0.4)
Italy	18 (1.5)	39 (2.0)	9 (1.0)	15 (1.2)	10 (1.0)	9 (1.1)
Sweden	15 (1.2)	38 (2.3)	10 (1.0)	16 (1.1)	18 (1.6)	4 (0.6)
‡ Lebanon	19 (1.9)	34 (2.7)	11 (1.3)	14 (2.4)	12 (2.1)	11 (1.7)
France	17 (1.2)	28 (1.5)	10 (0.7)	33 (1.4)	8 (0.8)	5 (0.6)

* 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

Exhibit P2.5.2: High International Benchmark – Example Item 2

Country	Percent Full Credit	
Norway	57 (2.4)	▲
Slovenia	49 (3.0)	▲
‡ Lebanon	47 (2.9)	▲
Russian Federation	37 (2.4)	
‡ United States	35 (2.7)	
International Avg.	34 (0.8)	
Portugal	29 (2.9)	
Sweden	25 (2.5)	▼
Italy	12 (1.4)	▼
France	11 (1.3)	▼

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: 2 m/s

$$(m_{DAVID} + m_{ROBERT}) v_f = m_{DAVID} v_{DAVID} + m_{ROBERT} v_{ROBERT}$$

$$= 0 + m_{ROBERT} \cdot v_{ROBERT}$$

$$v_f = \frac{m_{ROBERT} v_{ROBERT}}{m_{DAVID} + m_{ROBERT}}$$

$$= \frac{(60)(5)}{(60+90)} = 2 \text{ m/s}$$

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.

▲ 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.

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

Exhibit P2.5.2: High International Benchmark – Example Item 2 (Continued)

Scoring Guide

Code	Response	Item: PA33058
	Correct Response	
20	**Answer: 2** Student work includes both of these points: • The final momentum is equal to the initial momentum: $(m_D + m_R)v = m_D v_D + m_R v_R = 0 + m_R v_R$ (a mathematical statement of the conservation of momentum) • $v = \frac{m_R v_R}{(m_D + m_R)} = \left(\frac{60\text{ kg} \cdot 5\text{ m/s}}{60\text{ kg} + 90\text{ kg}}\right) = 2\text{ m/s}$ (substitution of the relevant values and final answer)	
	Partially Correct Response	
10	**Answer: 2** 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.	
11	Student sets up the equations as shown for a Code 20, but arrives at an incorrect answer by making a substitution error or a calculation error.	
	Incorrect Response	
79	Incorrect (including crossed out, erased, stray marks, illegible, or off task)	
	Nonresponse	
NR	Blank	

Country	Percent of Students in Each Scoring Guide Category				
	Correct Student Responses			Incorrect Student Responses	
	20	10	11	79	NR*
Norway	57 (2.4)	9 (0.9)	2 (0.5)	23 (1.6)	10 (1.3)
Slovenia	49 (3.0)	13 (1.6)	2 (0.7)	32 (2.8)	4 (0.9)
‡ Lebanon	47 (2.9)	12 (1.8)	5 (1.5)	24 (2.1)	12 (2.3)
Russian Federation	37 (2.4)	32 (1.8)	1 (0.3)	15 (1.2)	15 (1.8)
‡ United States	35 (2.7)	16 (2.3)	1 (0.4)	42 (3.2)	6 (1.3)
Portugal	29 (2.9)	4 (0.8)	1 (0.4)	45 (3.1)	21 (1.6)
Sweden	25 (2.5)	6 (0.9)	3 (0.6)	50 (2.1)	16 (1.4)
Italy	12 (1.4)	5 (0.8)	1 (0.3)	36 (1.6)	45 (2.2)
France	11 (1.3)	4 (0.6)	1 (0.3)	47 (1.3)	36 (1.6)

* 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

Exhibit P2.5.3: High International Benchmark – Example Item 3

Country	Percent Full Credit
Slovenia	77 (2.2) ▲
Russian Federation	68 (2.4) ▲
Portugal	57 (2.9) ▲
Sweden	53 (2.3) ▲
International Avg.	42 (0.7)
Italy	39 (1.7) ▼
France	29 (1.9) ▼
‡ United States	26 (2.1) ▼
Norway	17 (1.4) ▼
‡ Lebanon	12 (1.8) ▼

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

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: 69 kJ

$$Q = Cm\Delta T$$
$$= (4.2)(.5)(37-4)$$
$$= 69\text{kJ}$$

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 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

Exhibit P2.5.3: High International Benchmark – Example Item 3 (Continued)

Scoring Guide

Code	Response	Item: PA33075
	Correct Response	
10	**Answer: 69 (Answers between 69 and 70 are also acceptable.)** Student work shows the following: • $Q = c \cdot m \cdot \Delta T = (4.2\ \text{kJ/kg} \cdot {}^\circ\text{C}) \cdot (0.50\ \text{kg}) \cdot (33\ {}^\circ\text{C}) = 69\ \text{kJ}$	
	Incorrect Response	
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	
NR	Blank	

Country	Percent of Students in Each Scoring Guide Category				
	Correct Student Response	Incorrect Student Responses			
	10	70	71	79	NR*
Slovenia	77 (2.2)	1 (0.4)	11 (1.7)	9 (1.4)	2 (0.4)
Russian Federation	68 (2.4)	5 (0.8)	12 (1.3)	7 (1.0)	9 (1.5)
Portugal	57 (2.9)	6 (1.6)	15 (1.9)	13 (1.6)	10 (1.7)
Sweden	53 (2.3)	1 (0.3)	8 (0.8)	22 (1.9)	15 (1.2)
Italy	39 (1.7)	2 (0.4)	7 (0.8)	14 (1.0)	38 (1.8)
France	29 (1.9)	11 (0.9)	9 (0.8)	23 (1.7)	28 (1.8)
‡ United States	26 (2.1)	12 (1.4)	9 (1.5)	38 (2.2)	15 (1.4)
Norway	17 (1.4)	32 (1.9)	2 (0.5)	26 (1.5)	23 (1.6)
‡ Lebanon	12 (1.8)	3 (0.8)	3 (1.0)	32 (3.1)	51 (3.5)

* 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

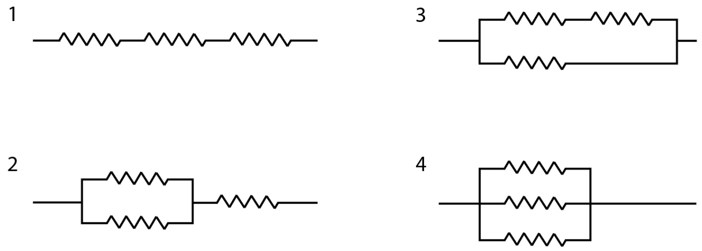
Exhibit P2.5.4: High International Benchmark – Example Item 4

Country	Percent Correct	
Slovenia	61 (2.6)	▲
Russian Federation	60 (2.1)	▲
Norway	42 (2.0)	
International Avg.	39 (0.7)	
Sweden	38 (1.6)	
‡ United States	36 (2.5)	
‡ Lebanon	32 (2.4)	▼
Italy	32 (2.0)	▼
Portugal	31 (2.7)	▼
France	23 (1.3)	▼

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?

● 1, 2, 3, 4

Ⓑ 1, 3, 2, 4

Ⓒ 4, 3, 2, 1

Ⓓ 4, 2, 3, 1

▲ 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.

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

Exhibit P2.5.4: High International Benchmark – Example Item 4 (Continued)

Country	Percent of Students Responding to Each Answer Option				
	A	B	C	D	NR*
Slovenia	61 (2.6)	20 (2.1)	10 (1.4)	8 (1.7)	1 (0.5)
Russian Federation	60 (2.1)	20 (1.5)	12 (1.7)	8 (1.3)	0 (0.2)
Norway	42 (2.0)	17 (1.4)	25 (1.2)	14 (1.3)	2 (0.5)
Sweden	38 (1.6)	18 (1.3)	24 (1.4)	18 (1.3)	2 (0.5)
‡ United States	36 (2.5)	19 (1.9)	28 (1.8)	16 (2.3)	1 (0.7)
‡ Lebanon	32 (2.4)	14 (2.0)	34 (2.7)	17 (1.9)	2 (0.6)
Italy	32 (2.0)	22 (1.8)	22 (1.5)	19 (1.6)	5 (1.1)
Portugal	31 (2.7)	17 (2.1)	26 (2.1)	23 (2.2)	3 (0.9)
France	23 (1.3)	15 (1.1)	35 (1.6)	23 (1.3)	4 (0.6)

* 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

Exhibit P2.5.5: High International Benchmark – Example Item 5

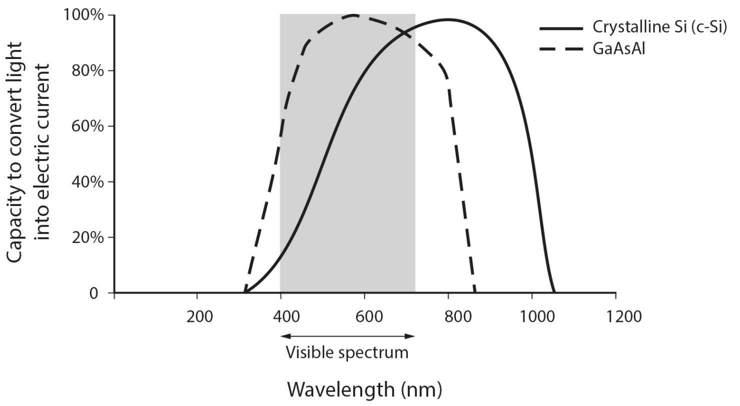
Country	Percent Full Credit
Slovenia	57 (2.4) ▲
Portugal	54 (2.7) ▲
‡ United States	51 (2.3) ▲
Norway	50 (1.8) ▲
France	45 (1.6)
International Avg.	44 (0.7)
Sweden	42 (2.1)
Russian Federation	39 (1.9) ▼
‡ Lebanon	35 (2.5) ▼
Italy	27 (2.0) ▼

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 semi-conductors 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.



Which material, c-Si or GaAsAl, is the better material to use as the semiconductor in solar panels?

(Check one box.)

☐ c-Si

☑ 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.

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

▲ 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

Code	Response	Item: PA33011
	Correct Response	
10	**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.	
	Incorrect Response	
79	Incorrect (including crossed out, erased, stray marks, illegible, or off task), including the following responses: • **GaAsAl** without an explanation or with an incorrect explanation. • **c-Si** with or without an explanation.	
	Nonresponse	
NR	Blank	

Country	Percent of Students in Each Scoring Guide Category		
	Correct Student Response	Incorrect Student Responses	
	10	79	NR*
Slovenia	57 (2.4)	43 (2.3)	1 (0.4)
Portugal	54 (2.7)	41 (2.7)	5 (1.1)
‡ United States	51 (2.3)	46 (2.4)	3 (0.5)
Norway	50 (1.8)	48 (1.8)	2 (0.4)
France	45 (1.6)	51 (1.5)	4 (0.5)
Sweden	42 (2.1)	52 (1.5)	7 (1.6)
Russian Federation	39 (1.9)	55 (2.0)	6 (0.8)
‡ Lebanon	35 (2.5)	46 (3.5)	19 (2.3)
Italy	27 (2.0)	55 (2.3)	17 (1.4)

* 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

Exhibit P2.6: Description of the TIMSS Advanced 2015 Advanced International Benchmark (625) of Physics Achievement

625 **Advanced International Benchmark** ●

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.

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

Exhibit P2.6.1: Advanced International Benchmark – Example Item 1

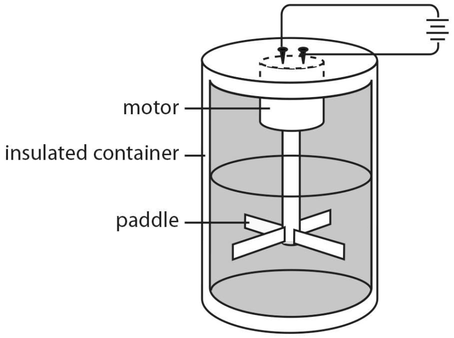
Country	Percent Full Credit	
Slovenia	59 (2.5)	▲
Portugal	47 (3.1)	▲
Sweden	32 (1.7)	
International Avg.	31 (0.7)	
‡ United States	31 (2.2)	
Norway	31 (1.6)	
Russian Federation	28 (2.3)	
Italy	26 (1.4)	▼
France	18 (1.3)	▼
‡ Lebanon	9 (1.6)	▼

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.



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 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

Exhibit P2.6.1: Advanced International Benchmark – Example Item 1 (Continued)

Scoring Guide

Code	Response	Item: PA33004
	Correct Response	
10	**Lower than the calculated value** with one or more of the following acceptable justifications: • Not all of the energy goes into heating up the water. • Some of the energy goes into raising the temperature of the motor and/or other mechanical parts of the system. • Some of the energy goes into raising the temperature of the walls. • Some of the energy is transferred to other parts of the system or the surroundings/environment • Some of the energy transfers to the kinetic energy of the moving paddle and/or moving water.	
	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	

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

Country	Percent of Students in Each Scoring Guide Category		
	Correct Student Response	Incorrect Student Responses	
	10	79	NR*
Slovenia	59 (2.5)	41 (2.6)	0 (0.3)
Portugal	47 (3.1)	51 (3.1)	2 (0.6)
Sweden	32 (1.7)	66 (1.7)	2 (0.5)
‡ United States	31 (2.2)	68 (2.2)	1 (0.4)
Norway	31 (1.6)	67 (1.6)	2 (0.5)
Russian Federation	28 (2.3)	65 (2.2)	7 (1.2)
Italy	26 (1.4)	63 (1.6)	12 (1.1)
France	18 (1.3)	79 (1.3)	3 (0.5)
‡ Lebanon	9 (1.6)	72 (2.7)	19 (2.5)

* 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

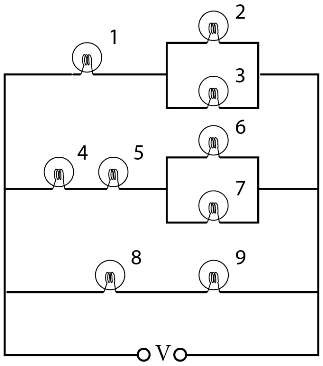
Country	Percent Correct	
Slovenia	59 (1.9)	▲
Sweden	51 (1.5)	▲
Norway	50 (1.9)	▲
‡ Lebanon	50 (2.4)	▲
International Avg.	44 (0.7)	
‡ United States	43 (2.4)	
Russian Federation	41 (2.4)	
Italy	36 (1.5)	▼
Portugal	36 (3.2)	▼
France	28 (1.5)	▼

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?

- Ⓐ Bulbs 2 and 3
- Ⓑ Bulbs 4 and 5
- ● Bulbs 6 and 7
- Ⓓ Bulbs 8 and 9

▲ 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.

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

Exhibit P2.6.2: Advanced International Benchmark – Example Item 2 (Continued)

Country	Percent of Students Responding to Each Answer Option				
	A	B	C	D	NR*
Slovenia	16 (1.9)	12 (1.8)	59 (1.9)	12 (1.7)	1 (0.4)
Sweden	22 (1.4)	16 (1.3)	51 (1.5)	6 (0.7)	5 (0.6)
Norway	28 (1.6)	7 (1.1)	50 (1.9)	13 (1.2)	2 (0.6)
‡ Lebanon	17 (1.9)	12 (2.0)	50 (2.4)	14 (2.2)	6 (1.8)
‡ United States	30 (2.4)	9 (0.9)	43 (2.4)	17 (1.6)	1 (0.3)
Russian Federation	29 (1.8)	10 (1.2)	41 (2.4)	19 (1.7)	2 (0.4)
Italy	29 (1.8)	9 (1.2)	36 (1.5)	19 (1.4)	7 (1.1)
Portugal	37 (3.4)	14 (1.8)	36 (3.2)	12 (1.7)	1 (0.4)
France	33 (1.4)	7 (0.7)	28 (1.5)	28 (1.3)	3 (0.6)

* 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

Exhibit P2.6.3: Advanced International Benchmark – Example Item 3

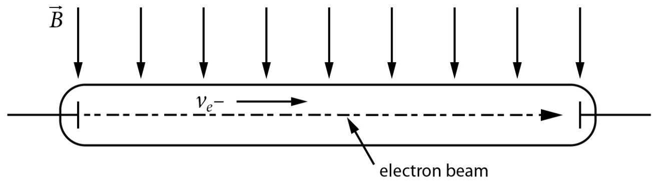
Country	Percent Correct	
Russian Federation	50 (2.3)	▲
Norway	39 (1.8)	▲
Sweden	39 (1.5)	▲
Slovenia	36 (2.5)	
International Avg.	32 (0.7)	
‡ Lebanon	28 (2.2)	▼
Italy	27 (1.6)	▼
‡ United States	23 (1.7)	▼
Portugal	13 (1.6)	▼
France	- -	

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?

Ⓐ The beam curves into the page.

● The beam curves out of the page.

Ⓒ The beam curves down.

Ⓓ The beam curves up.

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

▲ 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.
A dash (-) indicates comparable data not available.

Exhibit P2.6.3: Advanced International Benchmark – Example Item 3 (Continued)

Country	Percent of Students Responding to Each Answer Option				
	A	B	C	D	NR*
Russian Federation	23 (1.7)	50 (2.3)	16 (1.4)	8 (1.1)	2 (0.7)
Norway	33 (1.7)	39 (1.8)	12 (1.3)	13 (1.4)	2 (0.6)
Sweden	23 (1.8)	39 (1.5)	19 (1.5)	16 (1.1)	3 (0.7)
Slovenia	37 (2.6)	36 (2.5)	16 (1.5)	10 (1.6)	1 (0.6)
‡ Lebanon	18 (2.7)	28 (2.2)	26 (2.7)	15 (2.4)	14 (2.4)
Italy	24 (1.8)	27 (1.6)	28 (1.7)	14 (1.2)	8 (1.1)
‡ United States	21 (2.8)	23 (1.7)	36 (2.5)	20 (2.2)	1 (0.2)
Portugal	11 (1.3)	13 (1.6)	42 (2.4)	31 (2.2)	3 (0.9)
France	- -	- -	- -	- -	100 (0.0)

* 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

Country	Percent Full Credit	
Norway	52 (2.0)	▲
Russian Federation	51 (2.6)	▲
‡ Lebanon	40 (3.0)	▲
Sweden	34 (1.9)	▲
Slovenia	32 (2.9)	
International Avg.	28 (0.7)	
Portugal	17 (2.1)	▼
France	17 (1.1)	▼
‡ United States	9 (1.1)	▼
Italy	4 (0.9)	▼

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:

$$^{235}_{92}\mathrm{U} + ^{1}_{0}\mathrm{n} \rightarrow ^{144}_{56}\mathrm{Ba} + ^{89}_{36}\mathrm{Kr} + ?$$

Complete the equation of the above reaction.

$$^{235}_{92}U + ^{1}_{0}n \rightarrow ^{144}_{56}Ba + ^{89}_{36}Kr + \boxed{3\,^{1}_{0}n}$$

The answer shown illustrates the type of response that would receive full credit (1 point). To receive 1 point, students answered 3 neutrons: $3^{1}_{0}n$

▲ 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.

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

Exhibit P2.6.4: Advanced International Benchmark – Example Item 4 (Continued)

Scoring Guide

Code	Response	Item: PA23066
	Correct Response	
10	3 neutrons (standard notation): $3\,{}_{0}^{1}n$	
11	3 neutrons (other notation): 3 n, three neutrons, etc.	
	Incorrect Response	
70	2 neutrons (regardless of notation)	
79	Other incorrect (including crossed out, erased, stray marks, illegible, or off task)	
	Nonresponse	
NR	Blank	

Country	Percent of Students in Each Scoring Guide Category				
	Correct Student Responses		Incorrect Student Responses		
	10	11	70	79	NR*
Norway	35 (1.8)	17 (1.3)	12 (1.3)	28 (1.8)	7 (1.1)
Russian Federation	50 (2.7)	2 (0.4)	7 (1.2)	30 (2.4)	12 (1.1)
‡ Lebanon	40 (3.1)	1 (0.4)	3 (1.2)	36 (3.2)	21 (2.7)
Sweden	17 (1.4)	17 (1.3)	15 (1.0)	32 (1.3)	19 (1.6)
Slovenia	22 (2.3)	11 (1.8)	11 (1.8)	33 (2.5)	23 (2.4)
Portugal	15 (2.5)	2 (0.8)	4 (0.8)	60 (2.8)	19 (2.0)
France	16 (1.1)	1 (0.3)	11 (1.0)	60 (1.6)	13 (1.2)
‡ United States	7 (1.1)	2 (0.4)	3 (0.7)	63 (2.3)	24 (2.1)
Italy	3 (0.9)	1 (0.3)	2 (0.7)	20 (1.3)	74 (1.9)

* 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

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CHAPTER P3: ACHIEVEMENT IN CONTENT AND COGNITIVE DOMAINS

TIMSS ADVANCED 2015 INTERNATIONAL RESULTS IN ADVANCED MATHEMATICS AND PHYSICS

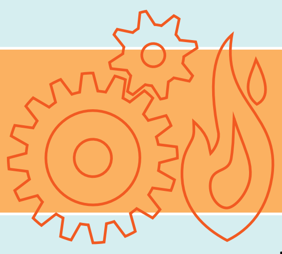
IEA
TIMSS & PIRLS
International Study Center
Lynch School of Education, Boston College

PHYSICS TIMSS Advanced 2015

Achievement by Content Domains

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.

Mechanics and Thermodynamics



Relative Strength

4 Countries Slovenia, Russian Federation, Portugal, and the United States

3 Countries Norway, Lebanon, and France

Relative Weakness

Electricity and Magnetism

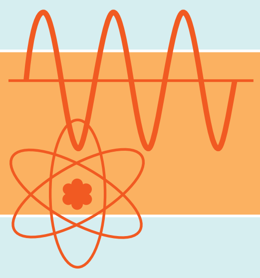
Relative Strength

2 Countries Russian Federation and Italy

3 Countries Portugal, the United States, and France

Relative Weakness

Wave Phenomena and Atomic/Nuclear Physics



Relative Strength

2 Countries Lebanon and France

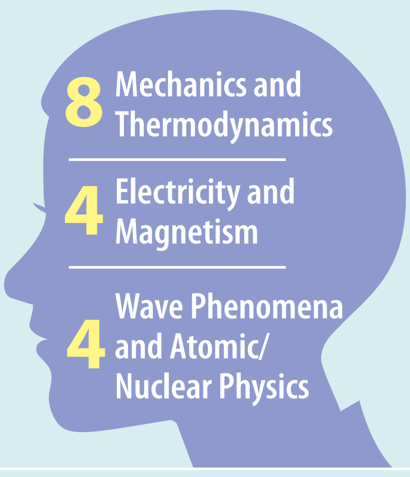
5 Countries Slovenia, Russian Federation, Portugal, the United States, and Italy

Relative Weakness

Differences reflected in Achievement by Gender

Achievement differences in content domains by gender reflect males' higher achievement in 8 countries in physics overall.

Number of Countries where Males had higher achievement than Females

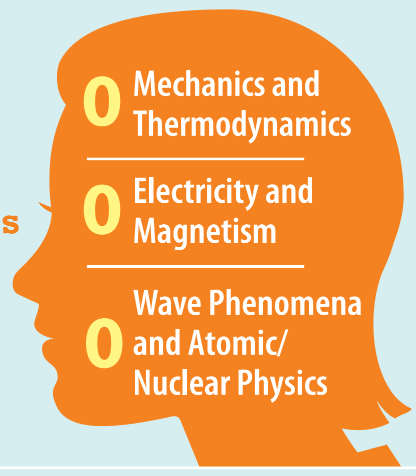


8 Mechanics and Thermodynamics

4 Electricity and Magnetism

4 Wave Phenomena and Atomic/ Nuclear Physics

Number of Countries where Females had higher achievement than Males



0 Mechanics and Thermodynamics

0 Electricity and Magnetism

0 Wave Phenomena and Atomic/ Nuclear Physics

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.

