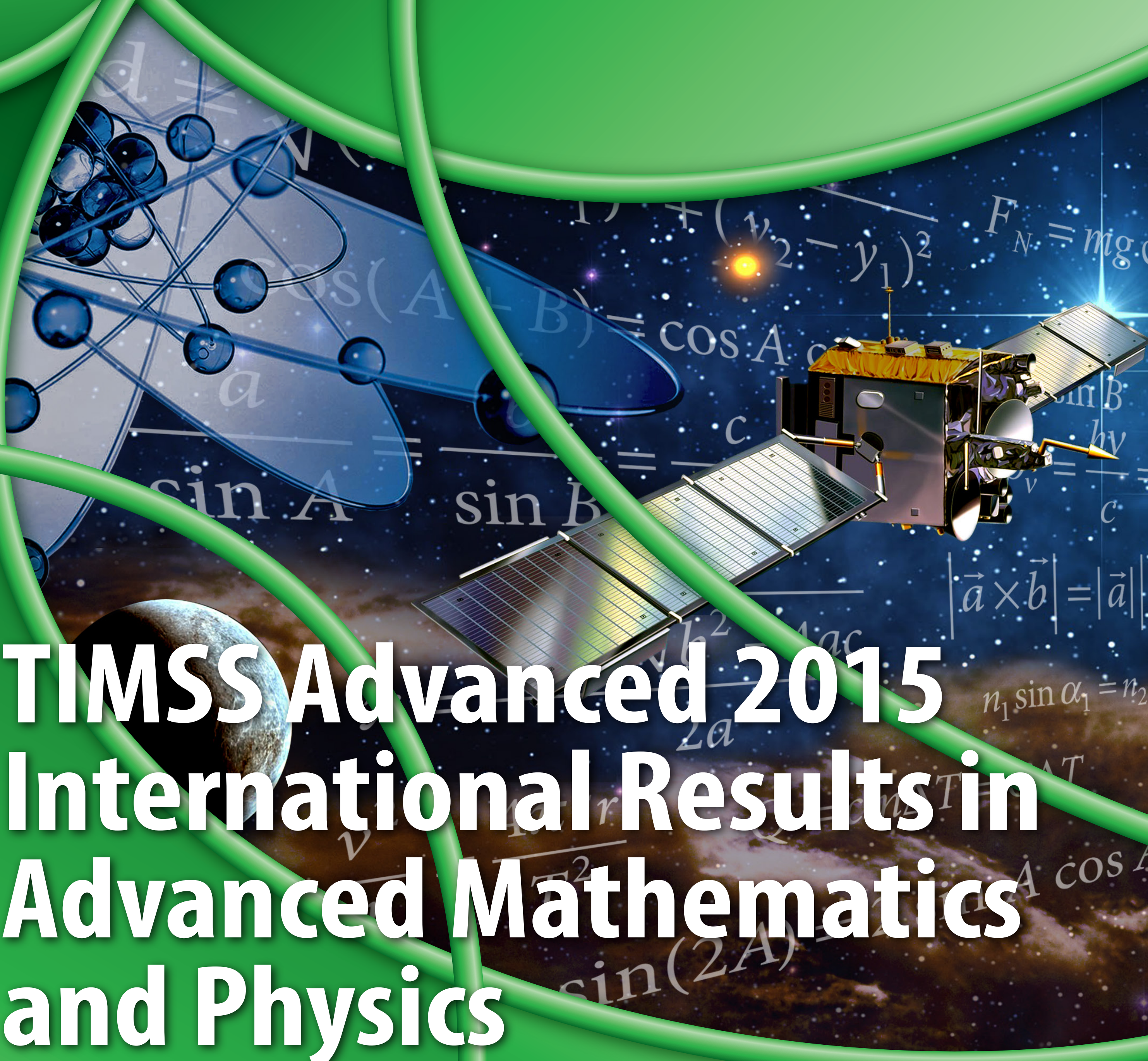
TRENDS IN INTERNATIONAL MATHEMATICS AND SCIENCE STUDY
TIMSS



TIMSS Advanced 2015 International Results in Advanced Mathematics and Physics

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TIMSS Advanced 2015

TIMSS ADVANCED 2015 INTERNATIONAL RESULTS IN ADVANCED MATHEMATICS AND PHYSICS

PHYSICS

IEA
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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 12^{th} 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 (4^{th} grade, 8^{th} 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 P1: STUDENT ACHIEVEMENT