Knowing

Relative Strength

3 Countries Russian Federation, Norway, and Portugal

2 Countries Slovenia and Lebanon

Relative Weakness

Applying

Relative Strength

2 Countries Slovenia and Lebanon

4 Countries Norway, Portugal, the United States, and France

Relative Weakness

Reasoning

Relative Strength

4 Countries Norway, Portugal, the United States, and France

3 Countries Slovenia, Russian Federation, and Lebanon

Relative Weakness

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.

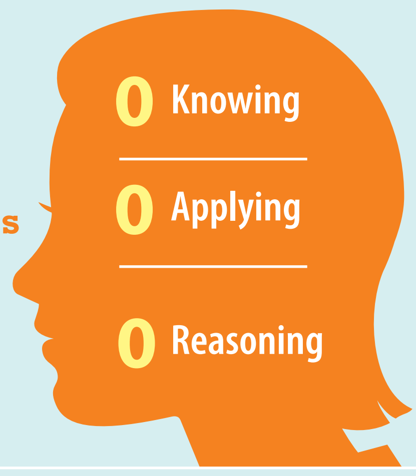
Number of Countries where Males had higher achievement than Females

7 Knowing

4 Applying

8 Reasoning

Number of Countries where Females had higher achievement than Males



0 Knowing

0 Applying

0 Reasoning

SOURCE: IEA's Trends in International Mathematics and Science Study – TIMSS Advanced 2015.
http://timss2015.org/advanced/download-center/

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Exhibit P3.1: Achievement in Physics Content Domains

Country	Overall Physics Average Scale Score	Mechanics and Thermodynamics (39 items)		Electricity and Magnetism (27 items)		Wave Phenomena and Atomic/Nuclear Physics (35 items)	
		Average Scale Score	Difference from Overall Physics Score	Average Scale Score	Difference from Overall Physics Score	Average Scale Score	Difference from Overall Physics Score
Slovenia	531 (2.5)	541 (2.7)	10 (1.6) ▲	530 (4.3)	-1 (4.5)	511 (4.5)	-20 (3.9) ▼
Russian Federation	508 (7.1)	514 (6.7)	7 (1.6) ▲	515 (8.0)	8 (2.8) ▲	490 (7.5)	-17 (2.1) ▼
Norway	507 (4.6)	503 (4.1)	-5 (1.7) ▼	514 (5.5)	7 (3.8)	507 (5.2)	0 (2.1)
Portugal	467 (4.6)	489 (4.8)	22 (3.2) ▲	431 (5.8)	-35 (4.5) ▼	456 (6.2)	-11 (5.2) ▼
Sweden	455 (5.9)	455 (6.1)	0 (2.7)	455 (6.0)	1 (2.6)	451 (6.3)	-4 (2.7)
‡ United States	437 (9.7)	462 (9.6)	25 (3.4) ▲	380 (12.2)	-58 (3.9) ▼	431 (8.7)	-7 (3.0) ▼
‡ Lebanon	410 (4.5)	395 (4.4)	-15 (4.7) ▼	399 (5.2)	-11 (5.9)	431 (6.8)	20 (5.7) ▲
Italy	374 (6.9)	376 (6.4)	2 (2.6)	425 (6.6)	51 (3.7) ▲	329 (7.9)	-45 (2.3) ▼
France	373 (4.0)	327 (5.7)	-46 (3.7) ▼	339 (4.7)	-34 (3.8) ▼	418 (4.5)	45 (2.5) ▲

▲ 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 ‡.

( ) 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 P3.2: Achievement in Physics Content Domains by Gender

Country	Mechanics and Thermodynamics		Electricity and Magnetism		Wave Phenomena and Atomic/Nuclear Physics	
	Females	Males	Females	Males	Females	Males
Slovenia	515 (6.1)	553 (3.6) ▲	515 (7.2)	537 (6.0) ▲	495 (10.6)	518 (5.4)
Russian Federation	502 (7.9)	523 (6.8) ▲	510 (9.2)	519 (8.1)	485 (8.4)	494 (7.7)
Norway	481 (5.0)	511 (4.7) ▲	507 (6.6)	517 (6.0)	488 (7.2)	515 (5.6) ▲
Portugal	476 (7.0)	493 (5.2) ▲	420 (9.0)	435 (6.8)	442 (10.8)	460 (6.4)
Sweden	441 (6.4)	465 (6.7) ▲	457 (6.3)	454 (7.0)	449 (7.0)	452 (8.0)
‡ United States	434 (11.7)	480 (9.4) ▲	346 (15.2)	401 (12.0) ▲	406 (10.9)	446 (8.4) ▲
‡ Lebanon	396 (9.8)	395 (4.6)	411 (13.0)	392 (6.0)	440 (6.4)	425 (8.8)
Italy	354 (6.7)	394 (7.4) ▲	414 (6.9)	434 (7.8) ▲	310 (8.9)	345 (9.4) ▲
France	303 (6.4)	349 (6.5) ▲	321 (7.4)	355 (4.5) ▲	402 (4.3)	432 (5.4) ▲
International Avg.	434 (2.6)	463 (2.1) ▲	434 (3.1)	449 (2.5) ▲	435 (2.9)	454 (2.5) ▲

▲ 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.

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

Exhibit P3.3: Achievement in Physics Cognitive Domains

Country	Overall Physics Average Scale Score	Knowing (30 items)		Applying (41 items)		Reasoning (30 items)	
		Average Scale Score	Difference from Overall Physics Score	Average Scale Score	Difference from Overall Physics Score	Average Scale Score	Difference from Overall Physics Score
Slovenia	531 (2.5)	521 (4.2)	-10 (3.3) ▼	543 (3.8)	12 (3.5) ▲	514 (5.7)	-17 (5.6) ▼
Russian Federation	508 (7.1)	517 (7.5)	9 (2.4) ▲	508 (7.6)	1 (1.3)	493 (6.7)	-15 (2.4) ▼
Norway	507 (4.6)	529 (4.2)	22 (2.9) ▲	484 (5.3)	-23 (1.8) ▼	519 (5.7)	12 (2.8) ▲
Portugal	467 (4.6)	474 (4.7)	7 (3.0) ▲	452 (5.7)	-15 (3.9) ▼	481 (3.9)	14 (2.9) ▲
Sweden	455 (5.9)	452 (6.0)	-3 (2.1)	454 (6.4)	0 (3.0)	450 (6.2)	-4 (3.2)
‡ United States	437 (9.7)	444 (9.8)	7 (3.5)	420 (10.2)	-17 (2.9) ▼	455 (8.8)	17 (3.3) ▲
‡ Lebanon	410 (4.5)	378 (4.7)	-32 (3.6) ▼	433 (5.4)	22 (5.3) ▲	375 (6.2)	-35 (4.1) ▼
Italy	374 (6.9)	367 (6.6)	-7 (4.4)	371 (7.3)	-3 (2.1)	375 (7.3)	1 (3.0)
France	373 (4.0)	375 (3.9)	2 (1.6)	358 (5.6)	-15 (3.4) ▼	397 (4.2)	24 (1.9) ▲

▲ Subscale score significantly higher than overall physics score
▼ Subscale score significantly lower than overall physics score

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

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 P3.4: Achievement in Physics Cognitive Domains by Gender

Country	Knowing		Applying		Reasoning	
	Females	Males	Females	Males	Females	Males
Slovenia	492 (8.1)	533 (4.9) ▲	537 (6.7)	546 (4.7)	477 (7.6)	529 (7.1) ▲
Russian Federation	512 (8.8)	520 (7.6)	502 (9.3)	513 (7.7)	476 (8.2)	505 (7.0) ▲
Norway	500 (7.0)	541 (4.5) ▲	475 (7.0)	488 (5.5) ▲	497 (9.4)	528 (5.9) ▲
Portugal	460 (7.6)	479 (5.3) ▲	443 (8.3)	455 (5.8)	467 (6.8)	485 (4.8) ▲
Sweden	438 (6.4)	461 (6.5) ▲	453 (6.6)	455 (7.1)	440 (6.7)	458 (6.5) ▲
‡ United States	401 (13.3)	471 (9.3) ▲	401 (13.0)	433 (9.8) ▲	425 (10.5)	474 (8.9) ▲
‡ Lebanon	385 (7.3)	374 (6.0)	441 (5.5)	427 (7.0)	386 (7.7)	368 (7.6)
Italy	343 (7.2)	388 (7.7) ▲	359 (7.4)	382 (8.8) ▲	353 (7.4)	394 (8.5) ▲
France	347 (4.8)	399 (4.5) ▲	345 (7.1)	369 (5.9) ▲	377 (5.5)	414 (6.0) ▲
International Avg.	431 (2.7)	463 (2.2) ▲	440 (2.7)	452 (2.4) ▲	433 (2.6)	462 (2.3) ▲

▲ 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.

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

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CHAPTER P4: HOME ENVIRONMENT AND FUTURE PLANS

TIMSS ADVANCED 2015 INTERNATIONAL RESULTS IN ADVANCED MATHEMATICS AND PHYSICS

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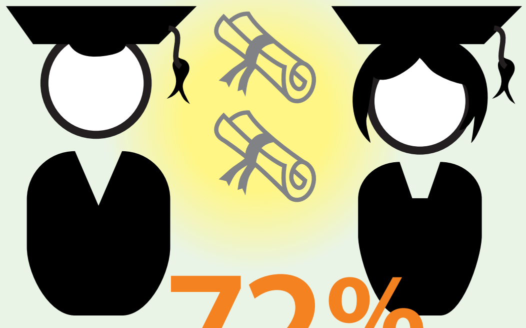
PHYSICS **TIMSS** *Advanced* **2015**

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.

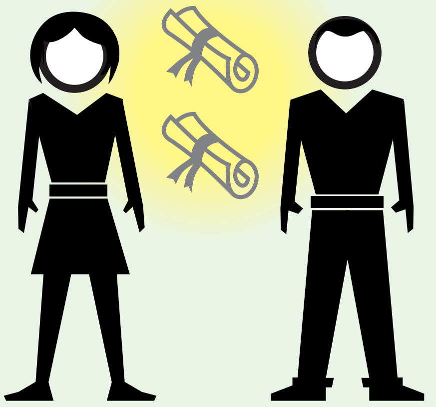


72%

of students expect to obtain an advanced degree

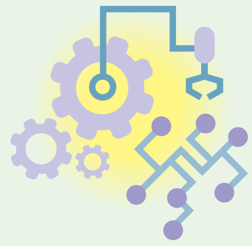
Higher percentages of the Females taking physics than of the Males expect to obtain an advanced degree.

76% **70%**



The most popular areas of future study included:

Engineering/ Technnology

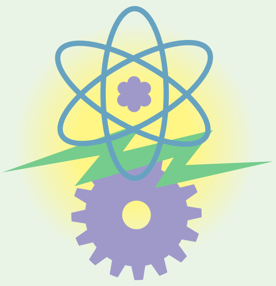


48%

Biological/ Biomedical

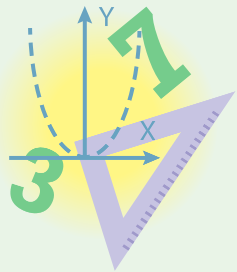
24%

Physics



22%

Mathematics



22%

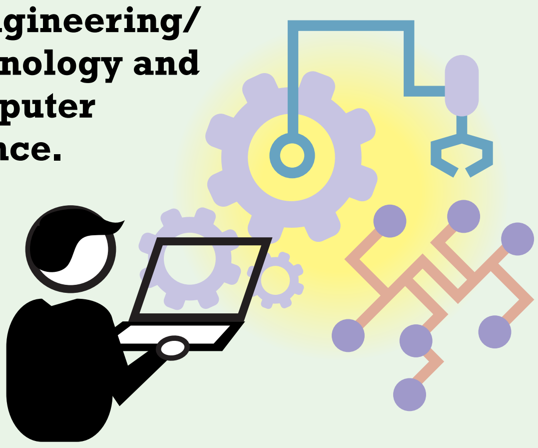
Education trailed behind (7%) as a future area of study.

Students' Plans for Future Professions

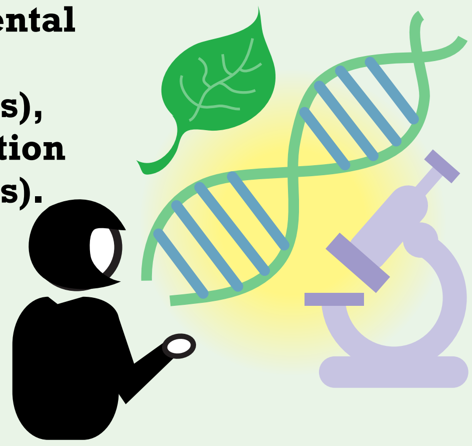
Students who studied physics in secondary school reported considering a number of professions.

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).



SOURCE: IEA's Trends in International Mathematics and Science Study – TIMSS Advanced 2015.
http://timss2015.org/advanced/download-center/

IEA
TIMSS & PIRLS
International Study Center
Lynch School of Education, Boston College

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.

Country	Many Resources		Some Resources		Few Resources		Average Scale Score
	Percent of Students	Average Achievement	Percent of Students	Average Achievement	Percent of Students	Average Achievement	
Norway	51 (1.4)	529 (4.5)	48 (1.4)	485 (5.1)	0 (0.1)	~ ~	11.1 (0.05)
Sweden	41 (1.1)	498 (6.0)	58 (1.1)	427 (5.9)	1 (0.2)	~ ~	10.7 (0.06)
United States	36 (3.0)	481 (9.7)	62 (2.7)	415 (9.9)	2 (0.5)	~ ~	10.4 (0.14)
Slovenia	29 (1.8)	559 (7.9)	70 (1.9)	521 (3.6)	0 (0.2)	~ ~	10.2 (0.06)
France	28 (1.0)	410 (4.9)	71 (1.0)	360 (4.1)	1 (0.2)	~ ~	10.0 (0.05)
Portugal	26 (1.9)	500 (5.5)	70 (1.9)	457 (5.0)	3 (0.6)	410 (16.7)	9.6 (0.10)
Russian Federation	22 (1.4)	533 (7.6)	78 (1.4)	501 (7.7)	0 (0.1)	~ ~	10.1 (0.05)
Italy	20 (1.1)	397 (9.7)	78 (1.2)	369 (7.4)	2 (0.3)	~ ~	9.5 (0.06)
Lebanon	8 (1.2)	434 (21.2)	84 (1.1)	412 (5.2)	8 (0.7)	370 (9.9)	8.5 (0.07)
International Avg.	29 (0.6)	482 (3.3)	69 (0.5)	439 (2.1)	2 (0.1)	390 (9.7)	

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

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.

Number of books in the home:

1) 0-10
2) 11-25
3) 26-100
4) 101-200
5) More than 200

Number of home study supports:

1) None
2) Study desk/table or own room
3) Both

Highest level of education of either parent:

1) Finished some primary or lower secondary or did not go to school
2) Finished lower secondary
3) Finished upper secondary
4) Finished post-secondary education
5) Finished university or higher

Highest level of occupation of either parent:

1) Has never worked outside home for pay, general laborer, or semi-professional (skilled agricultural or fishery worker, craft or trade worker, plant or machine operator)
2) Clerical (clerk or service or sales worker)
3) Small business owner
4) Professional (corporate manager or senior official, professional, or technician or associate professional)

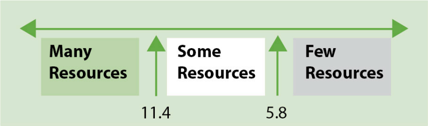


Exhibit P4.2: Students Working at a Paid Job on a Regular Basis During the School Year

Reported by Physics Students

Country	Time Spent Working at a Paid Job per Week							
	No Time		Less than 5 Hours		5 to 10 Hours		More than 10 Hours	
	Percent of Students	Average Achievement	Percent of Students	Average Achievement	Percent of Students	Average Achievement	Percent of Students	Average Achievement
France	97 (0.3)	375 (3.9)	2 (0.2)	~ ~	1 (0.2)	~ ~	0 (0.1)	~ ~
Italy	92 (0.5)	377 (6.9)	3 (0.3)	376 (21.1)	3 (0.4)	340 (17.1)	2 (0.3)	~ ~
Lebanon	93 (0.9)	414 (4.6)	2 (0.5)	~ ~	2 (0.5)	~ ~	2 (0.4)	~ ~
Norway	52 (1.6)	516 (4.6)	13 (0.7)	521 (7.8)	20 (1.1)	510 (6.7)	15 (0.9)	467 (8.3)
Portugal	95 (0.5)	468 (4.6)	1 (0.3)	~ ~	2 (0.4)	~ ~	2 (0.3)	~ ~
Russian Federation	94 (0.4)	510 (7.1)	2 (0.2)	~ ~	2 (0.2)	~ ~	2 (0.3)	~ ~
Slovenia	82 (1.3)	538 (3.0)	8 (0.7)	518 (14.0)	7 (0.8)	507 (13.0)	4 (0.6)	485 (15.4)
Sweden	70 (1.3)	452 (5.6)	12 (0.8)	483 (9.1)	13 (0.8)	469 (7.8)	5 (0.5)	404 (13.8)
United States	67 (1.7)	448 (10.2)	5 (0.6)	456 (17.9)	7 (0.6)	455 (12.7)	21 (1.6)	396 (10.6)
International Avg.	82 (0.4)	455 (2.0)	5 (0.2)	471 (6.6)	6 (0.2)	456 (5.4)	6 (0.2)	438 (6.2)

( ) 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

Country	Always		Almost Always		Sometimes		Never	
	Percent of Students	Average Achievement	Percent of Students	Average Achievement	Percent of Students	Average Achievement	Percent of Students	Average Achievement
France	89 (0.9)	376 (4.0)	8 (0.7)	354 (9.3)	2 (0.3)	~ ~	1 (0.2)	~ ~
Italy	76 (1.2)	388 (6.5)	18 (0.8)	343 (8.9)	5 (0.7)	295 (18.4)	1 (0.2)	~ ~
Lebanon	5 (0.9)	387 (24.1)	16 (1.3)	421 (10.2)	62 (1.7)	413 (5.0)	17 (1.1)	396 (8.1)
Norway	86 (0.9)	512 (4.2)	8 (0.6)	495 (10.7)	4 (0.5)	453 (15.8)	1 (0.3)	~ ~
Portugal	90 (1.0)	467 (4.9)	8 (0.8)	469 (8.8)	2 (0.3)	~ ~	1 (0.2)	~ ~
Russian Federation	83 (1.5)	505 (6.8)	12 (0.9)	520 (15.5)	4 (0.8)	523 (15.4)	1 (0.2)	~ ~
Slovenia	89 (0.8)	534 (2.7)	8 (0.7)	517 (12.9)	2 (0.4)	~ ~	1 (0.2)	~ ~
Sweden	76 (1.1)	469 (5.9)	14 (0.7)	421 (9.7)	8 (0.6)	398 (11.4)	3 (0.3)	395 (22.2)
United States	69 (3.5)	447 (9.1)	19 (2.3)	414 (18.1)	10 (1.7)	407 (19.3)	3 (0.8)	450 (25.5)
International Avg.	74 (0.5)	454 (3.2)	12 (0.4)	439 (4.0)	11 (0.3)	415 (6.1)	3 (0.2)	414 (11.6)

( ) 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 P4.4: Students' Expectations for Further Education

Reported by Physics Students

Country	Doctoral Degree		Master's Degree		Bachelor's Degree		Post-Secondary Education but Not Bachelor's Degree		Upper-Secondary Education	
	Percent of Students	Average Achievement	Percent of Students	Average Achievement	Percent of Students	Average Achievement	Percent of Students	Average Achievement	Percent of Students	Average Achievement
Lebanon	59 (1.6)	414 (5.5)	35 (1.6)	415 (5.8)	4 (0.6)	384 (16.6)	2 (0.4)	~ ~	0 (0.1)	~ ~
Portugal	26 (1.3)	492 (6.1)	54 (1.3)	476 (4.8)	16 (1.1)	414 (7.7)	2 (0.4)	~ ~	2 (0.3)	~ ~
United States	23 (1.7)	451 (13.2)	51 (1.4)	443 (8.2)	24 (1.7)	418 (12.7)	1 (0.6)	~ ~	1 (0.2)	~ ~
Slovenia	22 (1.3)	565 (7.4)	48 (1.3)	540 (4.3)	19 (1.0)	504 (6.3)	10 (1.1)	475 (8.9)	0 (0.1)	~ ~
France	21 (0.8)	395 (5.2)	53 (0.9)	393 (4.0)	14 (0.7)	324 (5.9)	10 (0.5)	314 (5.6)	1 (0.2)	~ ~
Italy	17 (0.7)	407 (10.2)	24 (0.9)	373 (8.6)	46 (1.0)	381 (7.0)	12 (0.8)	325 (10.0)	2 (0.3)	~ ~
Sweden	9 (0.5)	496 (11.9)	64 (0.9)	474 (5.5)	22 (0.8)	404 (7.0)	4 (0.4)	377 (14.9)	1 (0.2)	~ ~
Norway	8 (0.6)	550 (8.2)	68 (1.4)	520 (4.3)	22 (1.3)	461 (7.3)	1 (0.2)	~ ~	0 (0.1)	~ ~
Russian Federation	8 (0.5)	559 (11.3)	61 (1.1)	520 (6.8)	28 (1.0)	477 (8.6)	2 (0.4)	~ ~	1 (0.1)	~ ~
International Avg.	21 (0.4)	481 (3.1)	51 (0.4)	462 (2.0)	22 (0.4)	419 (3.1)	5 (0.2)	373 (5.2)	1 (0.1)	~ ~

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

Students' Expectations for Further Education by Gender

Reported by Physics Students

Country	Doctoral Degree		Master's Degree		Bachelor's Degree		Post-Secondary Education but Not Bachelor's Degree		Upper-Secondary Education	
	Percent of Females	Percent of Males	Percent of Females	Percent of Males	Percent of Females	Percent of Males	Percent of Females	Percent of Males	Percent of Females	Percent of Males
Lebanon	65 (2.0) ▲	55 (2.4)	33 (2.0)	37 (2.5)	1 (0.4)	5 (1.0) ▲	1 (0.3)	2 (0.6) ▲	0 (0.0)	0 (0.2) ▲
Portugal	28 (3.2)	25 (1.5)	53 (3.2)	54 (1.5)	17 (2.4)	16 (1.3)	1 (0.8)	2 (0.4)	0 (0.3)	2 (0.5) ▲
United States	27 (2.2) ▲	21 (2.0)	56 (2.5) ▲	48 (2.1)	17 (2.0)	29 (1.8) ▲	0 (0.3)	1 (0.8)	0 (0.1)	1 (0.3) ▲
Slovenia	21 (2.4)	23 (1.6)	55 (2.7) ▲	45 (1.9)	18 (2.2)	19 (1.4)	6 (1.4)	12 (1.4) ▲	0 (0.0)	0 (0.2) ▲
France	27 (1.3) ▲	15 (0.8)	47 (1.1)	59 (1.1) ▲	14 (1.1)	15 (0.7)	11 (0.8)	9 (0.6)	1 (0.3)	1 (0.3)
Italy	16 (1.0)	17 (1.0)	27 (1.2) ▲	21 (1.1)	48 (1.5)	45 (1.1)	9 (1.0)	14 (1.0) ▲	1 (0.3)	3 (0.5) ▲
Sweden	10 (0.9) ▲	8 (0.8)	67 (1.4) ▲	63 (1.3)	20 (1.3)	24 (1.2) ▲	2 (0.5)	5 (0.6) ▲	1 (0.2)	1 (0.3)
Norway	9 (1.3)	7 (0.7)	73 (2.0) ▲	67 (1.6)	17 (1.6)	24 (1.6) ▲	1 (0.3)	2 (0.3) ▲	0 (0.2)	0 (0.2)
Russian Federation	7 (0.6)	8 (0.8)	64 (1.6) ▲	60 (1.3)	26 (1.5)	29 (1.1)	2 (0.6)	2 (0.5)	1 (0.2)	1 (0.2) ▲
International Avg.	23 (0.6) ▲	20 (0.5)	53 (0.7) ▲	50 (0.5)	20 (0.6)	23 (0.4) ▲	4 (0.2)	6 (0.3) ▲	0 (0.1)	1 (0.1) ▲

▲ 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.

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

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.

Country	Physics		Mathematics or Statistics		Engineering and Engineering Technologies		Computer and Information Sciences		Chemistry	
	Percent of Students	Average Achievement	Percent of Students	Average Achievement	Percent of Students	Average Achievement	Percent of Students	Average Achievement	Percent of Students	Average Achievement
France	15 (0.7)	442 (5.3)	16 (0.7)	429 (5.6)	23 (0.8)	420 (5.2)	12 (0.7)	396 (7.9)	12 (0.6)	407 (6.6)
Italy	6 (0.4)	491 (12.7)	7 (0.5)	411 (15.2)	23 (0.8)	438 (8.1)	6 (0.5)	410 (13.4)	7 (0.5)	414 (11.5)
Lebanon	17 (1.1)	427 (9.3)	24 (1.3)	398 (8.5)	71 (1.8)	422 (5.5)	13 (1.3)	416 (10.3)	6 (1.1)	392 (18.5)
Norway	41 (1.0)	550 (4.5)	36 (1.2)	531 (5.1)	73 (1.0)	521 (4.2)	26 (1.1)	524 (5.6)	12 (0.7)	552 (7.2)
Portugal	23 (1.4)	520 (6.1)	17 (1.2)	505 (6.6)	64 (1.9)	476 (5.3)	24 (1.5)	475 (6.9)	5 (0.6)	484 (12.6)
Russian Federation	40 (1.5)	546 (7.5)	33 (1.3)	535 (8.0)	40 (1.4)	534 (7.2)	27 (1.2)	541 (7.9)	9 (0.7)	534 (10.1)
Slovenia	18 (1.3)	556 (7.9)	14 (1.0)	529 (7.8)	42 (1.5)	529 (4.3)	15 (1.1)	544 (6.8)	9 (1.0)	554 (10.7)
Sweden	15 (0.8)	527 (7.0)	19 (0.8)	499 (7.7)	54 (1.2)	477 (6.4)	19 (0.9)	442 (8.4)	13 (0.8)	477 (7.9)
United States	23 (1.7)	496 (9.4)	31 (2.1)	469 (9.6)	42 (1.9)	472 (8.0)	23 (1.7)	464 (10.8)	15 (1.0)	478 (12.8)
International Avg.	22 (0.4)	506 (2.7)	22 (0.4)	478 (2.9)	48 (0.5)	477 (2.1)	18 (0.4)	468 (3.0)	10 (0.3)	477 (3.8)

Country	Biological and Biomedical Sciences		Education		Business		Other	
	Percent of Students	Average Achievement	Percent of Students	Average Achievement	Percent of Students	Average Achievement	Percent of Students	Average Achievement
France	40 (0.9)	360 (3.9)	6 (0.5)	350 (10.2)	13 (0.6)	356 (5.9)	30 (0.8)	357 (4.0)
Italy	37 (1.1)	380 (8.1)	10 (0.6)	357 (12.5)	15 (0.8)	356 (9.1)	39 (1.2)	355 (7.6)
Lebanon	7 (0.9)	413 (14.6)	3 (0.5)	375 (23.0)	6 (1.2)	397 (19.6)	15 (1.2)	412 (8.3)
Norway	17 (1.0)	504 (7.3)	11 (0.7)	490 (9.3)	22 (0.8)	488 (6.7)	34 (1.1)	501 (5.4)
Portugal	14 (1.5)	478 (8.1)	1 (0.2)	~ ~	9 (0.8)	446 (8.1)	16 (1.4)	442 (8.6)
Russian Federation	12 (0.9)	491 (10.6)	8 (0.6)	482 (13.5)	25 (0.9)	508 (11.8)	42 (1.3)	492 (9.0)
Slovenia	21 (1.2)	552 (6.9)	5 (0.6)	498 (11.9)	4 (0.6)	467 (14.5)	17 (1.4)	494 (8.0)
Sweden	36 (1.1)	456 (6.3)	10 (0.6)	447 (7.9)	16 (0.8)	463 (7.3)	33 (1.1)	445 (7.3)
United States	29 (1.7)	417 (13.0)	6 (0.9)	407 (19.4)	24 (1.5)	417 (13.4)	37 (1.9)	425 (13.5)
International Avg.	24 (0.4)	450 (3.1)	7 (0.2)	426 (5.1)	15 (0.3)	433 (3.8)	29 (0.4)	436 (2.8)

( ) 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 P4.6: 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.

Country	Engineering and Engineering Technologies		Computer and Information Sciences		Biological and Biomedical Sciences		Environmental Sciences	
	Percent of Students	Average Achievement	Percent of Students	Average Achievement	Percent of Students	Average Achievement	Percent of Students	Average Achievement
France	49 (1.0)	403 (4.4)	29 (0.9)	395 (5.9)	57 (0.9)	367 (3.8)	33 (0.8)	384 (4.1)
Italy	42 (0.9)	419 (6.9)	30 (1.0)	394 (6.9)	56 (1.2)	384 (7.7)	34 (0.9)	382 (8.4)
Lebanon	92 (1.1)	415 (4.9)	r 60 (1.6)	414 (7.5)	s 24 (2.0)	406 (9.4)	s 22 (1.5)	416 (10.0)
Norway	92 (0.5)	513 (4.5)	61 (1.2)	517 (4.6)	48 (1.2)	513 (5.0)	57 (1.3)	525 (5.0)
Portugal	85 (1.5)	475 (4.6)	63 (2.1)	467 (5.5)	30 (1.8)	474 (6.2)	20 (1.4)	450 (7.4)
Russian Federation	69 (1.4)	526 (6.5)	60 (1.2)	522 (6.4)	28 (1.2)	502 (8.4)	27 (1.1)	509 (7.3)
Slovenia	73 (1.4)	540 (3.0)	52 (1.5)	540 (4.2)	66 (1.7)	553 (3.3)	41 (1.5)	539 (3.7)
Sweden	83 (0.9)	469 (5.9)	58 (1.0)	457 (6.5)	64 (1.3)	461 (6.1)	52 (1.3)	473 (5.6)
United States	67 (1.8)	461 (8.6)	50 (2.3)	446 (9.0)	51 (1.6)	429 (12.2)	30 (1.1)	453 (12.7)
International Avg.	72 (0.4)	469 (1.9)	51 (0.5)	461 (2.1)	47 (0.5)	454 (2.5)	35 (0.4)	459 (2.6)

Country	Agriculture and Agricultural Sciences		Education		Finance/Banking		Actuarial Sciences	
	Percent of Students	Average Achievement	Percent of Students	Average Achievement	Percent of Students	Average Achievement	Percent of Students	Average Achievement
France	10 (0.6)	369 (6.4)	43 (1.0)	387 (4.2)	29 (1.1)	368 (5.2)	15 (0.7)	355 (5.5)
Italy	18 (1.0)	376 (9.9)	43 (1.2)	382 (8.3)	40 (1.0)	363 (7.8)	17 (0.7)	376 (10.1)
Lebanon	s 20 (1.6)	400 (10.7)	r 58 (1.9)	418 (5.8)	s 37 (2.4)	395 (7.6)	s 18 (1.5)	384 (10.8)
Norway	16 (0.9)	512 (6.2)	58 (1.1)	519 (5.0)	43 (1.2)	496 (5.8)	33 (0.9)	510 (5.1)
Portugal	16 (1.2)	441 (7.4)	27 (1.7)	497 (6.9)	28 (1.4)	461 (7.4)	7 (0.8)	453 (13.2)
Russian Federation	20 (1.0)	491 (8.8)	35 (1.1)	514 (7.7)	62 (1.1)	507 (7.9)	27 (1.2)	516 (7.6)
Slovenia	29 (1.3)	535 (4.8)	50 (1.8)	543 (3.8)	39 (1.5)	521 (4.2)	15 (1.1)	520 (7.5)
Sweden	21 (1.1)	458 (7.0)	46 (1.1)	471 (5.8)	49 (1.3)	448 (7.0)	26 (1.0)	469 (7.4)
United States	15 (0.9)	424 (11.7)	45 (1.7)	453 (11.8)	38 (1.8)	424 (11.4)	29 (1.7)	453 (10.3)
International Avg.	18 (0.4)	445 (2.8)	45 (0.5)	465 (2.3)	40 (0.5)	443 (2.5)	21 (0.4)	448 (3.0)

( ) 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

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.

Country	Engineering and Engineering Technologies		Computer and Information Sciences		Biological and Biomedical Sciences		Environmental Sciences	
	Percent of Females	Percent of Males	Percent of Females	Percent of Males	Percent of Females	Percent of Males	Percent of Females	Percent of Males
France	34 (1.4)	62 (1.2) ▲	12 (0.7)	45 (1.3) ▲	72 (1.2) ▲	44 (1.3)	33 (1.2)	34 (1.1)
Italy	28 (1.2)	55 (1.3) ▲	15 (1.0)	43 (1.4) ▲	64 (1.7) ▲	49 (1.4)	34 (1.1)	35 (1.3)
Lebanon	89 (1.6)	94 (1.3) ▲	s 50 (3.0)	r 65 (2.3) ▲	s 25 (3.2)	s 24 (2.4)	s 21 (2.8)	s 22 (1.8)
Norway	87 (1.4)	94 (0.5) ▲	42 (2.1)	69 (1.2) ▲	63 (1.9) ▲	42 (1.1)	65 (1.8) ▲	54 (1.6)
Portugal	64 (3.9)	91 (0.9) ▲	34 (3.0)	72 (2.1) ▲	55 (2.7) ▲	21 (1.7)	33 (3.4) ▲	16 (1.3)
Russian Federation	50 (1.8)	83 (1.2) ▲	42 (1.9)	72 (0.9) ▲	41 (2.0) ▲	19 (1.1)	37 (1.5) ▲	20 (1.2)
Slovenia	50 (2.9)	83 (1.4) ▲	29 (2.4)	63 (1.6) ▲	72 (3.0) ▲	63 (1.8)	51 (3.2) ▲	37 (1.6)
Sweden	71 (1.7)	90 (0.7) ▲	36 (1.6)	73 (1.1) ▲	79 (1.6) ▲	53 (1.4)	59 (1.4) ▲	46 (1.8)
United States	47 (3.6)	78 (1.5) ▲	36 (3.5)	59 (2.2) ▲	65 (2.2) ▲	41 (1.9)	35 (2.1) ▲	28 (1.3)
International Avg.	58 (0.8)	81 (0.4) ▲	33 (0.8)	62 (0.5) ▲	59 (0.7) ▲	40 (0.5)	41 (0.7) ▲	32 (0.5)

Country	Agriculture and Agricultural Sciences		Education		Finance/Banking		Actuarial Sciences	
	Percent of Females	Percent of Males	Percent of Females	Percent of Males	Percent of Females	Percent of Males	Percent of Females	Percent of Males
France	11 (0.8)	10 (0.7)	45 (1.4) ▲	41 (1.2)	22 (1.3)	35 (1.4) ▲	14 (0.9)	16 (1.0)
Italy	14 (1.3)	21 (1.1) ▲	46 (1.6) ▲	40 (1.7)	31 (1.3)	48 (1.4) ▲	16 (1.1)	r 17 (1.1)
Lebanon	s 16 (2.2)	s 22 (2.3)	r 72 (2.4) ▲	r 49 (2.5)	s 40 (3.6)	s 35 (2.5)	s 17 (2.7)	s 19 (2.0)
Norway	17 (1.5)	16 (1.1)	59 (1.7)	57 (1.3)	34 (1.8)	47 (1.4) ▲	36 (1.9)	32 (1.1)
Portugal	16 (2.5)	16 (1.3)	24 (2.6)	28 (1.8)	29 (2.1)	27 (1.7)	9 (2.2)	6 (0.8)
Russian Federation	19 (1.2)	21 (1.4)	50 (1.4) ▲	24 (1.3)	62 (1.6)	62 (1.5)	31 (1.5) ▲	25 (1.5)
Slovenia	24 (2.3)	30 (1.8) ▲	60 (2.4) ▲	46 (1.9)	35 (2.4)	40 (1.7)	18 (2.3)	14 (1.3)
Sweden	21 (1.6)	20 (1.1)	47 (1.6)	46 (1.4)	42 (1.7)	54 (1.5) ▲	21 (1.3)	30 (1.1) ▲
United States	17 (2.0)	14 (1.2)	45 (2.0)	45 (2.1)	38 (4.6)	38 (1.6)	27 (3.1)	30 (1.2)
International Avg.	17 (0.6)	19 (0.5) ▲	50 (0.7) ▲	42 (0.6)	37 (0.8)	43 (0.6) ▲	21 (0.7)	21 (0.4)

▲ 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

TIMSS
Advanced
2015

CHAPTER P5:
SCHOOL COMPOSITION

TIMSS ADVANCED 2015 INTERNATIONAL RESULTS IN ADVANCED MATHEMATICS AND PHYSICS

IEA
TIMSS & PIRLS
International Study Center
Lynch School of Education, Boston College

PHYSICS TIMSS *Advanced* 2015

Socioeconomic Composition of Schools

PERCENT OF STUDENTS **57%**

Average Achievement **468**

Attended schools with more affluent than disadvantaged students

PERCENT OF STUDENTS **26%**

Average Achievement **436**

Attended schools with neither more affluent nor more disadvantaged students

PERCENT OF STUDENTS **17%**

Average Achievement **424**

Attended schools with more disadvantaged than affluent students

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

SOURCE: IEA's Trends in International Mathematics and Science Study – TIMSS Advanced 2015.
http://timss2015.org/advanced/download-center/

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Exhibit P5.1: School Composition by Economic Background of the Student Body

Reported by Principals

Country		**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		**Neither More Affluent nor More Disadvantaged**		**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	
		Percent of Students	Average Achievement	Percent of Students	Average Achievement	Percent of Students	Average Achievement
France		50 (4.1)	384 (5.6)	28 (3.9)	376 (6.6)	22 (3.4)	336 (8.0)
Italy		62 (4.4)	378 (8.9)	35 (4.5)	362 (17.7)	2 (1.4)	~ ~
Lebanon		34 (5.1)	442 (11.0)	29 (4.6)	404 (12.1)	38 (3.2)	391 (5.7)
Norway	r	71 (5.1)	510 (6.1)	27 (5.0)	503 (6.7)	2 (1.2)	~ ~
Portugal		19 (3.4)	502 (7.9)	42 (5.9)	454 (6.9)	39 (5.5)	457 (7.0)
Russian Federation		84 (3.4)	519 (6.9)	13 (2.9)	458 (18.4)	3 (1.2)	439 (46.9)
Slovenia		75 (3.9)	540 (4.0)	18 (3.6)	484 (8.3)	7 (1.5)	562 (15.5)
Sweden	r	75 (3.1)	468 (7.9)	19 (3.3)	409 (12.0)	6 (2.0)	384 (15.9)
United States	r	42 (5.9)	473 (15.5)	24 (4.2)	476 (14.8)	34 (4.6)	396 (14.8)
International Avg.		57 (1.5)	468 (2.9)	26 (1.4)	436 (4.1)	17 (1.0)	424 (7.9)

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

( ) 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

Exhibit P5.2: Schools with Students Having the Language of the Test as Their Native Language

Reported by Principals

Country	School Has More than 90% of Students with Language of Test as Their Native Language		School Has 51-90% of Students with Language of Test as Their Native Language		School Has 50% or Less of Students with Language of Test as Their Native Language	
	Percent of Students	Average Achievement	Percent of Students	Average Achievement	Percent of Students	Average Achievement
France	88 (3.1)	375 (4.3)	11 (3.1)	344 (15.5)	1 (0.6)	~ ~
Italy	89 (2.9)	375 (7.7)	11 (2.9)	366 (22.4)	0 (0.0)	~ ~
Lebanon	11 (3.6)	435 (12.9)	12 (2.8)	387 (18.3)	76 (4.3)	412 (5.8)
Norway r	68 (5.3)	504 (5.7)	30 (5.3)	512 (10.4)	2 (1.5)	~ ~
Portugal	93 (2.2)	466 (4.9)	3 (0.7)	500 (13.7)	4 (2.1)	475 (22.0)
Russian Federation	84 (2.5)	503 (7.4)	10 (2.7)	524 (22.4)	5 (1.8)	552 (12.2)
Slovenia	91 (3.2)	536 (3.1)	8 (3.2)	487 (12.5)	0 (0.0)	~ ~
Sweden	38 (5.0)	465 (7.0)	53 (5.3)	448 (10.2)	9 (3.1)	434 (37.7)
United States r	63 (5.9)	458 (12.7)	25 (5.1)	447 (12.7)	13 (4.5)	397 (42.3)
International Avg.	69 (1.3)	457 (2.7)	18 (1.2)	446 (5.3)	12 (0.8)	454 (12.5)

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

( ) 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.

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CHAPTER M6:
SCHOOL CLIMATE

TIMSS ADVANCED 2015 INTERNATIONAL RESULTS IN
ADVANCED MATHEMATICS AND PHYSICS

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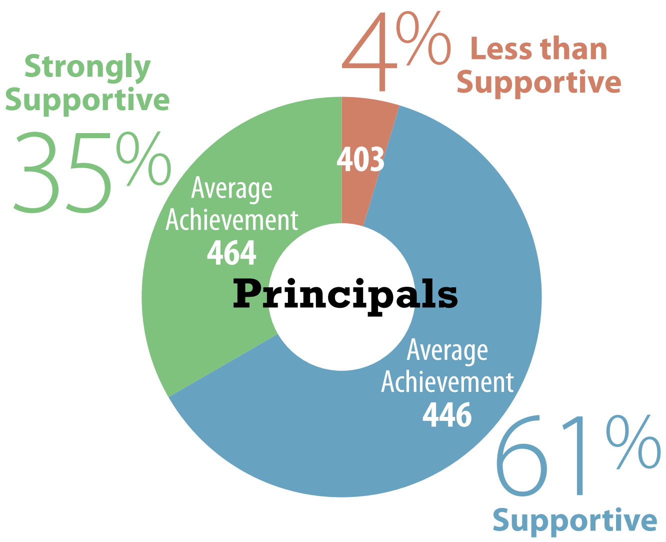
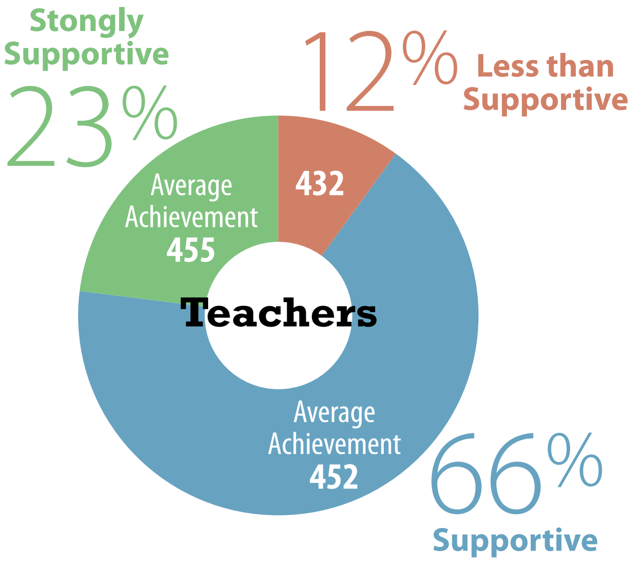
PHYSICS **TIMSS** *Advanced* **2015**

Schools Have Positive Environments

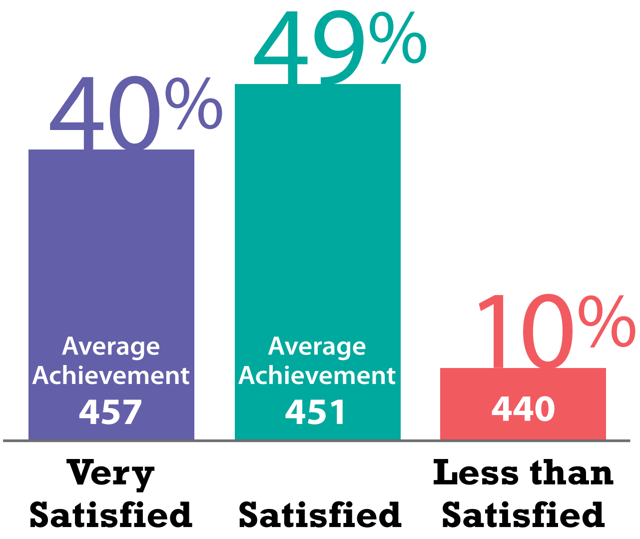
Generally, students taking physics courses are in positive school environments, and the more positive the school environment the higher the average achievement.



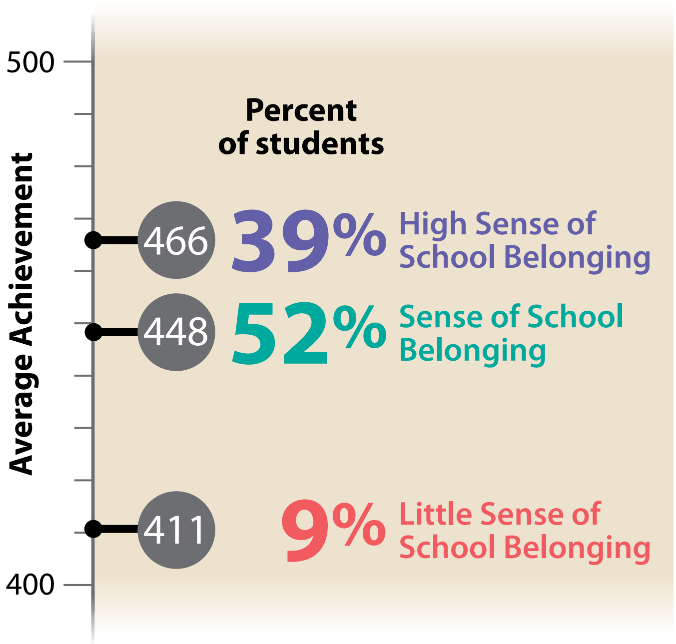


Principals and teachers agree that high percentages of TIMSS Advanced students attend schools that support physics education, although the principals have more positive attitudes than the teachers.

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.



SOURCE: IEA's Trends in International Mathematics and Science Study – TIMSS Advanced 2015.
http://timss2015.org/advanced/download-center/

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Exhibit P6.1: Programs to Encourage Students to Study Physics

Reported by National Research Coordinators

Country	School Partnerships with Industry	School Collaborations with Universities	Contests/ Competitions in Physics
France	●	●	●
Italy	●	●	●
Lebanon	○	○	○
Norway	○	●	●
Portugal	○	●	●
Russian Federation	○	●	●
Slovenia	○	○	○
Sweden	●	●	●
United States	●	●	●

● 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

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 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.