TIMSS ADVANCED 2015 INTERNATIONAL RESULTS IN ADVANCED MATHEMATICS AND PHYSICS

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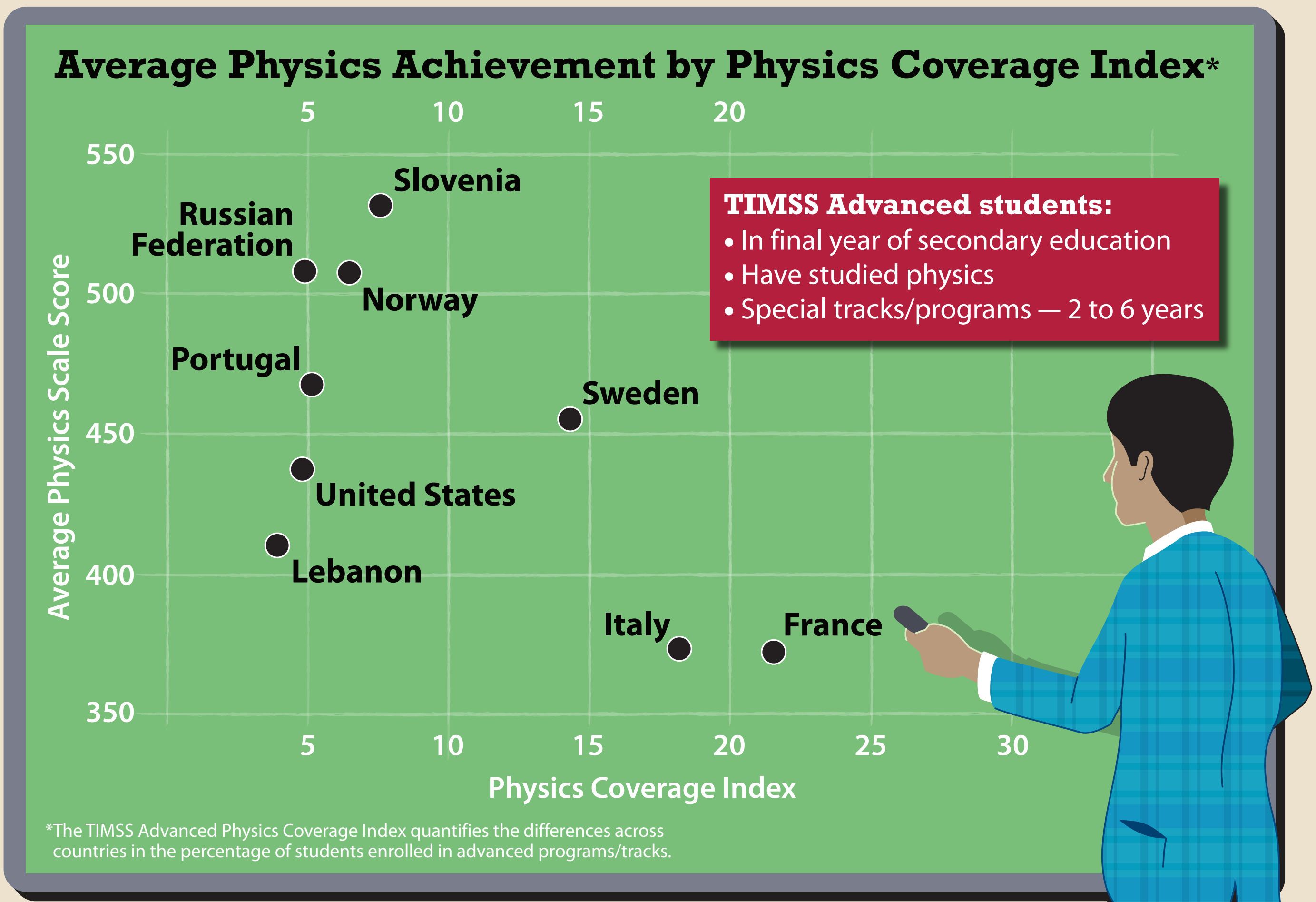
International Achievement in Physics

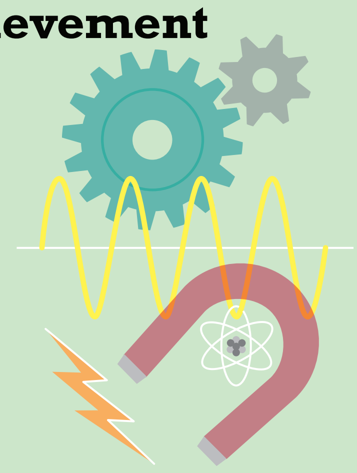


Physics in an essential element of STEM education. How many physics students are countries educating to a high level, and how well are they achieving?