Country	Strongly Supportive		Supportive		Less than Supportive		Average Scale Score
	Percent of Students	Average Achievement	Percent of Students	Average Achievement	Percent of Students	Average Achievement	
Russian Federation	79 (2.6)	521 (8.3)	21 (2.6)	456 (15.1)	0 (0.0)	~ ~	11.8 (0.11)
United States r	58 (6.0)	443 (16.4)	40 (6.0)	455 (12.1)	2 (1.1)	~ ~	10.8 (0.22)
Norway r	54 (5.7)	511 (6.2)	46 (5.7)	501 (6.5)	0 (0.0)	~ ~	10.9 (0.21)
Lebanon	39 (2.5)	410 (8.0)	59 (2.5)	411 (5.3)	2 (0.3)	~ ~	10.5 (0.10)
Portugal	34 (3.9)	468 (8.1)	61 (4.5)	467 (6.1)	5 (2.0)	465 (15.4)	10.0 (0.16)
Italy	29 (4.3)	385 (12.6)	67 (4.4)	369 (10.5)	4 (1.9)	377 (58.8)	9.7 (0.17)
Slovenia	10 (2.1)	591 (14.7)	90 (2.1)	525 (2.9)	0 (0.0)	~ ~	9.2 (0.06)
Sweden	8 (2.4)	449 (14.4)	77 (3.8)	461 (7.7)	15 (3.1)	412 (13.7)	8.5 (0.15)
France	8 (2.3)	400 (12.0)	84 (3.4)	369 (4.4)	8 (2.5)	360 (13.5)	8.7 (0.13)
International Avg.	35 (1.3)	464 (3.9)	61 (1.4)	446 (2.9)	4 (0.6)	403 (15.9)	

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

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?

	Agree a lot	Agree a little	Disagree a little	Disagree a lot
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) The school has initiatives to promote student interest in advanced mathematics and physics (e.g., student clubs, competitions)	○	○	○	○
5) The school has partnership initiatives 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	○	○	○	○

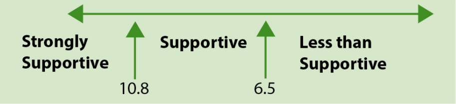


Exhibit P6.3: School Supports Advanced Mathematics and Physics Education – Teacher Version

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.

Country	Strongly Supportive		Supportive		Less than Supportive		Average Scale Score
	Percent of Students	Average Achievement	Percent of Students	Average Achievement	Percent of Students	Average Achievement	
Russian Federation	58 (4.0)	508 (8.9)	42 (4.0)	510 (14.1)	1 (0.6)	~ ~	11.8 (0.15)
Lebanon	48 (3.4)	412 (7.2)	50 (3.5)	410 (5.9)	2 (0.1)	~ ~	11.6 (0.12)
United States r	37 (5.2)	456 (15.1)	58 (5.1)	434 (14.5)	4 (1.7)	423 (39.9)	10.6 (0.26)
Norway	23 (3.6)	512 (9.0)	75 (3.8)	503 (5.9)	2 (1.0)	~ ~	10.5 (0.11)
Portugal	18 (3.3)	483 (10.9)	75 (4.0)	464 (5.4)	7 (2.4)	460 (9.1)	9.9 (0.14)
Italy	10 (2.1)	386 (22.1)	67 (2.8)	377 (8.9)	23 (3.0)	388 (11.0)	9.0 (0.14)
France	3 (1.1)	400 (14.5)	79 (2.2)	376 (4.1)	18 (2.2)	367 (9.5)	8.9 (0.09)
Sweden	3 (1.3)	480 (16.7)	79 (3.4)	456 (6.8)	19 (3.2)	448 (14.5)	8.9 (0.13)
Slovenia	2 (0.1)	~ ~	69 (1.9)	538 (3.5)	28 (2.0)	508 (5.8)	8.7 (0.04)
International Avg.	23 (1.0)	455 (4.9)	66 (1.2)	452 (2.9)	12 (0.7)	432 (7.7)	

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

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?

	Agree a lot	Agree a little	Disagree a little	Disagree a lot
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	○	○	○	○

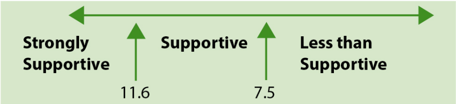


Exhibit P6.4: Teacher Job Satisfaction

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.

Country	Very Satisfied		Satisfied		Less than Satisfied		Average Scale Score
	Percent of Students	Average Achievement	Percent of Students	Average Achievement	Percent of Students	Average Achievement	
Lebanon	67 (4.2)	412 (5.1)	30 (4.1)	409 (10.5)	3 (0.7)	373 (14.8)	11.2 (0.14)
United States r	52 (4.9)	458 (9.7)	37 (5.3)	432 (20.5)	11 (1.8)	394 (28.2)	10.3 (0.15)
Norway	51 (4.1)	504 (6.1)	45 (4.0)	505 (6.1)	4 (1.6)	508 (10.7)	10.5 (0.15)
Russian Federation	44 (4.4)	511 (11.3)	51 (4.0)	504 (10.8)	5 (1.4)	515 (30.0)	10.3 (0.17)
Sweden	34 (4.3)	462 (11.8)	56 (3.9)	449 (7.6)	10 (2.6)	461 (23.1)	9.8 (0.15)
Italy	31 (3.4)	355 (13.4)	53 (3.7)	392 (8.5)	17 (2.8)	390 (13.6)	9.4 (0.16)
Slovenia	29 (2.1)	557 (6.7)	58 (3.5)	531 (3.6)	13 (3.5)	472 (10.8)	9.6 (0.16)
Portugal	29 (4.0)	477 (8.0)	62 (4.8)	462 (5.8)	9 (2.4)	470 (17.5)	9.6 (0.15)
France	25 (2.5)	377 (7.0)	53 (3.3)	373 (4.5)	22 (2.7)	375 (8.7)	9.2 (0.13)
International Avg.	40 (1.3)	457 (3.1)	49 (1.4)	451 (3.3)	10 (0.8)	440 (6.3)	

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

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.

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?

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

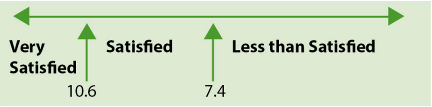


Exhibit P6.5: Students' Sense of School Belonging

Reported by Physics 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 10.5, 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**.

Country	High Sense of School Belonging		Sense of School Belonging		Little Sense of School Belonging		Average Scale Score
	Percent of Students	Average Achievement	Percent of Students	Average Achievement	Percent of Students	Average Achievement	
Norway	63 (1.4)	519 (4.4)	34 (1.2)	491 (6.0)	3 (0.4)	444 (13.8)	11.0 (0.06)
Sweden	55 (1.6)	474 (6.3)	41 (1.5)	440 (7.4)	5 (0.4)	364 (13.4)	10.7 (0.07)
Russian Federation	52 (1.3)	513 (8.1)	41 (1.2)	503 (7.5)	6 (0.5)	491 (9.8)	10.7 (0.06)
United States	45 (2.1)	448 (10.3)	48 (1.9)	433 (11.1)	7 (0.9)	401 (18.9)	10.2 (0.10)
Lebanon	44 (1.9)	412 (6.5)	46 (2.0)	413 (5.5)	10 (1.5)	409 (10.5)	10.2 (0.10)
Portugal	43 (1.7)	475 (5.6)	51 (1.5)	465 (5.1)	5 (0.8)	421 (12.3)	10.2 (0.07)
France	22 (1.2)	402 (5.2)	71 (1.0)	370 (4.1)	7 (0.6)	321 (7.4)	9.4 (0.05)
Italy	16 (1.0)	379 (13.0)	63 (1.0)	381 (7.4)	21 (1.1)	354 (8.6)	8.8 (0.05)
Slovenia	14 (0.9)	569 (7.3)	70 (1.4)	533 (3.5)	17 (1.1)	493 (9.4)	8.8 (0.04)
International Avg.	39 (0.5)	466 (2.6)	52 (0.5)	448 (2.3)	9 (0.3)	411 (4.0)	

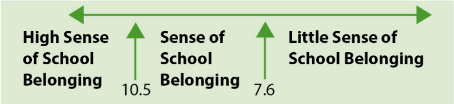
SOURCE: IEA's Trends in International Mathematics and Science Study – TIMSS Advanced 2015

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.

	Agree a lot	Agree a little	Disagree a little	Disagree a lot
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	○	○	○	○



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CHAPTER P7:
SCHOOL SAFETY

TIMSS ADVANCED 2015 INTERNATIONAL RESULTS IN
ADVANCED MATHEMATICS AND PHYSICS

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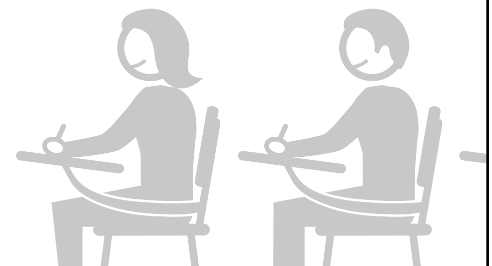
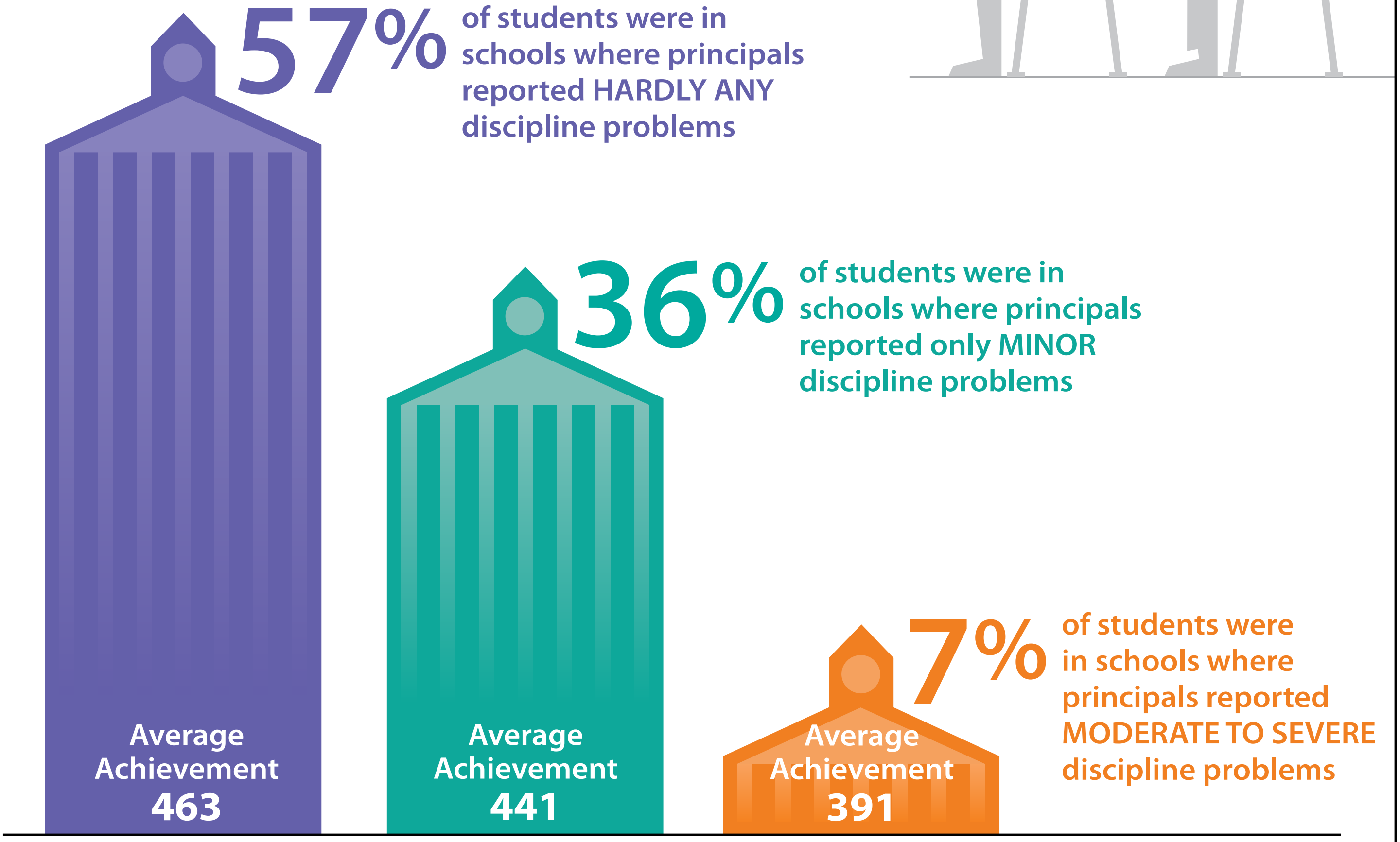
PHYSICS **TIMSS Advanced 2015**

Students Are in Safe Schools

Principals and teachers agreed that ALMOST ALL the TIMSS Advanced students were in safe school environments.



Principals' Reports

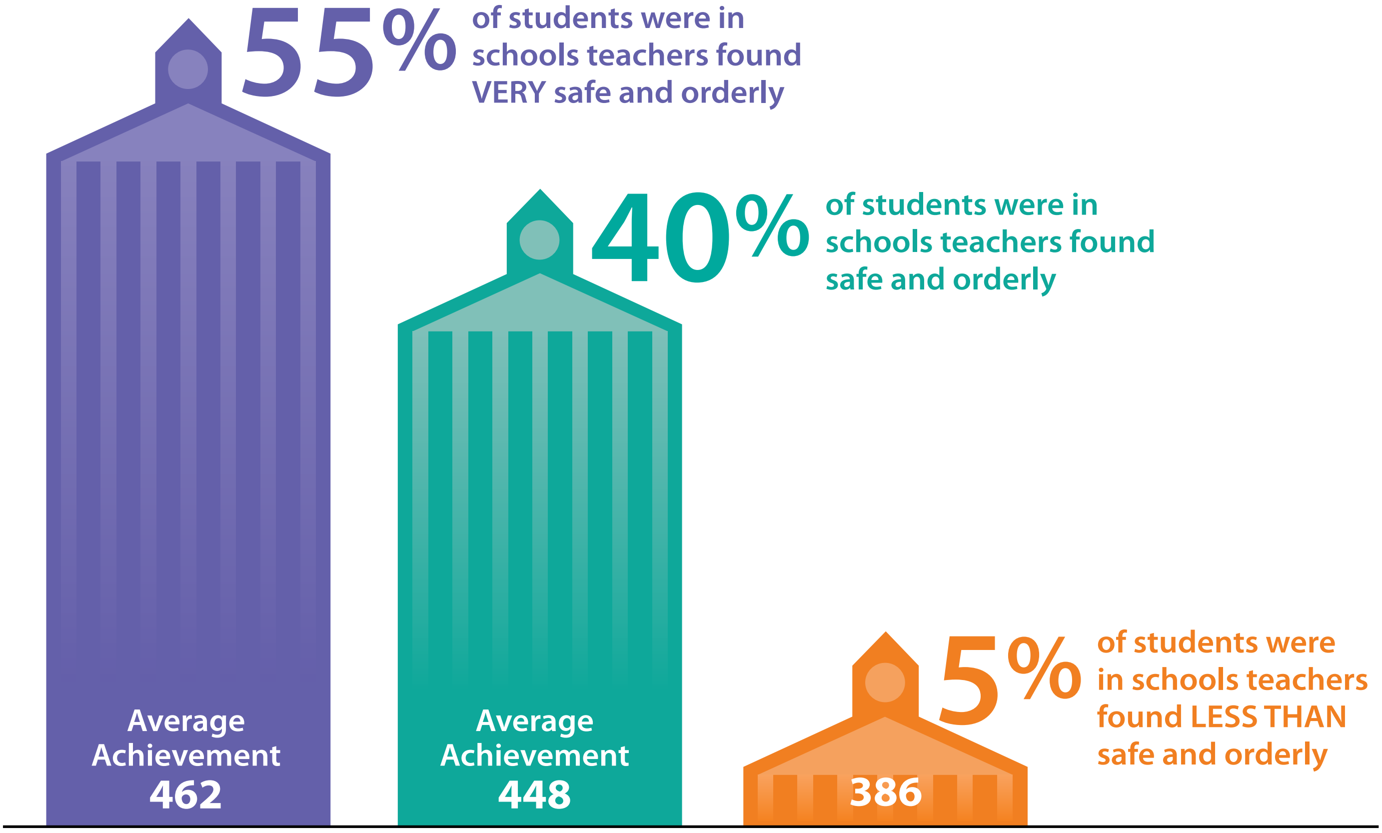


57% of students were in schools where principals reported HARDLY ANY discipline problems

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

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

SOURCE: IEA's Trends in International Mathematics and Science Study – TIMSS Advanced 2015.
http://timss2015.org/advanced/download-center/

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Exhibit P7.1: 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**.

Country		Hardly Any Problems		Minor Problems		Moderate to Severe Problems		Average Scale Score
		Percent of Students	Average Achievement	Percent of Students	Average Achievement	Percent of Students	Average Achievement	
Russian Federation		86 (2.3)	510 (8.6)	14 (2.3)	495 (20.2)	0 (0.0)	~ ~	11.1 (0.08)
France		65 (4.7)	375 (5.2)	31 (4.5)	363 (8.4)	4 (1.7)	367 (10.5)	10.4 (0.18)
Norway	r	65 (5.1)	512 (5.4)	35 (5.0)	497 (7.4)	1 (0.6)	~ ~	10.3 (0.16)
Slovenia		62 (4.1)	545 (4.2)	38 (4.1)	509 (5.8)	0 (0.0)	~ ~	10.4 (0.09)
Portugal		56 (4.6)	467 (6.1)	36 (4.5)	470 (7.4)	8 (2.8)	451 (16.7)	10.0 (0.21)
Lebanon		49 (3.7)	417 (6.6)	25 (4.8)	406 (12.0)	26 (3.4)	401 (10.4)	9.2 (0.18)
United States	r	46 (6.1)	462 (16.0)	53 (6.1)	437 (13.1)	1 (0.7)	~ ~	9.8 (0.21)
Italy		44 (4.4)	403 (11.5)	37 (4.8)	353 (12.5)	19 (3.5)	345 (21.2)	9.2 (0.18)
Sweden		42 (4.0)	473 (10.5)	56 (4.2)	441 (7.4)	2 (1.2)	~ ~	9.6 (0.13)
International Avg.		57 (1.5)	463 (3.0)	36 (1.5)	441 (3.8)	7 (0.7)	391 (7.7)	

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

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.

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	○	○	○	○

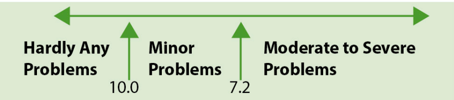


Exhibit P7.2: Safe and Orderly School – Teachers' Reports

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.

Country	Very Safe and Orderly		Safe and Orderly		Less than Safe and Orderly		Average Scale Score
	Percent of Students	Average Achievement	Percent of Students	Average Achievement	Percent of Students	Average Achievement	
Russian Federation	83 (3.0)	512 (8.4)	17 (3.0)	489 (16.2)	0 (0.0)	~ ~	10.9 (0.11)
Norway	77 (3.4)	509 (5.0)	22 (3.5)	497 (10.0)	2 (1.2)	~ ~	10.9 (0.14)
Lebanon	67 (4.0)	413 (5.3)	32 (4.0)	405 (9.8)	1 (0.0)	~ ~	10.7 (0.12)
Sweden	55 (4.5)	461 (8.4)	42 (4.6)	454 (9.7)	3 (1.1)	359 (30.4)	10.1 (0.12)
United States r	52 (5.3)	458 (10.4)	34 (5.8)	458 (15.0)	14 (4.5)	341 (26.0)	10.0 (0.28)
Italy	50 (3.9)	384 (8.4)	45 (3.8)	379 (11.7)	5 (1.4)	357 (20.4)	9.6 (0.16)
Portugal	50 (4.3)	475 (6.1)	48 (4.1)	458 (6.8)	2 (1.1)	~ ~	9.9 (0.15)
Slovenia	35 (2.6)	558 (5.9)	56 (1.8)	515 (4.0)	9 (2.9)	525 (11.2)	9.0 (0.21)
France	27 (2.8)	384 (7.1)	67 (3.1)	374 (4.0)	6 (1.6)	348 (14.6)	8.9 (0.11)
International Avg.	55 (1.3)	462 (2.5)	40 (1.3)	448 (3.5)	5 (0.7)	386 (9.7)	

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

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.

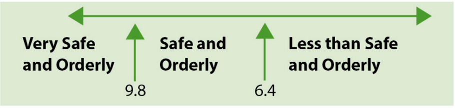
( ) Standard errors appear in parentheses. Because of rounding some results may appear inconsistent.

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.

	Agree a lot	Agree a little	Disagree a little	Disagree a lot
1) This school is located in a safe neighborhood ----------	○	○	○	○
2) I feel safe at this school --	○	○	○	○
3) This school's security policies and practices are sufficient--	○	○	○	○
4) The students behave in an orderly manner -------------	○	○	○	○
5) The students are respectful of the teachers ------------	○	○	○	○
6) The students respect school property---------------------	○	○	○	○
7) This school has clear rules about student conduct--	○	○	○	○
8) This school's rules are enforced in a fair and consistent manner---	○	○	○	○



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CHAPTER P8: TEACHERS' AND PRINCIPALS' PREPARATION

TIMSS ADVANCED 2015 INTERNATIONAL RESULTS IN ADVANCED MATHEMATICS AND PHYSICS

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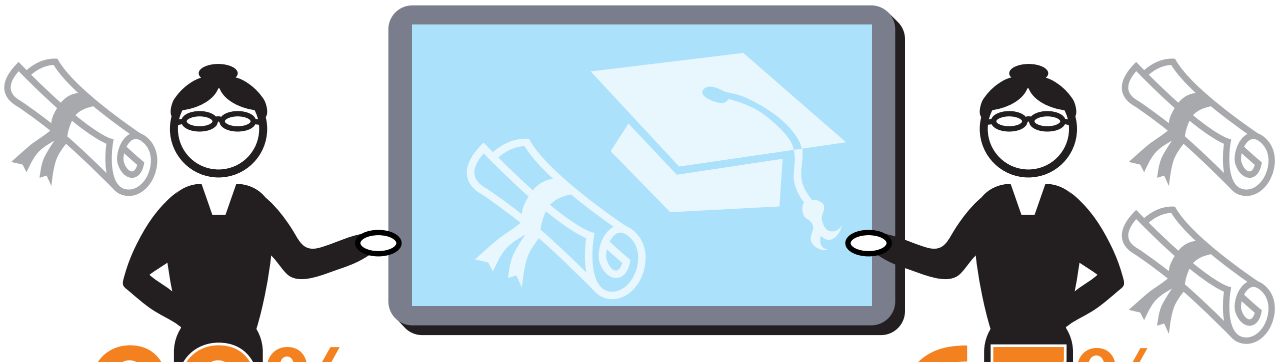
PHYSICS **TIMSS** *Advanced* **2015**

Students Have Well Qualified Teachers and Principals

Physics teachers of TIMSS Advanced students reported high levels of education and considerable experience.

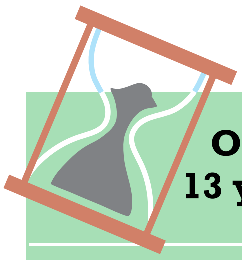


99%

of students were taught by physics teachers with at least a Bachelor's degree

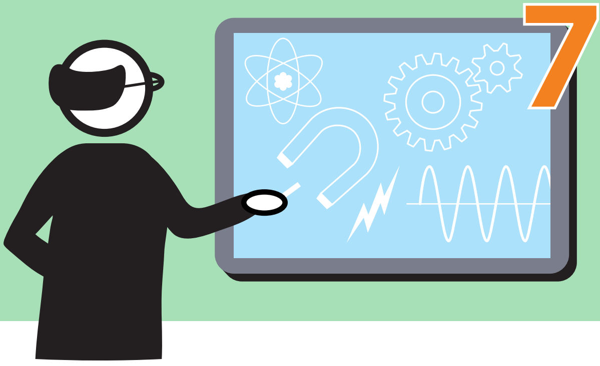
67%

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.

SOURCE: IEA's Trends in International Mathematics and Science Study – TIMSS Advanced 2015.
http://timss2015.org/advanced/download-center/

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Exhibit P8.1: National Requirements for Being a Physics Teacher in the Final Year of School

Reported by National Research Coordinators

Country	Requirements
France	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.
Italy	Teachers must hold a degree in physics (5 years of university study), complete a 1-year teacher certification course, and win a public contest.
Lebanon	Teachers must hold a Bachelor of Science degree or teaching diploma in physics for Grades 9, 10, 11, and 12.
Norway	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.
Portugal	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.
Russian Federation	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.
Slovenia	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.
Sweden	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.
United States	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.

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

Exhibit P8.2: Physics Teachers' Formal Education*

Reported by Physics Teachers

Country	Completed Postgraduate University Degree**		Completed Bachelor's Degree or Equivalent but Not a Postgraduate Degree		Did Not Complete Bachelor's Degree	
	Percent of Students	Average Achievement	Percent of Students	Average Achievement	Percent of Students	Average Achievement
France	81 (2.5)	375 (4.4)	19 (2.5)	377 (8.3)	0 (0.3)	~ ~
Italy	14 (2.3)	362 (17.4)	86 (2.3)	384 (7.7)	0 (0.0)	~ ~
Lebanon	71 (2.9)	406 (4.9)	22 (2.3)	423 (7.3)	7 (1.7)	405 (22.5)
Norway	86 (2.8)	506 (4.8)	14 (2.8)	496 (12.7)	0 (0.0)	~ ~
Portugal	27 (4.5)	466 (9.0)	72 (4.6)	467 (5.4)	1 (0.8)	~ ~
Russian Federation	79 (3.5)	510 (8.0)	21 (3.5)	495 (12.8)	0 (0.0)	~ ~
Slovenia	100 (0.0)	531 (2.5)	0 (0.0)	~ ~	0 (0.0)	~ ~
Sweden	73 (4.5)	459 (7.3)	25 (4.5)	456 (11.1)	2 (1.0)	~ ~
United States r	77 (6.0)	447 (7.7)	23 (6.0)	423 (34.4)	0 (0.0)	~ ~
International Avg.	67 (1.2)	451 (2.8)	31 (1.2)	440 (5.4)	1 (0.2)	405 (22.5)

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.

( ) 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 P8.3: Physics Teachers Majored in Physics and Education

Reported by Physics Teachers

Country	Major in Physics and Physics Education		Major in Physics but No Major in Physics Education		Major in Physics Education but No Major in Physics		All Other Majors	
	Percent of Students	Average Achievement	Percent of Students	Average Achievement	Percent of Students	Average Achievement	Percent of Students	Average Achievement
France	25 (2.8)	371 (7.2)	71 (2.8)	376 (4.6)	0 (0.0)	~ ~	4 (1.2)	385 (7.5)
Italy	38 (2.9)	369 (12.4)	37 (3.0)	393 (9.2)	1 (0.5)	~ ~	24 (3.3)	379 (14.6)
Lebanon	51 (4.8)	406 (7.2)	48 (4.8)	419 (8.0)	1 (0.4)	~ ~	0 (0.0)	~ ~
Norway	10 (2.9)	513 (11.6)	88 (3.3)	506 (5.1)	1 (0.6)	~ ~	2 (1.0)	~ ~
Portugal	42 (4.5)	470 (7.1)	55 (4.4)	466 (6.4)	0 (0.0)	~ ~	2 (1.2)	~ ~
Russian Federation	64 (3.7)	513 (9.3)	34 (3.9)	498 (9.1)	1 (0.7)	~ ~	1 (0.6)	~ ~
Slovenia	41 (3.1)	531 (4.2)	44 (3.3)	526 (4.8)	14 (3.9)	541 (9.0)	1 (0.0)	~ ~
Sweden	71 (4.3)	463 (7.9)	21 (3.8)	446 (12.9)	6 (1.8)	456 (20.5)	2 (1.0)	~ ~
United States r	24 (4.1)	444 (14.7)	31 (4.7)	429 (22.4)	6 (2.1)	457 (18.8)	39 (5.1)	448 (16.3)
International Avg.	41 (1.2)	453 (3.2)	48 (1.3)	451 (3.5)	3 (0.5)	485 (9.7)	8 (0.7)	404 (7.7)

( ) 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 P8.4: Physics Teachers’ Gender, Age, and Number of Years Teaching

Reported by Physics Teachers

Country	Percent of Students by Teacher Characteristics							Average Number of Years Teaching	
	Gender		Age						
	Female	Male	29 Years or Under	30-39 Years	40-49 Years	50-59 Years	60 Years or Older	Teaching Altogether	Teaching Physics at the Advanced Level
France	38 (3.3)	62 (3.3)	2 (1.0)	24 (3.4)	49 (2.9)	20 (2.6)	4 (1.2)	20 (0.6)	11 (0.5)
Italy	57 (3.1)	43 (3.1)	2 (0.7)	4 (1.3)	33 (3.5)	46 (3.3)	15 (2.8)	23 (0.6)	14 (0.6)
Lebanon	20 (2.8)	80 (2.8)	3 (0.6)	27 (3.7)	28 (3.6)	18 (2.4)	24 (4.2)	24 (1.0)	20 (0.7)
Norway	24 (4.1)	76 (4.1)	7 (1.9)	21 (3.1)	29 (4.4)	21 (3.4)	22 (3.3)	18 (0.8)	14 (0.8)
Portugal	56 (4.8)	44 (4.8)	0 (0.0)	12 (2.5)	43 (4.3)	39 (4.4)	7 (2.1)	24 (0.8)	9 (0.6)
Russian Federation	77 (3.0)	23 (3.0)	3 (1.4)	13 (2.1)	25 (3.8)	42 (3.6)	18 (3.0)	26 (0.8)	11 (0.6)
Slovenia	31 (3.3)	69 (3.3)	1 (0.0)	22 (2.6)	31 (3.0)	37 (3.7)	8 (0.8)	21 (0.7)	15 (0.6)
Sweden	27 (4.8)	73 (4.8)	7 (1.7)	23 (3.9)	28 (3.9)	28 (4.7)	14 (2.0)	16 (0.8)	12 (0.7)
United States	r 31 (5.7)	69 (5.7)	r 19 (4.7)	21 (3.5)	30 (4.1)	21 (5.3)	9 (3.4)	r 14 (1.1)	s 8 (0.8)
International Avg.	40 (1.3)	60 (1.3)	5 (0.6)	19 (1.0)	33 (1.3)	30 (1.3)	13 (0.9)	21 (0.3)	13 (0.2)

( ) 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

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.

Country	Percent of Students by Teacher's Area of Professional Development						
	Physics Content	Physics Pedagogy/ Instruction	Physics Curriculum	Integrating Information Technology into Physics	Improving Students' Critical Thinking or Problem Solving Skills	Physics Assessment	Addressing Individual Students' Needs
France	32 (2.8)	51 (3.4)	37 (3.5)	20 (2.9)	21 (2.8)	32 (2.8)	9 (1.9)
Italy	42 (3.6)	35 (3.4)	21 (2.8)	21 (2.9)	9 (2.0)	8 (1.7)	13 (2.7)
Lebanon	53 (4.1)	58 (2.6)	50 (3.8)	69 (2.5)	50 (3.7)	60 (3.1)	46 (4.3)
Norway	35 (4.6)	18 (3.7)	15 (3.6)	20 (3.4)	5 (1.8)	17 (3.5)	6 (2.0)
Portugal	59 (5.0)	48 (4.6)	35 (5.1)	55 (5.0)	16 (3.1)	17 (3.9)	13 (3.7)
Russian Federation	62 (4.1)	79 (3.8)	82 (2.7)	76 (3.4)	58 (4.8)	53 (4.3)	50 (3.9)
Slovenia	82 (2.4)	76 (3.0)	49 (3.6)	61 (3.0)	48 (3.0)	40 (3.6)	24 (3.4)
Sweden	42 (4.2)	28 (4.8)	15 (3.1)	27 (4.4)	9 (2.6)	26 (4.2)	17 (4.1)
United States	s 64 (5.8)	s 67 (5.3)	s 76 (5.4)	s 38 (5.1)	s 53 (6.2)	s 43 (5.6)	s 37 (5.9)
International Avg.	52 (1.4)	51 (1.3)	42 (1.3)	43 (1.2)	30 (1.2)	33 (1.3)	24 (1.2)

( ) 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*

Reported by Principals

Country		Percent of Students by Principal Educational Level		
		Completed Postgraduate University Degree**	Completed Bachelor's Degree or Equivalent but Not a Postgraduate Degree	Did Not Complete Bachelor's Degree
France		73 (4.0)	25 (4.0)	1 (1.1)
Italy		30 (4.7)	67 (4.8)	3 (1.8)
Lebanon		71 (4.3)	26 (4.3)	3 (0.5)
Norway	r	77 (4.7)	23 (4.7)	0 (0.0)
Portugal		38 (5.4)	62 (5.4)	0 (0.0)
Russian Federation		82 (2.8)	18 (2.8)	0 (0.0)
Slovenia		100 (0.0)	0 (0.0)	0 (0.0)
Sweden		61 (6.1)	35 (5.9)	4 (1.7)
United States	r	100 (0.3)	0 (0.3)	0 (0.0)
International Avg.		70 (1.4)	29 (1.4)	1 (0.3)

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.

( ) 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 P8.7: Principals' Years of Experience

Reported by Principals

Country	Percent of Students by Principal Years of Experience as a Principal				Average Years of Experience as a Principal
	20 Years or More	At Least 10 but Less than 20 Years	At Least 5 but Less than 10 Years	Less than 5 Years	
France	14 (2.7)	31 (4.1)	27 (3.9)	28 (4.4)	10 (0.7)
Italy	18 (3.6)	27 (4.2)	41 (4.4)	13 (3.0)	11 (0.7)
Lebanon	33 (5.0)	20 (2.8)	26 (3.4)	21 (2.9)	14 (0.9)
Norway r	24 (5.2)	40 (5.9)	28 (5.1)	8 (2.7)	14 (0.7)
Portugal	18 (3.1)	30 (3.6)	25 (4.7)	26 (4.8)	11 (0.8)
Russian Federation	24 (4.0)	35 (3.8)	20 (3.0)	21 (3.5)	13 (0.8)
Slovenia	12 (3.3)	39 (4.4)	30 (2.8)	20 (1.3)	12 (0.5)
Sweden	6 (2.6)	33 (5.1)	27 (4.0)	34 (4.5)	8 (0.6)
United States r	5 (1.7)	30 (5.3)	27 (4.4)	38 (5.6)	8 (0.7)
International Avg.	17 (1.2)	32 (1.5)	28 (1.3)	23 (1.3)	11 (0.2)

( ) 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

TIMSS
Advanced
2015

CHAPTER P9: CLASSROOM INSTRUCTION

TIMSS ADVANCED 2015 INTERNATIONAL RESULTS IN
ADVANCED MATHEMATICS AND PHYSICS

IEA
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International Study Center
Lynch School of Education, Boston College

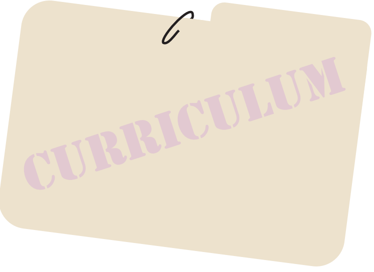
PHYSICS **TIMSS** *Advanced* **2015**

Instruction in Physics Classes

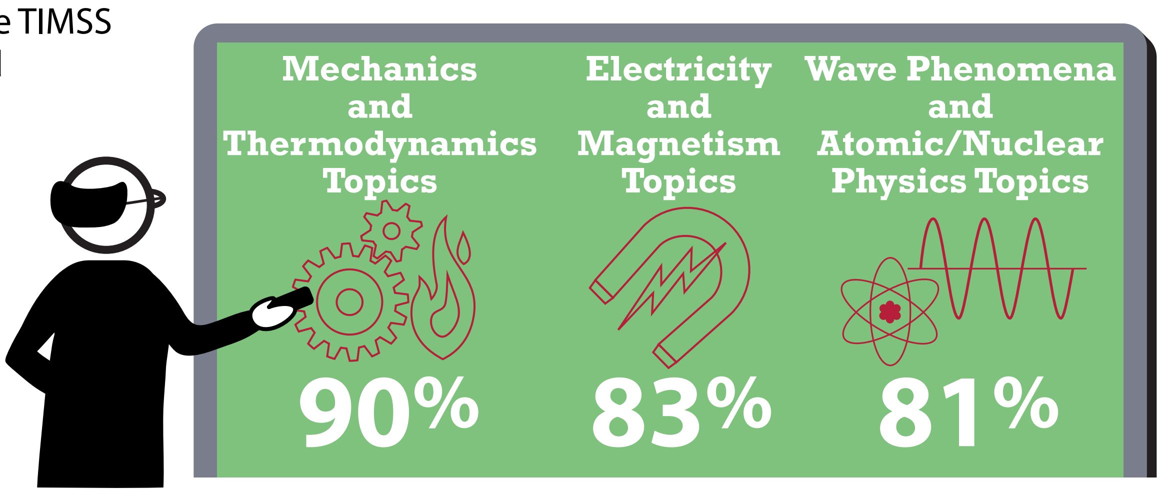
Curriculum

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 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.



Mechanics and Thermodynamics Topics 90%

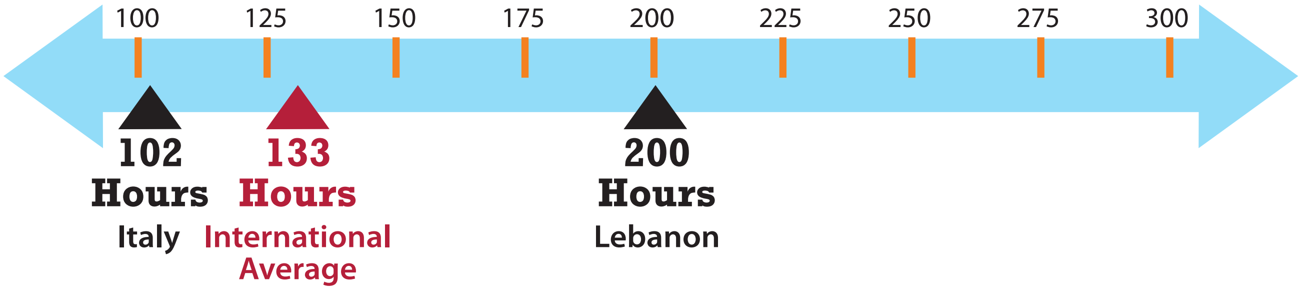
Electricity and Magnetism Topics 83%

Wave Phenomena and Atomic/Nuclear Physics Topics 81%

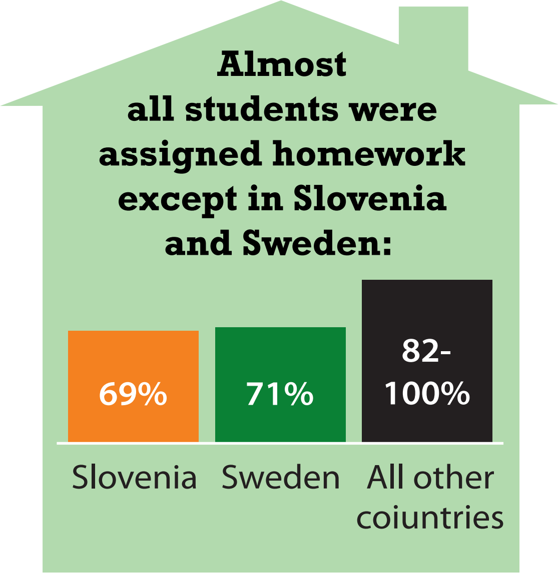
Instructional Time

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 physics.



Students also studied outside of school:



Almost all students were assigned homework except in Slovenia and Sweden:

Except in the Russian Federation, Portugal, and France, few Physics students reported attending extra tutoring outside of school to improve their achievement.

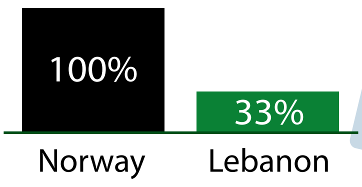
52% **attended tutoring in the Russian Federation.**

20-27% **attended tutoring in France and Portugal.**

On average, students attending extra tutoring had lower achievement.

Technology

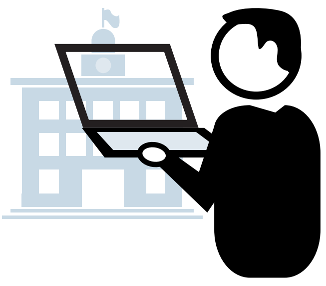
Across the TIMSS Advanced countries there was a wide range in access to digital devices to use in physics lessons, with 79% of students on average having digital devices available.



Teachers have students use their digital devices primarily to process and analyze data (71%), draw graphs of functions (67%), look up ideas and information (66%), and do scientific procedures or experiments (62%).

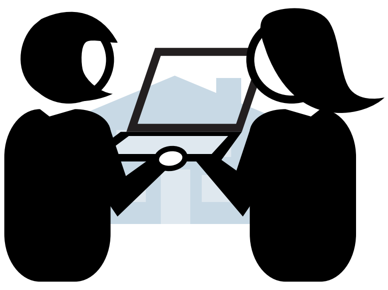
Students used the Internet for their TIMSS Advanced school work primarily to:

Find information about physics concepts or solve problems



72-74%

Collaborate with classmates on physics assignements or projects



64%

SOURCE: IEA's Trends in International Mathematics and Science Study – TIMSS Advanced 2015.
http://timss2015.org/advanced/download-center/

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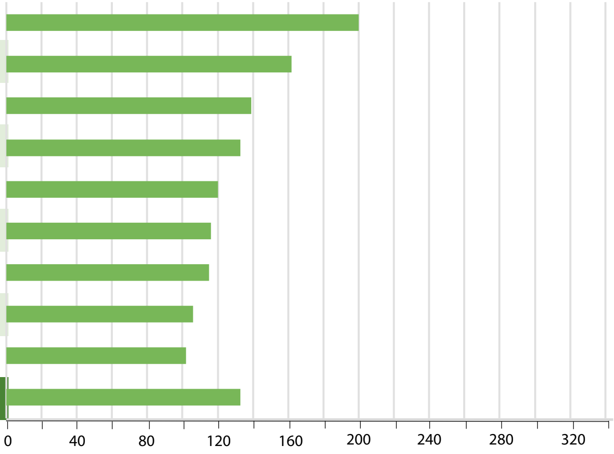
Exhibit P9.1: Instructional Time Spent on Physics

Reported by Principals and Physics Teachers

Country		Total Instructional Hours per Year		Hours per Year for Physics Instruction
Lebanon		932 (11.2)		200 (3.1)
United States	r	1132 (22.5)	s	162 (13.3)
Norway	r	991 (14.1)	r	139 (3.0)
Russian Federation		920 (8.7)		133 (2.0)
Portugal	r	1046 (37.1)		120 (6.2)
France		1340 (22.5)	r	116 (4.2)
Slovenia		902 (5.9)		115 (1.0)
Sweden		920 (13.8)		106 (3.0)
Italy	r	1018 (8.2)	r	102 (1.7)
International Avg.		1023 (6.2)		133 (1.8)



( ) 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

Total Instructional Hours per Year = Principal Reports of School Days per Year X Principal Reports of Instructional Hours per Day

Hours per Year for Physics Instruction = $\frac{\text{Teacher Reports of Weekly Physics Instructional Hours}}{\text{Principal Reports of School Days per Week}}$ X Principal Reports of School Days per Year

Exhibit P9.2: Types of Homework Assignments

Reported by Physics Teachers

Country	Physics Homework Assigned to Class			Percent of Students Whose Teachers "Sometimes" or "Always or Almost Always" Assign Each Type of Homework					
	Percent of Students	Average Achievement							
	Yes	Yes	No	Doing Problem/ Question Sets	Reading the Textbook	Memorizing Formulas and Procedures	Gathering, Analyzing, and Reporting Data	Finding Applications of the Content Covered	Working on Projects
France	98 (0.4)	375 (4.0)	~ ~	97 (0.6)	56 (3.0)	92 (1.3)	77 (2.6)	44 (3.0)	14 (2.0)
Italy	97 (1.2)	377 (7.2)	443 (30.8)	97 (1.2)	90 (2.3)	67 (3.0)	62 (3.4)	74 (2.6)	38 (3.7)
Lebanon	97 (1.1)	409 (4.6)	446 (14.3)	96 (1.4)	86 (2.3)	89 (3.3)	87 (3.2)	89 (2.8)	60 (3.6)
Norway	95 (2.1)	504 (4.5)	512 (18.8)	94 (2.2)	87 (2.8)	50 (3.9)	37 (3.7)	28 (3.9)	25 (3.7)
Portugal	82 (3.9)	465 (4.6)	472 (12.4)	80 (3.8)	45 (4.9)	19 (3.2)	52 (4.7)	62 (4.3)	43 (5.4)
Russian Federation	100 (0.0)	508 (7.1)	~ ~	100 (0.0)	100 (0.0)	97 (1.4)	94 (1.7)	96 (1.2)	82 (2.8)
Slovenia	69 (2.2)	531 (3.3)	535 (6.4)	69 (2.2)	39 (4.6)	34 (3.5)	51 (4.5)	50 (3.5)	28 (2.9)
Sweden	71 (3.8)	454 (7.8)	458 (10.6)	70 (3.9)	62 (4.7)	18 (2.8)	35 (3.9)	27 (3.1)	38 (3.7)
United States	s 93 (4.4)	443 (11.0)	448 (13.3)	s 93 (4.4)	s 66 (5.8)	s 42 (5.6)	s 75 (5.4)	s 53 (5.7)	s 66 (6.0)
International Avg.	89 (0.9)	452 (2.1)	473 (6.4)	88 (0.9)	70 (1.3)	56 (1.1)	63 (1.3)	58 (1.2)	44 (1.3)

( ) 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.

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

Exhibit P9.3: Students Attended Extra Tutoring in Physics Not Provided by the School

Reported by Physics Students

Country	Students Did Not Attend Extra Tutoring		Students Attended Extra Tutoring		Reasons for Attending Extra Tutoring (Students Could Indicate More than One)					
					To Excel in Class		To Keep Up in Class		To Do Well on an Examination	
	Percent of Students	Average Achievement	Percent of Students	Average Achievement	Percent of Students	Average Achievement	Percent of Students	Average Achievement	Percent of Students	Average Achievement
France	80 (0.9)	384 (4.2)	20 (0.9)	333 (5.0)	5 (0.4)	365 (9.3)	13 (0.7)	325 (5.1)	16 (0.8)	330 (5.4)
Italy	83 (0.9)	377 (7.3)	17 (0.9)	362 (8.4)	2 (0.3)	~ ~	11 (0.8)	340 (9.6)	8 (0.6)	361 (11.2)
Lebanon	85 (1.3)	418 (4.9)	15 (1.3)	370 (8.0)	7 (0.8)	377 (14.0)	6 (0.8)	377 (12.0)	10 (1.1)	363 (9.5)
Norway	97 (0.4)	509 (4.5)	3 (0.4)	449 (17.3)	2 (0.3)	~ ~	2 (0.3)	~ ~	2 (0.3)	~ ~
Portugal	73 (1.6)	467 (4.9)	27 (1.6)	466 (6.1)	16 (1.3)	468 (6.8)	18 (1.4)	456 (6.5)	20 (1.4)	463 (6.9)
Russian Federation	48 (1.5)	481 (8.7)	52 (1.5)	532 (7.5)	21 (0.9)	540 (8.2)	14 (0.9)	518 (9.9)	48 (1.5)	533 (7.7)
Slovenia	92 (0.8)	536 (2.8)	8 (0.8)	485 (11.8)	3 (0.6)	462 (17.8)	3 (0.7)	417 (25.8)	7 (0.9)	458 (13.4)
Sweden	91 (0.7)	460 (5.9)	9 (0.7)	409 (12.0)	5 (0.4)	437 (15.8)	4 (0.5)	386 (17.1)	7 (0.6)	405 (12.5)
United States	89 (0.8)	443 (9.9)	11 (0.8)	388 (15.0)	7 (0.5)	381 (14.8)	7 (0.6)	371 (18.5)	9 (0.7)	379 (15.0)
International Avg.	82 (0.4)	453 (2.1)	18 (0.4)	422 (3.6)	8 (0.2)	433 (4.9)	9 (0.3)	399 (5.2)	14 (0.3)	412 (3.8)

( ) 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 P9.4: Examinations With Consequences for Students in Physics Programs (Tracks)

Reported by National Research Coordinators

Country	Examinations with Consequences for Individual Students	Grades at Which Examinations with Consequences for Individual Students are Given	Format of Examinations with Consequences for Individual Students	Comments
France	●	Grade 12	Written and oral examinations	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.
Italy	○	n/a	n/a	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.
Lebanon	●	Grade 12	Written examinations	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.
Norway	●	Grades 12 and 13	Written and oral examinations	A written examination is set and marked centrally (at national level) and an oral examination is prepared and marked locally. About 7% of the first year (Physics 1) students are sampled for an oral examination. About 60% of the second year (Physics 2) students are sampled for a national written examination, while about 20% are sampled for an oral examination.
Portugal	●	Grade 11	Written examinations	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.
Russian Federation	●	Grades 9 and 11	Written examinations	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.
Slovenia	●	Grades 9 and 13	Written and oral examinations	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.
Sweden	○	n/a	n/a	n/a
United States	○	n/a	n/a	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.

● Yes
○ No

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

Exhibit P9.5: Characteristics and Methods Used to Evaluate the Physics Curriculum

Reported by National Research Coordinators

Country	National Curriculum	Year Introduced	Being Revised	Methods Used to Evaluate the Implementation of the Physics Curriculum			
				Visits by Inspectors	Research Programs	School Self-Evaluation	National or Regional Assessments
France	●	2011	○	●	○	○	●
Italy	●	2010	○	○	○	○	○
Lebanon	●	2001	○	○	○	●	●
Norway	●	2006	○	○	○	○	●
Portugal	●	2005	●	○	○	●	●
Russian Federation	●	2004	●	○	●	●	●
Slovenia	●	2008	○	○	●	●	●
Sweden	●	2011	○	●	●	●	●
United States	○	Varies by school and by course	●	Varies by state	●	●	○

● 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

Reported by National Research Coordinators

Country	All Physics (22 topics)	Mechanics and Thermodynamics (9 topics)	Electricity and Magnetism (6 topics)	Wave Phenomena and Atomic/Nuclear Physics (7 topics)
France	15	5	3	7
Italy	17	4	6	7
Lebanon	22	9	6	7
Norway	21	9	6	6
Portugal	19	8	5	6
Russian Federation	20	9	6	5
Slovenia	22	9	6	7
Sweden	22	9	6	7
United States	21	9	6	6

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

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

Exhibit P9.7: Percentages of Students Taught* the TIMSS Advanced Topics in Physics

Mechanics and Thermodynamics Topics

Reported by Physics Teachers

Country	Mechanics and Thermodynamics Topics								
	Newton's Laws	Forces	Body Moving in a Circular Path	The Law of Gravitation	Kinetic and Potential Energy	Conservation of Momentum	The First Law of Thermodynamics	Heat Transfer	Ideal Gases
France	98 (0.6)	94 (1.2)	96 (1.1)	98 (0.6)	97 (1.0)	78 (2.5)	37 (3.0)	87 (2.1)	37 (2.6)
Italy	99 (0.6)	99 (0.6)	99 (0.6)	98 (1.0)	99 (0.6)	98 (0.7)	98 (1.4)	98 (1.4)	98 (1.4)
Lebanon	100 (0.0)	100 (0.0)	100 (0.0)	95 (0.9)	100 (0.0)	97 (0.5)	31 (3.5)	40 (4.1)	34 (4.1)
Norway	99 (0.6)	99 (0.6)	99 (0.6)	99 (0.8)	99 (0.6)	99 (0.6)	99 (0.8)	71 (3.8)	42 (3.5)
Portugal	100 (0.0)	100 (0.0)	100 (0.0)	96 (2.4)	100 (0.0)	92 (2.9)	99 (1.1)	100 (0.0)	37 (4.8)
Russian Federation	- -	- -	- -	- -	- -	- -	- -	- -	- -
Slovenia	100 (0.0)	100 (0.0)	100 (0.0)	100 (0.0)	100 (0.0)	100 (0.0)	100 (0.0)	100 (0.0)	100 (0.0)
Sweden	99 (0.9)	99 (0.9)	99 (0.9)	94 (2.3)	99 (1.1)	96 (1.5)	98 (1.2)	98 (1.2)	90 (2.6)
United States	s 100 (0.2)	s 100 (0.0)	s 97 (2.1)	s 95 (2.6)	s 99 (0.7)	s 99 (0.4)	s 52 (5.2)	s 52 (5.3)	s 56 (6.0)
International Avg.	99 (0.2)	99 (0.2)	99 (0.3)	97 (0.6)	99 (0.2)	95 (0.5)	77 (0.9)	81 (1.0)	62 (1.3)

* 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.

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

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

Exhibit P9.7: Percentages of Students Taught* the TIMSS Advanced Topics in Physics (Continued)

Electricity and Magnetism Topics

Reported by Physics Teachers

Country	Electricity and Magnetism Topics					
	Coulomb's Law	Charged Particles in an Electric Field	Electrical Circuits	Charged Particles in a Magnetic Field	Magnetism	Faraday's and Lenz's Laws
France	93 (1.5)	96 (0.9)	72 (2.8)	28 (3.1)	18 (2.3)	3 (1.0)
Italy	100 (0.0)	100 (0.0)	100 (0.0)	97 (1.2)	94 (1.4)	90 (1.9)
Lebanon	99 (0.1)	95 (1.0)	100 (0.0)	74 (4.2)	98 (0.3)	98 (0.3)
Norway	98 (1.0)	98 (1.1)	100 (0.0)	95 (1.7)	90 (3.0)	84 (3.6)
Portugal	92 (3.2)	94 (3.2)	80 (4.1)	61 (4.1)	84 (4.0)	69 (4.3)
Russian Federation	- -	- -	- -	- -	- -	- -
Slovenia	99 (1.4)	99 (1.4)	99 (1.4)	99 (0.1)	99 (0.1)	95 (2.4)
Sweden	99 (0.9)	98 (1.2)	98 (1.1)	91 (2.6)	88 (2.1)	84 (2.1)
United States	s 80 (3.9)	s 66 (4.7)	s 78 (3.7)	s 48 (4.9)	s 45 (5.2)	s 40 (5.2)
International Avg.	95 (0.7)	93 (0.8)	91 (0.8)	74 (1.1)	77 (1.0)	70 (1.1)

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

* 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

Exhibit P9.7: Percentages of Students Taught* the TIMSS Advanced Topics in Physics (Continued)

Wave Phenomena and Atomic/Nuclear Physics Topics

Reported by Physics Teachers

Country	Wave Phenomena and Atomic/Nuclear Physics Topics						
	Mechanical Waves	Electromagnetic Radiation	Thermal Radiation	Reflection, Refraction, Interference, and Diffraction	The Atom	Wave-Particle Duality	Mass-Energy Equivalence
France	98 (0.8)	98 (0.9)	92 (1.6)	97 (0.9)	98 (0.6)	89 (2.1)	89 (2.0)
Italy	91 (2.2)	72 (3.1)	62 (3.5)	85 (2.6)	35 (3.0)	19 (2.8)	20 (3.1)
Lebanon	99 (0.1)	99 (0.1)	54 (3.3)	r 100 (0.3)	98 (0.5)	97 (0.4)	96 (0.7)
Norway	100 (0.0)	99 (0.9)	99 (0.7)	89 (3.6)	99 (0.8)	67 (4.3)	93 (2.4)
Portugal	94 (2.5)	97 (1.5)	96 (2.1)	97 (1.5)	95 (2.0)	80 (3.3)	42 (5.2)
Russian Federation	- -	- -	- -	- -	- -	- -	- -
Slovenia	99 (1.4)	98 (1.9)	95 (0.8)	97 (1.9)	96 (1.8)	88 (1.8)	89 (1.8)
Sweden	92 (3.3)	77 (3.2)	60 (4.9)	83 (4.0)	72 (4.7)	64 (4.7)	86 (3.1)
United States	s 84 (3.0)	s 64 (4.9)	s 42 (5.4)	s 56 (5.0)	s 68 (4.9)	s 42 (5.7)	s 39 (6.7)
International Avg.	95 (0.7)	88 (0.9)	75 (1.1)	88 (1.0)	83 (1.0)	68 (1.2)	69 (1.3)

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

* 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 requency 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
7) **Mass-Energy Equivalence:** Mass-energy equivalence in nuclear reactions and particle transformations

Exhibit P9.8: Percentages of Students Taught the TIMSS Advanced Physics Topics Averaged Across All Topics and by Content Domain*

Reported by Physics Teachers

Country		All Physics (22 topics)		Mechanics and Thermodynamics (9 topics)		Electricity and Magnetism (6 topics)		Wave Phenomena and Atomic/Nuclear Physics (7 topics)
France		77 (0.7)		80 (0.8)		52 (1.1)		94 (0.9)
Italy		84 (0.8)		99 (0.7)		97 (0.6)		55 (1.8)
Lebanon	r	87 (0.7)		78 (1.0)		94 (0.8)	r	92 (0.5)
Norway		92 (0.6)		90 (0.8)		94 (1.4)		92 (0.9)
Portugal		87 (1.0)		92 (0.7)		80 (3.0)		86 (1.7)
Russian Federation		- -		- -		- -		- -
Slovenia		98 (0.5)		100 (0.0)		98 (0.8)		95 (1.3)
Sweden		89 (1.2)		97 (1.0)		93 (1.3)		76 (3.0)
United States	s	68 (2.9)	s	83 (1.7)	s	59 (4.0)	s	56 (4.3)
International Avg.		85 (0.5)		90 (0.3)		83 (0.7)		81 (0.8)

* 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

Exhibit P9.9: National Policies Regarding the Use of Technology in Physics Instruction and Assessment

Reported by National Research Coordinators

Country	Description of National Policies for Technology Use in Physics Instruction	Description of National Policies for Technology Use in Physics Assessment
France	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.	Graphing and programmable calculators are allowed during national examinations.
Italy	No policy. The national curriculum mentions experimental activities in general, but not specifically the use of technology.	Only scientific calculators are allowed during physics tests or examinations. Programmable calculators are not allowed.
Lebanon	No policy	No policy
Norway	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.	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.
Portugal	In some subjects, laboratory practices are taught/exemplified with graphing-scientific calculators and computers equipped with simulation software.	Some items in physics examinations require the use of a graphing-scientific calculator.
Russian Federation	No policy. Teachers may choose methods and technologies for instruction.	In the national examination (USE) in physics or regional physics tests, students may use only non-programmable calculators.
Slovenia	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.	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.
Sweden	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.	No policy
United States	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.	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.

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

Exhibit P9.10: Availability of Digital Devices in Physics Lessons

Reported by Physics Teachers

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

Country		Digital Devices Available for Students to Use in Physics Lessons		
		Percent of Students	Average Achievement	
		Yes	Yes	No
France		87 (2.3)	375 (4.2)	371 (9.4)
Italy		59 (3.8)	372 (8.8)	388 (10.0)
Lebanon		33 (3.3)	405 (7.0)	413 (6.0)
Norway		100 (0.0)	505 (4.6)	~ ~
Portugal		76 (4.5)	469 (5.4)	462 (8.0)
Russian Federation		90 (2.5)	509 (7.9)	499 (16.9)
Slovenia		80 (1.8)	529 (3.0)	539 (7.0)
Sweden		99 (0.9)	456 (6.2)	~ ~
United States	r	89 (3.8)	440 (11.1)	456 (18.1)
International Avg.		79 (1.0)	451 (2.3)	447 (4.4)

( ) 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.

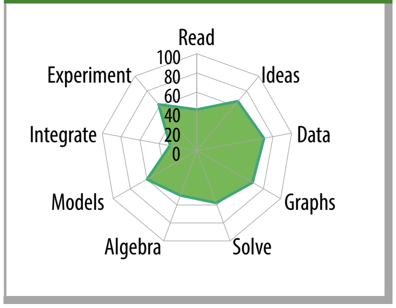
SOURCE: IEA's Trends in International Mathematics and Science Study – TIMSS Advanced 2015

Exhibit P9.11: Profiles of Uses of Digital Devices at Least Monthly in Physics Lessons

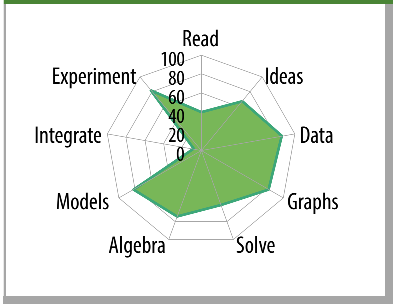
Reported by Physics Teachers

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.

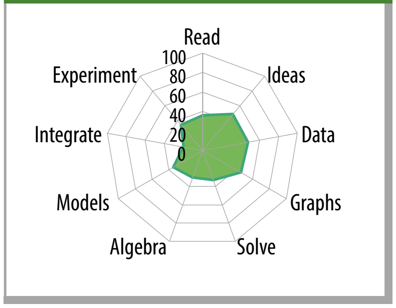
International Avg.



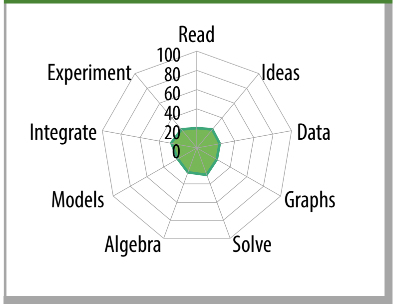
France



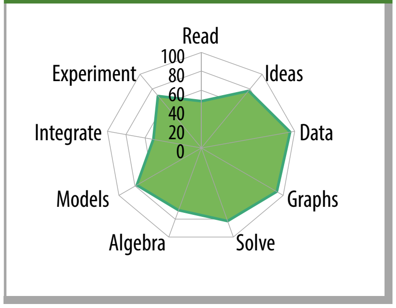
Italy



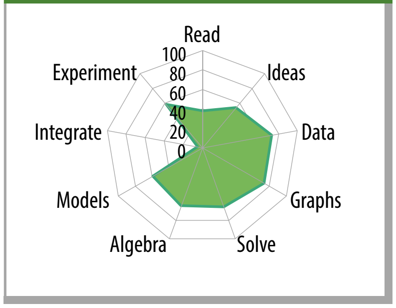
Lebanon



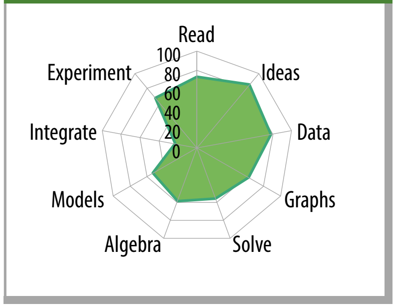
Norway



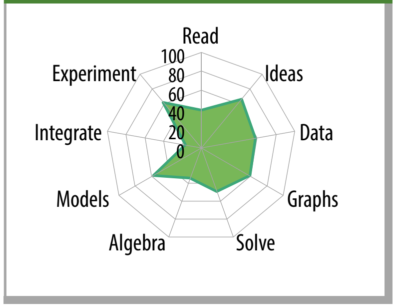
Portugal



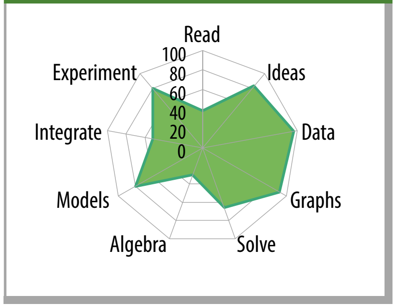
Russian Federation



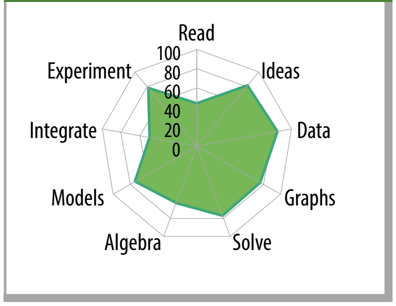
Slovenia



Sweden



United States r



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

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 P9.12: Percentages of Students Whose Teachers Have Them Use Digital Devices at Least Monthly in Physics Lessons

Reported by Physics Teachers

Country	Percent of Students Whose Teachers Have Them Use Digital Devices at Least Monthly								
	Read the Textbook or Course Materials	Look Up Ideas and Information	Process and Analyze Data	Draw Graphs of Functions	Solve Equations	Manipulate Algebraic Expressions	Conduct Modeling and Simulations	Perform Numerical Integration	Do Scientific Procedures or Experiments
France	40 (3.3)	67 (3.5)	86 (2.4)	82 (2.5)	61 (3.0)	74 (3.0)	82 (2.6)	8 (1.4)	82 (2.7)
Italy	36 (3.6)	49 (4.1)	48 (3.4)	46 (3.6)	33 (3.3)	30 (3.2)	35 (3.3)	20 (3.1)	34 (3.5)
Lebanon	20 (4.2)	25 (3.5)	24 (3.5)	24 (3.5)	30 (3.5)	27 (3.6)	23 (3.5)	27 (3.7)	25 (3.6)
Norway	49 (3.9)	78 (3.7)	95 (1.8)	92 (2.4)	82 (2.9)	70 (3.4)	78 (3.3)	51 (4.0)	71 (3.5)
Portugal	38 (4.8)	54 (5.5)	73 (4.9)	74 (4.6)	65 (4.2)	64 (4.1)	59 (5.2)	5 (1.8)	58 (5.3)
Russian Federation	73 (4.0)	85 (2.5)	78 (4.0)	62 (4.1)	56 (4.0)	59 (3.9)	53 (4.9)	23 (3.6)	67 (3.5)
Slovenia	39 (4.3)	66 (3.1)	58 (3.9)	59 (3.3)	49 (2.9)	34 (3.8)	58 (3.3)	17 (2.6)	62 (2.4)
Sweden	38 (4.1)	83 (3.5)	96 (1.2)	92 (3.0)	66 (4.3)	30 (3.8)	80 (3.0)	52 (4.6)	80 (2.8)
United States	r 44 (6.5)	r 82 (3.8)	r 85 (3.0)	r 76 (3.6)	r 77 (4.4)	r 63 (6.0)	r 74 (4.6)	r 50 (5.4)	r 78 (4.6)
International Avg.	42 (1.5)	66 (1.3)	71 (1.1)	67 (1.2)	58 (1.2)	50 (1.3)	60 (1.3)	28 (1.2)	62 (1.2)

( ) 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.

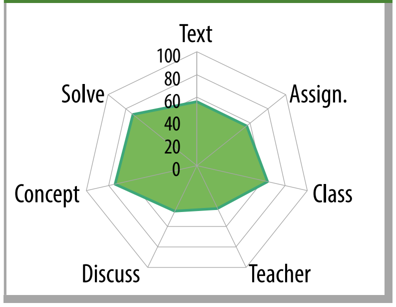
SOURCE: IEA's Trends in International Mathematics and Science Study – TIMSS Advanced 2015

Exhibit P9.13: Profiles of Student Use of the Internet for Physics Schoolwork

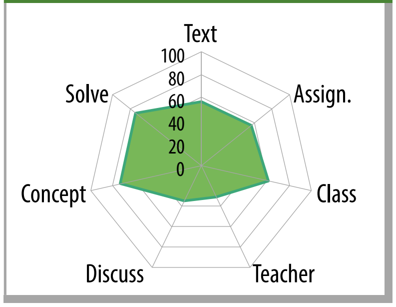
Reported by Physics Students

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.

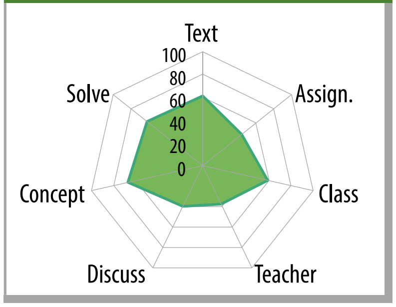
International Avg.



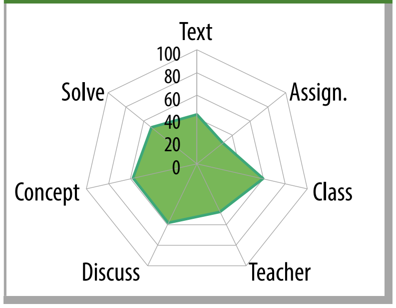
France



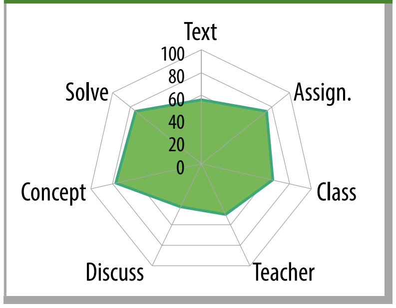
Italy



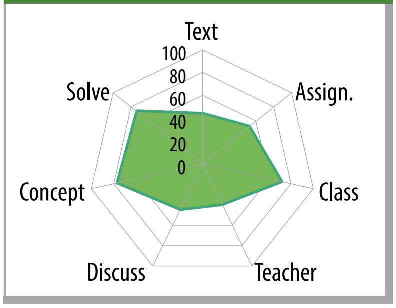
Lebanon



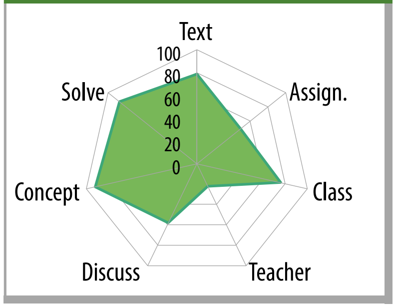
Norway



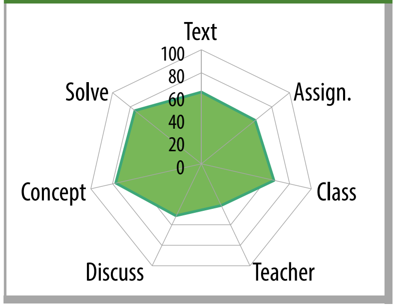
Portugal



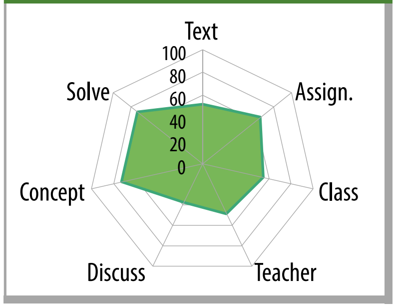
Russian Federation



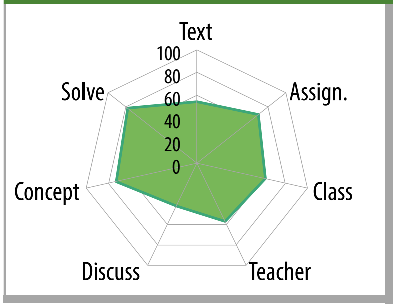
Slovenia



Sweden



United States



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

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

Exhibit P9.14: Percentages of Students Who Use the Internet for Physics Schoolwork

Reported by Physics Students

Country	Percent of Students Who Use the Internet To Do the Following Tasks						
	Access the Textbook or Other Course Materials	Access Assignments Posted Online by the Teacher	Collaborate with Classmates on Physics Assignments or Projects	Communicate with the Teacher	Discuss Physics Topics with Other Students	Find Information, Articles, or Tutorials to Aid in Understanding Physics Concepts	Find Information, Articles, or Tutorials to Aid in Solving Physics Problems
France	56 (1.1)	57 (1.5)	61 (1.1)	31 (2.0)	35 (1.0)	73 (1.0)	74 (0.9)
Italy	61 (1.2)	44 (2.2)	59 (1.5)	38 (1.8)	40 (1.2)	67 (1.1)	62 (1.2)
Lebanon	43 (1.6)	29 (1.8)	60 (1.8)	47 (2.0)	58 (2.1)	58 (1.5)	51 (1.5)
Norway	56 (2.2)	74 (1.7)	65 (1.5)	50 (1.7)	42 (1.6)	77 (1.1)	74 (1.4)
Portugal	44 (1.6)	53 (2.9)	72 (2.3)	40 (2.7)	45 (1.9)	77 (1.5)	74 (1.4)
Russian Federation	79 (0.7)	49 (2.3)	76 (1.1)	22 (2.4)	58 (0.9)	92 (0.6)	87 (0.8)
Slovenia	63 (1.2)	61 (1.9)	66 (1.4)	41 (1.8)	51 (1.8)	77 (1.2)	75 (1.3)
Sweden	52 (1.8)	65 (2.1)	55 (1.6)	49 (2.0)	38 (1.0)	73 (1.2)	73 (1.1)
United States	54 (2.3)	69 (2.9)	62 (2.4)	57 (1.7)	42 (2.4)	73 (1.1)	78 (1.2)
International Avg.	56 (0.5)	56 (0.7)	64 (0.6)	42 (0.7)	45 (0.5)	74 (0.4)	72 (0.4)

( ) 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 P9.15: Resources for Conducting Physics Experiments

Reported by Physics Teachers

Country	Schools Have a Physics Laboratory				Teachers Have Assistance Available When Students Are Conducting Physics Experiments			
	Yes		No		Yes		No	
	Percent of Students	Average Achievement	Percent of Students	Average Achievement	Percent of Students	Average Achievement	Percent of Students	Average Achievement
France	99 (0.5)	375 (3.9)	1 (0.5)	~ ~	38 (3.1)	386 (5.8)	62 (3.1)	368 (4.6)
Portugal	95 (1.9)	464 (4.9)	5 (1.9)	452 (19.3)	6 (2.0)	448 (11.2)	94 (2.0)	466 (4.8)
Lebanon	94 (1.4)	412 (4.7)	6 (1.4)	396 (21.8)	51 (3.4)	415 (5.8)	49 (3.4)	404 (7.0)
Norway	92 (2.0)	506 (4.7)	8 (2.0)	495 (18.2)	6 (1.8)	505 (11.7)	94 (1.8)	505 (4.7)
Italy	90 (2.5)	388 (7.4)	10 (2.5)	300 (20.5)	r 61 (4.1)	385 (8.7)	39 (4.1)	368 (13.9)
Sweden	88 (2.3)	461 (6.3)	12 (2.3)	411 (21.1)	1 (0.8)	~ ~	99 (0.8)	455 (6.3)
Russian Federation	87 (2.6)	509 (7.4)	13 (2.6)	509 (13.6)	56 (5.0)	503 (8.6)	44 (5.0)	511 (12.7)
Slovenia	62 (4.0)	538 (3.8)	38 (4.0)	519 (5.7)	88 (1.4)	527 (2.5)	12 (1.4)	562 (12.2)
United States	s 59 (6.0)	463 (10.7)	41 (6.0)	405 (16.9)	s 6 (1.9)	443 (18.2)	94 (1.9)	439 (11.2)
International Avg.	85 (1.0)	457 (2.1)	15 (1.0)	436 (6.3)	35 (1.0)	452 (3.6)	65 (1.0)	453 (3.1)

( ) 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. 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

TIMSS
Advanced
2015

CHAPTER P10: STUDENT ENGAGEMENT AND ATTITUDES

TIMSS ADVANCED 2015 INTERNATIONAL RESULTS IN ADVANCED MATHEMATICS AND PHYSICS

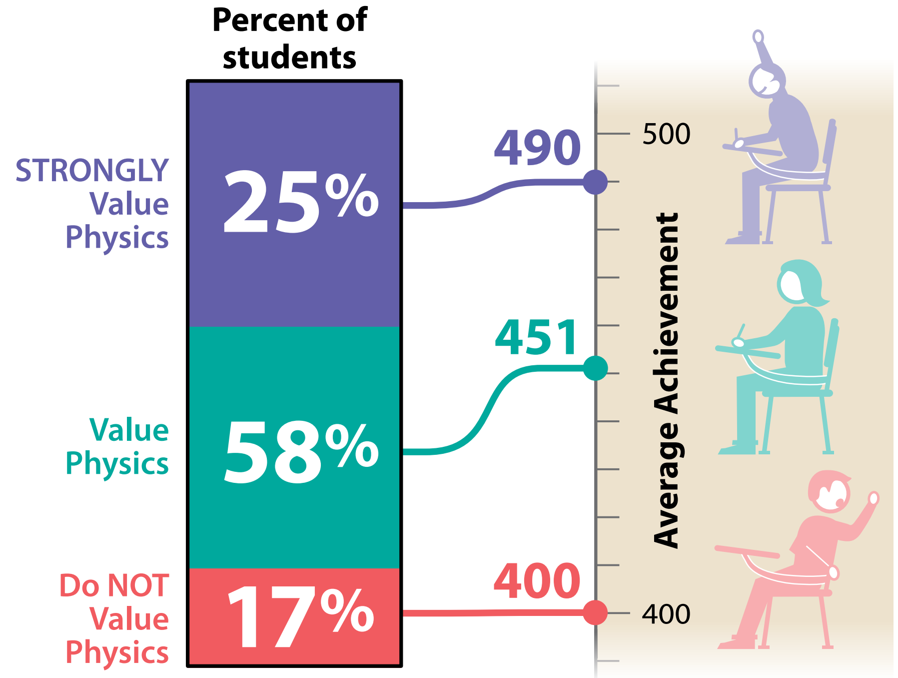
IEA
TIMSS & PIRLS
International Study Center
Lynch School of Education, Boston College

PHYSICS TIMSS Advanced 2015

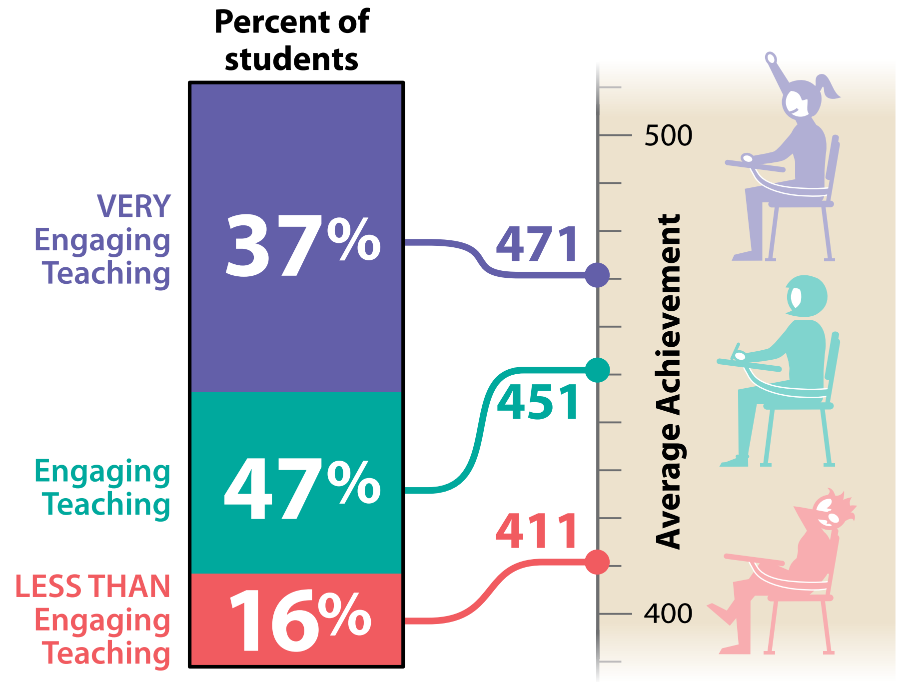
Students' Attitudes Toward Physics

Most students in physics courses had positive attitudes toward physics and more positive attitudes were associated with higher achievement.

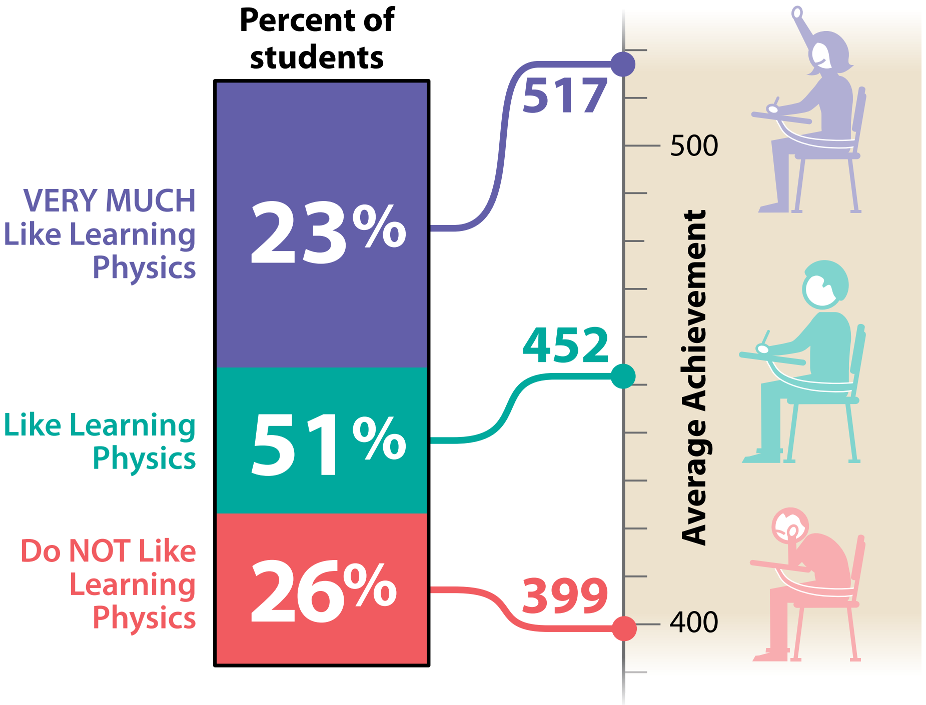
Most students (83%) STRONGLY value or value physics.



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.



SOURCE: IEA's Trends in International Mathematics and Science Study – TIMSS Advanced 2015.
http://timss2015.org/advanced/download-center/

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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.

Country	Very Engaging Teaching		Engaging Teaching		Less than Engaging Teaching		Average Scale Score
	Percent of Students	Average Achievement	Percent of Students	Average Achievement	Percent of Students	Average Achievement	
Lebanon	56 (2.9)	419 (5.2)	33 (1.7)	409 (6.9)	10 (2.1)	378 (16.2)	10.8 (0.17)
Russian Federation	55 (1.8)	526 (8.1)	37 (1.1)	493 (7.4)	8 (1.3)	452 (13.5)	10.8 (0.09)
United States	45 (2.6)	452 (10.1)	38 (1.5)	442 (9.9)	17 (1.7)	390 (14.1)	10.3 (0.13)
Portugal	44 (3.2)	466 (6.4)	41 (2.0)	470 (5.4)	15 (2.1)	460 (9.2)	10.2 (0.14)
Norway	43 (1.9)	529 (4.5)	46 (1.7)	500 (5.8)	11 (0.9)	451 (7.6)	10.3 (0.07)
Sweden	26 (1.4)	491 (8.1)	54 (1.1)	456 (6.1)	21 (1.5)	406 (9.5)	9.5 (0.07)
France	23 (1.5)	402 (7.1)	59 (1.4)	373 (3.9)	18 (1.5)	339 (4.6)	9.5 (0.07)
Slovenia	23 (1.7)	570 (7.1)	61 (2.1)	534 (4.2)	16 (2.0)	468 (7.1)	9.5 (0.09)
Italy	20 (1.4)	387 (14.0)	50 (1.4)	381 (7.0)	31 (1.7)	356 (8.7)	9.1 (0.08)
International Avg.	37 (0.7)	471 (2.8)	47 (0.5)	451 (2.2)	16 (0.6)	411 (3.6)	

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

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 physics lessons?

	Agree a lot	Agree a little	Disagree a little	Disagree a lot
1) The teacher clearly communicates the purpose of each physics 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 physics	○	○	○	○
10) My teacher provides the opportunity for me to show what I have learned	○	○	○	○
11) My teacher encourages me to keep working on physics 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 physics material	○	○	○	○

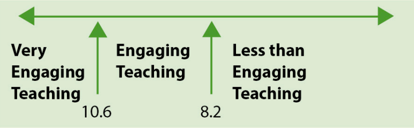

Exhibit P10.1: Students' Views on Engaging Teaching in Physics Lessons (Continued)

Students' Views on Engaging Teaching in Physics Lessons by Gender

Reported by Physics Students

Country	Very Engaging Teaching		Engaging Teaching		Less than Engaging Teaching	
	Percent of Students	Average Achievement	Percent of Students	Average Achievement	Percent of Students	Average Achievement
Lebanon						
Females	64 (3.7)	421 (5.7)	28 (2.5)	416 (8.8)	8 (2.6)	405 (23.8)
Males	52 (3.5)	417 (7.1)	36 (2.5)	406 (10.0)	12 (2.1)	367 (19.1)
Russian Federation						
Females	54 (2.2)	519 (9.4)	37 (1.6)	481 (9.3)	9 (1.4)	448 (15.4)
Males	55 (2.0)	531 (8.0)	37 (1.4)	502 (8.2)	7 (1.2)	456 (18.1)
United States						
Females	40 (3.3)	425 (13.9)	41 (1.9)	414 (13.0)	20 (2.3)	370 (20.7)
Males	48 (2.8)	467 (10.4)	36 (1.9)	462 (9.4)	16 (2.1)	407 (13.9)
Portugal						
Females	51 (4.4)	449 (7.6)	35 (3.5)	465 (11.6)	14 (2.7)	460 (15.6)
Males	42 (3.2)	473 (6.8)	43 (2.1)	471 (5.8)	16 (2.2)	459 (10.2)
Norway						
Females	35 (2.8)	509 (7.3)	51 (2.5)	486 (8.5)	14 (1.7)	452 (11.0)
Males	47 (2.1)	536 (4.8)	44 (1.9)	507 (5.9)	9 (0.9)	451 (9.7)
Sweden						
Females	23 (1.6)	483 (10.7)	52 (1.8)	455 (7.2)	26 (2.4)	404 (8.8)
Males	28 (1.7)	496 (8.9)	55 (1.4)	457 (6.5)	17 (1.3)	408 (13.6)
France						
Females	21 (1.5)	382 (8.2)	60 (1.6)	354 (4.3)	19 (1.7)	327 (6.2)
Males	24 (1.9)	418 (8.5)	58 (1.7)	391 (4.7)	18 (1.6)	351 (5.7)
Slovenia						
Females	19 (2.2)	564 (11.8)	62 (3.1)	509 (7.9)	19 (3.0)	461 (15.8)
Males	24 (2.3)	572 (9.4)	61 (2.4)	545 (4.4)	15 (2.2)	473 (9.2)
Italy						
Females	19 (1.7)	360 (16.1)	50 (1.7)	361 (8.0)	31 (1.9)	349 (8.5)
Males	21 (1.6)	407 (15.9)	49 (1.7)	398 (8.8)	30 (2.0)	363 (10.8)
International Avg.						
Females	36 (0.9)	457 (3.5)	46 (0.8)	438 (3.0)	18 (0.8)	408 (5.0)
Males	38 (0.8)	480 (3.1)	47 (0.6)	460 (2.4)	16 (0.6)	415 (4.3)

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

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**.

Country	Very Much Like Learning Physics		Like Learning Physics		Do Not Like Learning Physics		Average Scale Score
	Percent of Students	Average Achievement	Percent of Students	Average Achievement	Percent of Students	Average Achievement	
Norway	36 (1.2)	560 (3.7)	49 (1.1)	494 (5.4)	15 (1.0)	422 (7.3)	10.7 (0.05)
Lebanon	35 (2.4)	439 (8.7)	52 (1.7)	400 (5.7)	13 (2.1)	392 (10.6)	10.7 (0.12)
Portugal	32 (1.7)	512 (6.0)	51 (1.3)	455 (5.6)	17 (1.1)	416 (5.9)	10.6 (0.08)
Russian Federation	28 (1.6)	568 (9.2)	50 (1.2)	501 (6.2)	22 (1.2)	447 (8.1)	10.3 (0.09)
United States	21 (1.6)	513 (8.7)	48 (1.0)	442 (8.0)	31 (1.9)	380 (11.9)	9.8 (0.10)
Sweden	15 (0.6)	540 (6.8)	46 (1.4)	472 (6.1)	39 (1.4)	403 (6.4)	9.3 (0.05)
Italy	15 (0.9)	467 (10.0)	45 (0.9)	384 (7.4)	40 (1.3)	331 (7.0)	9.4 (0.06)
Slovenia	15 (1.0)	599 (8.5)	63 (1.7)	538 (3.3)	23 (1.6)	472 (6.0)	9.8 (0.05)
France	11 (0.6)	454 (5.4)	54 (0.8)	386 (4.1)	35 (1.0)	329 (4.5)	9.4 (0.04)
International Avg.	23 (0.5)	517 (2.6)	51 (0.4)	452 (2.0)	26 (0.5)	399 (2.6)	

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

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?

	Agree a lot	Agree a little	Disagree a little	Disagree a lot
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

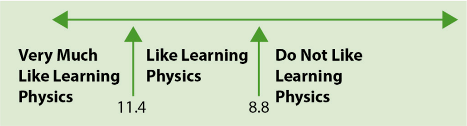

Exhibit P10.2: Students Like Learning Physics (Continued)

Students Like Learning Physics by Gender

Reported by Physics Students

Country	Very Much Like Learning Physics		Like Learning Physics		Do Not Like Learning Physics	
	Percent of Students	Average Achievement	Percent of Students	Average Achievement	Percent of Students	Average Achievement
Norway						
Females	27 (1.7)	541 (6.3)	52 (1.8)	487 (8.1)	20 (1.7)	425 (8.7)
Males	40 (1.5)	566 (4.4)	48 (1.4)	497 (5.5)	12 (1.0)	421 (8.5)
Lebanon						
Females	35 (3.2)	436 (11.7)	51 (2.5)	412 (6.9)	13 (2.9)	399 (12.7)
Males	35 (2.8)	440 (9.8)	53 (2.2)	393 (7.4)	13 (1.8)	388 (15.6)
Portugal						
Females	28 (3.4)	507 (10.7)	51 (3.3)	449 (7.5)	22 (2.9)	408 (11.9)
Males	34 (1.8)	514 (6.6)	51 (1.3)	456 (5.8)	15 (1.2)	419 (6.5)
Russian Federation						
Females	20 (1.6)	567 (14.5)	48 (1.5)	504 (6.7)	32 (1.6)	446 (10.4)
Males	34 (2.0)	568 (8.2)	51 (1.6)	499 (7.4)	15 (1.0)	448 (8.6)
United States						
Females	13 (1.9)	487 (14.5)	42 (2.1)	427 (11.5)	44 (3.1)	371 (13.1)
Males	27 (1.8)	521 (10.1)	51 (1.7)	450 (7.9)	22 (2.1)	391 (12.6)
Sweden						
Females	9 (0.8)	536 (13.2)	41 (2.1)	473 (6.7)	50 (2.1)	412 (6.6)
Males	19 (0.8)	541 (7.5)	49 (1.3)	471 (6.8)	32 (1.3)	393 (8.1)
Italy						
Females	11 (0.9)	430 (13.2)	42 (1.4)	366 (9.3)	47 (1.6)	332 (7.7)
Males	18 (1.5)	486 (11.1)	48 (1.4)	398 (8.4)	34 (1.5)	329 (9.6)
Slovenia						
Females	13 (1.9)	595 (15.3)	53 (2.8)	516 (8.8)	34 (2.5)	470 (9.0)
Males	16 (1.4)	601 (9.2)	67 (2.1)	545 (4.2)	18 (1.9)	474 (9.0)
France						
Females	7 (0.6)	428 (9.5)	52 (1.2)	372 (4.7)	41 (1.4)	322 (5.0)
Males	15 (1.0)	464 (5.9)	57 (1.1)	397 (5.0)	29 (1.2)	338 (5.7)
International Avg.						
Females	18 (0.7)	503 (4.1)	48 (0.7)	445 (2.7)	34 (0.8)	398 (3.3)
Males	26 (0.6)	522 (2.8)	53 (0.5)	456 (2.2)	21 (0.5)	400 (3.3)

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

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 P10.3: Students Value Physics

Reported by Physics Students

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**.

Country	Strongly Value Physics		Value Physics		Do Not Value Physics		Average Scale Score
	Percent of Students	Average Achievement	Percent of Students	Average Achievement	Percent of Students	Average Achievement	
Portugal	44 (1.6)	489 (4.9)	50 (1.6)	456 (5.5)	7 (0.8)	400 (8.0)	11.0 (0.08)
Lebanon	43 (2.6)	431 (6.5)	50 (1.9)	399 (5.3)	7 (1.1)	394 (10.1)	11.0 (0.13)
United States	35 (2.1)	483 (8.7)	55 (1.9)	422 (11.0)	11 (0.8)	368 (14.1)	10.5 (0.09)
Russian Federation	28 (1.4)	549 (6.6)	48 (1.1)	514 (7.2)	24 (1.5)	446 (8.7)	9.9 (0.09)
Norway	27 (1.2)	538 (6.4)	62 (1.1)	507 (4.5)	11 (0.7)	439 (8.3)	10.2 (0.05)
Sweden	21 (0.8)	492 (7.0)	66 (0.8)	456 (5.9)	13 (0.7)	386 (9.3)	9.9 (0.03)
Italy	12 (0.8)	435 (10.2)	56 (1.0)	386 (7.0)	32 (1.1)	333 (7.1)	9.1 (0.05)
France	10 (0.5)	431 (6.2)	65 (0.9)	382 (3.9)	25 (0.9)	331 (4.7)	9.2 (0.03)
Slovenia	4 (0.6)	563 (16.3)	75 (1.3)	538 (2.8)	21 (1.0)	503 (7.1)	9.0 (0.03)
International Avg.	25 (0.5)	490 (2.9)	58 (0.4)	451 (2.1)	17 (0.3)	400 (3.0)	

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

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?

	Agree a lot	Agree a little	Disagree a little	Disagree a lot
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

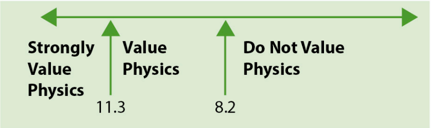

Exhibit P10.3: Students Value Physics (Continued)

Students Value Physics by Gender

Reported by Physics Students

Country	Strongly Value Physics		Value Physics		Do Not Value Physics	
	Percent of Students	Average Achievement	Percent of Students	Average Achievement	Percent of Students	Average Achievement
Portugal						
Females	37 (3.6)	485 (8.9)	54 (4.2)	446 (8.1)	9 (2.3)	399 (14.3)
Males	46 (2.0)	490 (6.1)	49 (1.7)	460 (5.8)	6 (0.8)	401 (9.9)
Lebanon						
Females	45 (3.1)	431 (8.4)	49 (2.8)	412 (7.5)	6 (1.3)	397 (25.4)
Males	42 (3.1)	431 (7.9)	50 (2.5)	392 (7.7)	7 (1.3)	393 (16.5)
United States						
Females	27 (2.5)	450 (11.4)	61 (2.5)	406 (15.0)	12 (1.5)	334 (16.8)
Males	40 (2.3)	497 (8.6)	51 (2.2)	435 (10.2)	10 (1.0)	395 (17.1)
Russian Federation						
Females	20 (1.4)	548 (8.9)	46 (1.5)	517 (8.1)	34 (2.0)	443 (10.0)
Males	34 (1.7)	549 (7.0)	50 (1.3)	512 (7.7)	16 (1.3)	449 (11.1)
Norway						
Females	21 (1.6)	522 (9.4)	66 (1.8)	492 (6.4)	14 (1.3)	425 (10.9)
Males	29 (1.5)	543 (7.0)	60 (1.3)	513 (4.8)	10 (0.8)	447 (9.7)
Sweden						
Females	21 (1.6)	477 (9.2)	64 (1.4)	451 (6.8)	15 (1.0)	392 (9.3)
Males	21 (1.0)	502 (7.8)	67 (1.2)	460 (6.3)	12 (0.7)	381 (13.5)
Italy						
Females	11 (0.8)	397 (14.8)	56 (1.4)	368 (7.7)	34 (1.4)	328 (8.4)
Males	13 (1.2)	460 (12.5)	57 (1.1)	402 (8.3)	30 (1.4)	337 (9.4)
France						
Females	8 (0.6)	395 (8.2)	64 (1.3)	365 (4.5)	29 (1.2)	321 (5.2)
Males	12 (0.8)	452 (7.0)	66 (1.2)	396 (4.6)	22 (1.2)	342 (5.7)
Slovenia						
Females	3 (0.9)	545 (44.4)	71 (2.6)	517 (7.5)	26 (2.4)	488 (10.2)
Males	5 (0.8)	568 (16.1)	76 (1.5)	546 (3.9)	19 (1.4)	512 (9.6)
International Avg.						
Females	21 (0.7)	472 (5.9)	59 (0.8)	442 (2.8)	20 (0.6)	392 (4.5)
Males	27 (0.6)	499 (3.1)	58 (0.5)	457 (2.3)	15 (0.4)	406 (4.0)

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

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.

TIMSS
Advanced
2015

CHAPTER P11: DESCRIPTION OF PHYSICS PROGRAMS AND CURRICULUM

TIMSS ADVANCED 2015 INTERNATIONAL RESULTS IN ADVANCED MATHEMATICS AND PHYSICS

IEA
TIMSS & PIRLS
International Study Center
Lynch School of Education, Boston College

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.

Scientific Processes	Content Areas	Topics
To Observe: Waves and Matter	Waves and particles; Properties and characteristics of a wave; and Spectral analysis	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 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 Spectral analysis, including visible and UV spectroscopy, infrared spectroscopy, nuclear magnetic resonance spectroscopy

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.

Grade	Topics
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

Grade	Topics
Grades 11 and 12 (Continued)	Circuits and Ohm's law, resistors in series and in parallel, resistivity and conductivity, voltmeters and ammeters, electrolytic conductivity, R-C circuits Magnets and magnetic force: magnetic force on a charge, magnetic force on a current carrying wire Magnetic field created by a current carrying wire, magnetic force between two currents going in the same and in opposite direction Electric motors
Grade 13	Electromagnetic induction Applications of induction R-L circuits Maxwell's Equations Electromagnetic radiation and electromagnetic spectrum Relativity, mass-energy equivalence The photoelectric effect and the nature of light Planck's theory of blackbody radiation Atomic spectra and quantum theory Structure of the nucleus, radioactivity Recommended insights: astrophysics and cosmology Elementary particles Nano- and micro-technologies, new materials Solid state physics: semiconductors Renewable energy

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.

General Objectives
Develop learners' intellectual and practical scientific skills
Deepen learners' awareness of the ability of humans to understand, invent, and create
Understand the nature of science and technology, their development across history, and their impact on human thought
Insure that learners have acquired the facts, concepts, and principles necessary to understand natural phenomena
Motivate students to apply basic scientific principles in all sciences
Explain the scientific concepts and principles behind commonly used machines and devices
Acquire knowledge about health, environment, and safety practices and behave accordingly
Realize that some natural resources can be depleted and make the learner aware of the role of science in sustaining these resources
Encourage learners to use scientific knowledge and skills in novel situations, especially in everyday life
Emphasize the role of scientists in the advancement of human kind
Encourage learners to be open to the ideas of scientists from different cultures and to their contribution to the advancement of science
Encourage learners to abide by scientific values such as honesty and objectivity
Develop learners' scientific curiosity and orientation toward scientific research
Encourage learners to work independently and cooperatively when solving scientific problems
Make learners aware of career possibilities in different science-related areas

Reference document: Educational Center for Research and Development, *General objectives of the curricula and their details*. 1997, Beirut, Lebanon.

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.

Content Area	Topics
Classical Physics (Physics 1 and 2)	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
Modern Physics (Physics 1 and 2)	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”

Content Area	Topics
Explaining Nature Through Mathematics (Physics 1 and 2)	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
The Young Researcher (Physics 1 and 2)	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
Physics and Technology (Physics 1 and 2)	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

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.

Content Area	Units	Topics
Mechanics	Particle Mechanics	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 Motion under the action of a constant force: importance of motion initial conditions, motion equations, projectile motion 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
	Oscillations	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
	Linear Momentum	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
	Fluids	Hydrostatic: density, pressure, variation of pressure with depth, Pascal's Law, buoyant force, Archimedes' Principle, floating objects equilibrium Fluid dynamics: steady flow, equation of continuity, Bernoulli's equation, viscosity
	Gravitation	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
Electricity and Magnetism	Electricity and Magnetism	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 Electrical potential: electric potential energy, electric potential, equipotential surfaces, capacitors

Content Area	Units	Topics
Electricity and Magnetism (Continued)	Electric Circuits	Electric current: microscopic model of current, current and potential difference, resistance and resistivity, Ohm's law 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 Electric circuits equations: resistors in series and parallel, applying Ohm's law to circuits with batteries, motors and resistors, R-C circuits
	Magnetic Fields	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
Modern Physics	Relativity	Relative motion: inertial frames and accelerated frames, the principle of Galilean relativity, Galilean transformation equations 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
	Introduction to Quantum Physics	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
	Nuclear Physics and Radioactivity	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)

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.

Content Area	Topics
Physics as a Science and the Nature of Science	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
Mechanics	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
Molecular Physics	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
Electrodynamics	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

Content Area	Topics
Quantum Physics	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
Structure of the Universe	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

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.

Compulsory Content Areas	Topics
Measurement, Physical Quantities and Units	Use and measurement of physical quantities, conversion of units, calculating error (absolute and relative)
Motion	Displacement, average and instantaneous velocity, acceleration, circular motion (frequency, period, angular velocity and radial acceleration)
Force and Moments of Force	Composing and decomposing forces (graphically), equilibrium of forces, Newton's Third Law, frictional force, resistance force, moments of force, pressure and pressure in fluids
Newton's Laws of Motion and Law of Gravitation	Applying Newton's law in motion and circular motion, Newton's law of gravitation, Kepler's Laws
Work and Energy	Work, kinetic energy, potential energy, mechanical energy and law of conservation of mechanical energy
Structure of Matter and Temperature	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
Internal Energy and Heat	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

Compulsory Content Areas	Topics
The Electric Charge and Electric Fields	Conductors and insulators, electroscope, Coulomb’s law, capacitors, electric fields
Electric Current	Electric current, voltage, Ohm’s law, resistance and resistivity, series and parallel electric circuits, equations for resistors in series and parallel circuits, electric power, Kirchhoff's circuit laws
Magnetic Field	Permanent magnet, magnetic fields around electrical conductors, magnetic field lines, magnetic force acting on a charge moving in a magnetic field, magnetic torque, density of the magnetic field, mass spectrometer, Hall effect sensor (working principle)
Induction	Induction in a moving conductor in a magnetic field, changes of the magnetic field in a coil and in a transformer, Faraday’s and Lenz’ laws of induction, L-C circuit
Oscillations	Simple harmonic motion (period, frequency, displacement from equilibrium and amplitude, velocity, acceleration and energy), damped oscillation and resonance
Waves	Transverse and longitudinal waves, sinusoidal waves (amplitude, wavelength), absorption, reflection, refraction, interference, polarization and Doppler Effect
Light	Electromagnetic spectrum, specular reflection, Snell's law, optical physics and geometric optics
Atoms	Structure of atoms, photoelectric effect, energy levels of atoms
Atomic Nuclei	Structure of atomic nuclei, mass and atomic number, radioactive isotopes and their half-lives, radioactive decay, fission and fusion, nuclear reactions (conservation law, energy)
Astronomy	Solar system, nuclear processes on the Sun, stars, the galaxy

Elective Content Areas	Topics
Linear Momentum	Linear momentum (theorem), conversion of linear momentum, elastic and inelastic collisions
Angular Momentum	Angular momentum (theorem, conversion)
Fluids	Volumetric and mass flow rate, Bernoulli’s equation, surface tension
Semiconductors	Difference between metals, insulators and semiconductors; semiconductor diode, photodiode and solar cell (characteristics)
Theory of Relativity	Speed of light, speed of light in vacuum, time dilation and length contraction, relativistic particles (linear momentum and kinetic energy)

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.

TIMSS
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2015

PHYSICS APPENDICES

TIMSS ADVANCED 2015 INTERNATIONAL RESULTS IN ADVANCED MATHEMATICS AND PHYSICS

IEA
TIMSS & PIRLS
International Study Center
Lynch School of Education, Boston College

Exhibit PA.1: Countries Participating in the TIMSS Advanced 2015 Physics Assessment and in Earlier TIMSS Advanced Assessments

Country	2015	2008	1995
France	●		●
Italy	●	●	●
Lebanon	●	●	
Norway	●	●	●
Portugal	●		
Russian Federation	●	●	●
Slovenia	●	●	●
Sweden	●	●	●
United States	●		●

● Indicates participation in that testing cycle.

SOURCE: IEA's 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

Physics Items	Multiple-Choice Items	Constructed Response Items	Total Items	Percentage of Score Points
Content Domain				
Mechanics and Thermodynamics	24 (24)	16 (24)	40 (48)	41%
Electricity and Magnetism	18 (18)	10 (13)	28 (31)	26%
Wave Phenomena and Atomic/Nuclear Physics	19 (19)	16 (19)	35 (38)	33%
Total	61 (61)	42 (56)	103 (117)	100%
Percentage of Score Points	52%	48%		
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.

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

Appendix PC.1: Coverage of the TIMSS Advanced 2015 Target Population for Physics

Country	International Target Population Coverage	Exclusions from National Target Population		
		School-Level Exclusions	Within-Sample Exclusions	Overall Exclusions
France	100%	4.6%	0.1%	4.7%
Italy	100%	0.4%	0.4%	0.8%
Lebanon	100%	1.3%	0.0%	1.3%
Norway	100%	3.3%	0.1%	3.4%
Portugal	100%	0.4%	0.1%	0.6%
Russian Federation	100%	0.2%	0.2%	0.4%
Slovenia	100%	1.1%	0.9%	2.0%
Sweden	100%	1.9%	0.0%	2.0%
United States	100%	0.0%	0.1%	0.1%

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

Country	Years of Formal Schooling*	Age Cohort Corresponding to the Final Year of Secondary School	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)	Size of the Age Cohort Corresponding to the TIMSS Advanced Population Based on National Census Figures**	TIMSS Advanced Physics Coverage Index – the Percentage of the Entire Corresponding Age Cohort Covered by the TIMSS Advanced Target Population
France	12	18	172,178	801,889	21.5%
Italy	13	19	104,650	576,506	18.2%
Lebanon	12	18	4,464	113,204	3.9%
Norway	13	19	4,163	63,894	6.5%
Portugal	12	18	5,661	109,984	5.1%
Russian Federation	11	18	66,746	1,365,790	4.9%
Slovenia	13	19	1,491	19,598	7.6%
Sweden	12	19	15,423	108,138	14.3%
United States	12	18	199,944	4,168,000	4.8%

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

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

** France: Estimate derived by dividing the population of 15–19-year-olds by 5 for the single year estimate. Data retrieved from INSEE (National Institute of Statistics and Economic Studies), Estimations de Population (résultats provisoires à fin 2015); http://www.insee.fr/fr/themes/detail.asp?reg_id=99&ref_id=estim-pop.

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.

Lebanon: Value is the total population of 18-year olds in Lebanon in 2015. Data retrieved from http://databank.worldbank.org/data/reports.aspx?source=health-nutrition-and-population-statistics:-population-estimates-and-projections&Type=TABLE&preview=on.

Norway: Estimate derived by dividing the population of 15–19-year-olds by 5 for the single year estimate. Data retrieved from https://stats.oecd.org/Index.aspx?DataSetCode=POP_PROJ.

Portugal: Estimate derived by dividing the 2014 population of 15–19-year-olds by 5 for the single year estimate. Data retrieved from INE (Instituto Nacional de Estatística) Annual Estimates of Resident Population; http://www.pordata.pt/en/Portugal/Resident+population+total+and+by+age+group-10.

Russian Federation: Estimate derived by dividing the population of 15–19-year-olds by 5 for the single year estimate. Data retrieved from The Demographic Yearbook of Russia, 2015; http://www.gks.ru/wps/wcm/connect/rosstat_main/rosstat/ru/statistics/publications/catalog/doc_1137674209312.

Slovenia: Value is the total population of 18-year olds in Slovenia as of July 1st 2015. Data retrieved from the Statistical Office of the Republic of Slovenia; http://pxweb.stat.si.

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/BefolkningR1860/table/tableViewLayout1/?rxid=06695d79-5fa1-41d1-81c1-3ae51dcd09b7.

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/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:

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

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

Country	Number of Schools in Original Sample	Number of Eligible Schools in Original Sample	Number of Schools in Original Sample that Participated	Number of Replacement Schools that Participated	Total Number of Schools that Participated
France	146	145	144	0	144
Italy	120	120	106	8	114
Lebanon	356	355	250	0	250
Norway	130	130	127	0	127
Portugal	251	173	142	7	149
Russian Federation	193	193	187	6	193
Slovenia	59	59	50	0	50
Sweden	134	134	132	1	133
United States	348	237	156	9	165

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

Appendix PC.4: Student Sample Sizes - Physics

Country	Within-School Student Participation (Weighted Percentage)	Number of Sampled Students in Participating Schools	Number of Students Withdrawn from Class/School	Number of Students Excluded	Number of Eligible Students	Number of Students Absent	Number of Students Assessed
France	96%	4,297	41	7	4,249	291	3,958
Italy	97%	3,652	25	20	3,607	183	3,424
Lebanon	98%	1,215	0	0	1,215	59	1,156
Norway	94%	2,674	44	2	2,628	156	2,472
Portugal	93%	1,968	21	4	1,943	160	1,783
Russian Federation	98%	3,925	2	8	3,915	93	3,822
Slovenia	86%	1,302	6	12	1,284	178	1,106
Sweden	90%	4,236	65	3	4,168	441	3,727
United States	85%	3,539	114	6	3,419	487	2,932

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 PC.5: Participation Rates (Weighted) - Physics

Country	School Participation		Class Participation	Student Participation	Overall Participation	
	Before Replacement	After Replacement			Before Replacement	After Replacement
France	99%	99%	100%	96%	95%	95%
Italy	89%	95%	99%	97%	85%	91%
‡ Lebanon	70%	70%	100%	98%	68%	68%
Norway	98%	98%	100%	94%	93%	93%
Portugal	83%	87%	100%	93%	78%	81%
Russian Federation	97%	100%	100%	98%	95%	98%
Slovenia	86%	86%	100%	86%	74%	74%
Sweden	99%	100%	99%	90%	88%	89%
‡ United States	65%	68%	100%	85%	55%	58%

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.

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

Appendix PC.6: Trends in Student Populations – Physics

Country	Years of Formal Schooling*			Average Age at Time of Testing			Overall Exclusion Rates**			Physics Coverage Index***			Overall Participation Rates		
	2015	2008	1995	2015	2008	1995	2015	2008	1995	2015	2008	1995	2015	2008	1995
France	12		12	18.0		18.2	4.7%		1.0%	21.5%		19.9%	96%		77%
Italy	13	13		18.9	18.9		0.8%	0.9%		18.2%	3.8%		91%	97%	
Lebanon	12	12		17.8	17.9		1.3%	1.3%		3.9%	5.9%		68%	82%	
Norway	13	12	12	18.8	18.8	19.0	3.4%	0.5%	3.8%	6.5%	6.8%	8.4%	93%	73%	83%
Russian Federation	11	10/11	10	17.7	17.1	16.9	0.4%	0.0%	2.0%	4.9%	2.6%	1.5%	98%	97%	95%
Slovenia	13	12	12	18.8	18.7	18.8	2.0%	0.5%	6.0%	7.6%	7.5%	38.6%	74%	67%	43%
Sweden	12	12	12	18.8	18.8	18.9	2.0%	2.3%	0.2%	14.3%	11.0%	16.3%	89%	89%	89%
United States	12		12	18.1		18.0	0.1%		3.7%	4.8%		2.7%	58%		64%

* 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.

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

Appendix PD.1: Average Percent Correct in the Physics Content and Cognitive Domains

Country	Overall Physics	Physics Content Domains			Physics Cognitive Domains		
		Mechanics and Thermodynamics	Electricity and Magnetism	Wave Phenomena and Atomic/Nuclear Physics	Knowing	Applying	Reasoning
France	32 (0.4)	26 (0.4)	30 (0.4)	40 (0.5)	40 (0.5)	28 (0.4)	30 (0.5)
Italy	32 (0.6)	30 (0.7)	37 (0.8)	30 (0.7)	39 (0.7)	30 (0.7)	29 (0.6)
Lebanon	35 (0.4)	31 (0.6)	33 (0.6)	41 (0.6)	40 (0.6)	37 (0.6)	26 (0.5)
Norway	49 (0.7)	48 (0.7)	48 (0.8)	52 (0.8)	60 (0.7)	46 (0.7)	44 (0.7)
Portugal	42 (0.6)	45 (0.8)	37 (0.7)	44 (0.8)	52 (0.7)	40 (0.8)	37 (0.7)
Russian Federation	50 (1.1)	49 (1.2)	50 (1.1)	51 (1.0)	58 (1.0)	50 (1.3)	42 (0.9)
Slovenia	52 (0.5)	54 (0.6)	51 (0.5)	52 (0.7)	58 (0.7)	54 (0.5)	45 (0.6)
Sweden	42 (0.8)	41 (0.9)	41 (0.8)	44 (0.8)	49 (0.7)	41 (0.9)	36 (0.7)
United States	39 (1.1)	42 (1.3)	34 (1.2)	41 (1.1)	48 (1.3)	37 (1.2)	35 (1.0)
International Avg.	41 (0.2)	40 (0.3)	40 (0.3)	44 (0.3)	49 (0.3)	40 (0.3)	36 (0.2)

( ) 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 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

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[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.[2] 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.[3]

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

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[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.

Country	Average Percent Correct on All Items	Slovenia	Russian Federation	Norway	Portugal	Sweden	United States	Lebanon	Italy	France
Slovenia	52 (0.5)	52	54	51	52	53	53	52	52	52
Russian Federation	50 (1.1)	50	51	49	49	50	50	50	50	49
Norway	49 (0.7)	49	49	51	50	49	50	50	49	49
Portugal	42 (0.6)	42	44	43	44	43	43	42	42	44
Sweden	42 (0.8)	42	43	42	42	42	42	42	42	42
United States	39 (1.1)	39	40	40	40	39	39	39	39	40
Lebanon	35 (0.4)	35	36	35	34	35	35	36	35	35
Italy	32 (0.6)	32	33	32	31	32	33	31	32	31
France	31 (0.4)	31	31	32	31	31	31	31	31	32
International Avg.	41 (0.2)	41	42	42	41	42	42	42	41	42
Number of Items (Score Points) Identified*	115	115	104	107	94	107	111	93	115	92

* 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.

( ) 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

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

Exhibit PE.2: Standard Errors 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.

Country	Average Percent Correct on All Items	Slovenia	Russian Federation	Norway	Portugal	Sweden	United States	Lebanon	Italy	France
Slovenia	52 (0.5)	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Russian Federation	50 (1.1)	1.1	1.1	1.0	1.1	1.1	1.1	1.0	1.1	1.1
Norway	49 (0.7)	0.7	0.6	0.7	0.7	0.7	0.7	0.7	0.7	0.7
Portugal	42 (0.6)	0.6	0.6	0.6	0.7	0.6	0.6	0.6	0.6	0.7
Sweden	42 (0.8)	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
United States	39 (1.1)	1.1	1.2	1.1	1.1	1.2	1.1	1.2	1.1	1.1
Lebanon	35 (0.4)	0.4	0.5	0.4	0.5	0.5	0.4	0.4	0.4	0.5
Italy	32 (0.6)	0.6	0.7	0.6	0.7	0.7	0.7	0.6	0.6	0.6
France	31 (0.4)	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.5
International Avg.	41 (0.2)	0.2	0.2	0.2	0.3	0.2	0.2	0.2	0.2	0.2
Number of Items (Score Points) Identified*	115	115	104	107	94	107	111	93	115	92

* 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.

( ) 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

selections, with the Russian Federation, Norway, Portugal, and Sweden next in order (with some ties) on practically all selections of items.[4]

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.

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[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

Country	5th Percentile	10th Percentile	25th Percentile	50th Percentile	75th Percentile	90th Percentile	95th Percentile
France	226 (5.7)	258 (6.4)	311 (5.9)	373 (4.3)	434 (4.5)	490 (5.2)	521 (5.9)
Italy	158 (13.3)	206 (12.4)	286 (10.0)	380 (8.1)	465 (6.8)	533 (5.9)	573 (9.0)
Lebanon	253 (10.2)	290 (7.2)	348 (4.8)	412 (5.3)	476 (6.0)	526 (8.3)	557 (9.3)
Norway	333 (8.6)	377 (10.0)	443 (6.8)	511 (5.5)	577 (5.0)	632 (5.9)	664 (5.3)
Portugal	330 (8.3)	361 (5.6)	412 (6.5)	466 (6.1)	522 (6.5)	573 (6.7)	603 (8.5)
Russian Federation	303 (10.1)	348 (9.3)	427 (8.1)	513 (7.6)	592 (8.5)	657 (11.1)	695 (14.9)
Slovenia	367 (10.1)	408 (8.1)	468 (6.2)	532 (4.2)	596 (5.9)	655 (7.9)	693 (7.0)
Sweden	245 (10.2)	295 (9.2)	380 (8.3)	463 (7.1)	537 (5.7)	600 (6.0)	636 (6.3)
United States	235 (16.7)	283 (15.6)	357 (13.0)	440 (10.9)	522 (9.9)	589 (10.0)	626 (10.3)

( ) 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

Country	Overall		Females		Males	
	Mean	Standard Deviation	Mean	Standard Deviation	Mean	Standard Deviation
France	373 (4.0)	90 (1.7)	354 (4.2)	84 (2.1)	390 (4.6)	91 (2.3)
Italy	374 (6.9)	126 (3.5)	356 (7.3)	121 (4.8)	389 (8.4)	129 (4.4)
Lebanon	410 (4.5)	94 (2.7)	417 (5.2)	87 (4.5)	406 (6.4)	97 (4.1)
Norway	507 (4.6)	100 (2.5)	489 (6.0)	92 (3.9)	515 (4.8)	101 (2.6)
Portugal	467 (4.6)	83 (2.2)	456 (6.2)	84 (4.1)	470 (5.1)	82 (2.4)
Russian Federation	508 (7.1)	119 (4.3)	498 (7.9)	119 (6.1)	514 (7.3)	119 (4.1)
Slovenia	531 (2.5)	98 (2.7)	510 (6.5)	95 (6.3)	540 (3.7)	98 (3.1)
Sweden	455 (5.9)	118 (2.5)	448 (6.1)	113 (3.2)	459 (6.6)	122 (2.8)
United States	437 (9.7)	118 (4.3)	409 (11.9)	115 (5.5)	455 (9.3)	117 (4.3)

( ) 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 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.

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