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

TIMSS Advanced 2015 Reveals Disappointing Trends in Physics Achievement

Of the 6 countries with 20-year trend data, France, Norway, the Russian Federation, and Sweden had lower average achievement in 2015 than in 1995.



In Slovenia and the United States, average physics achievement was essentially unchanged since 1995.

Attracting Women to STEM Education Remains a Challenge

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

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

0 Countries

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

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

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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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

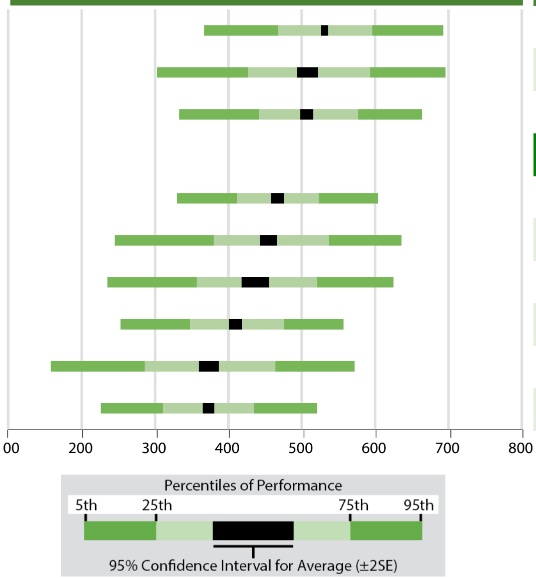
Exhibit P1.1: Structural Characteristics of the Physics Programs (Tracks) (Continued)

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*	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*

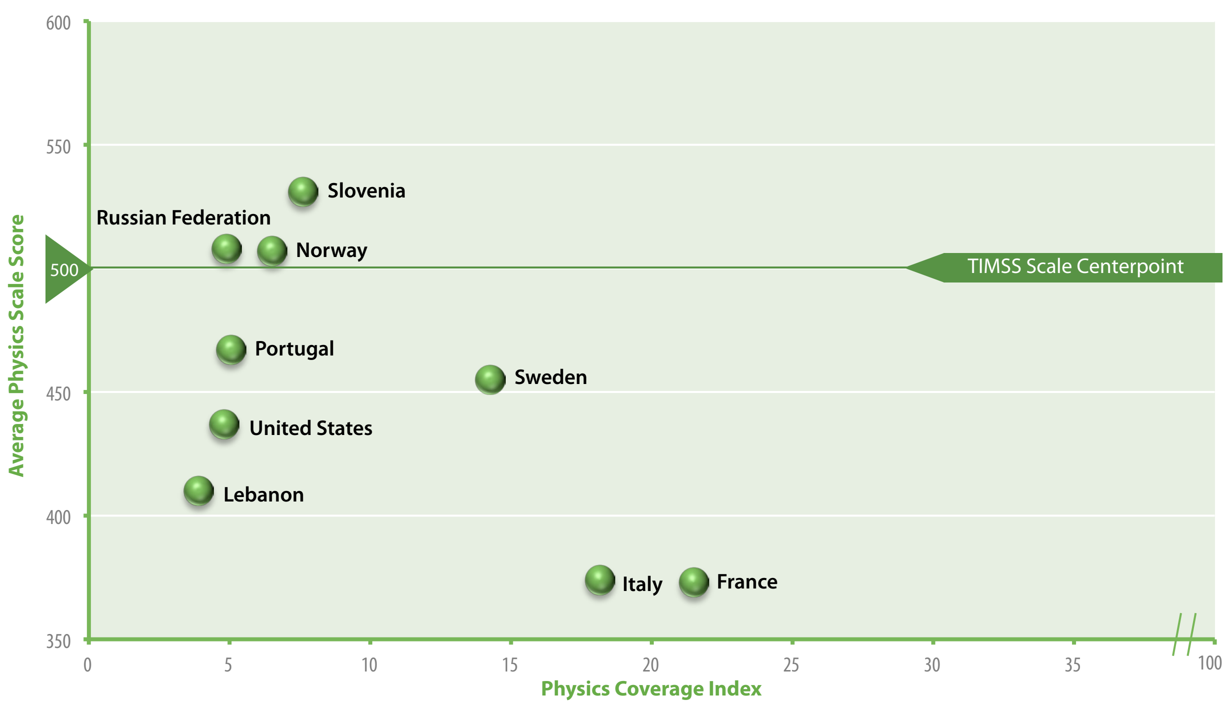


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Exhibit P1.3: Multiple Comparisons of Average Physics Achievement

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.

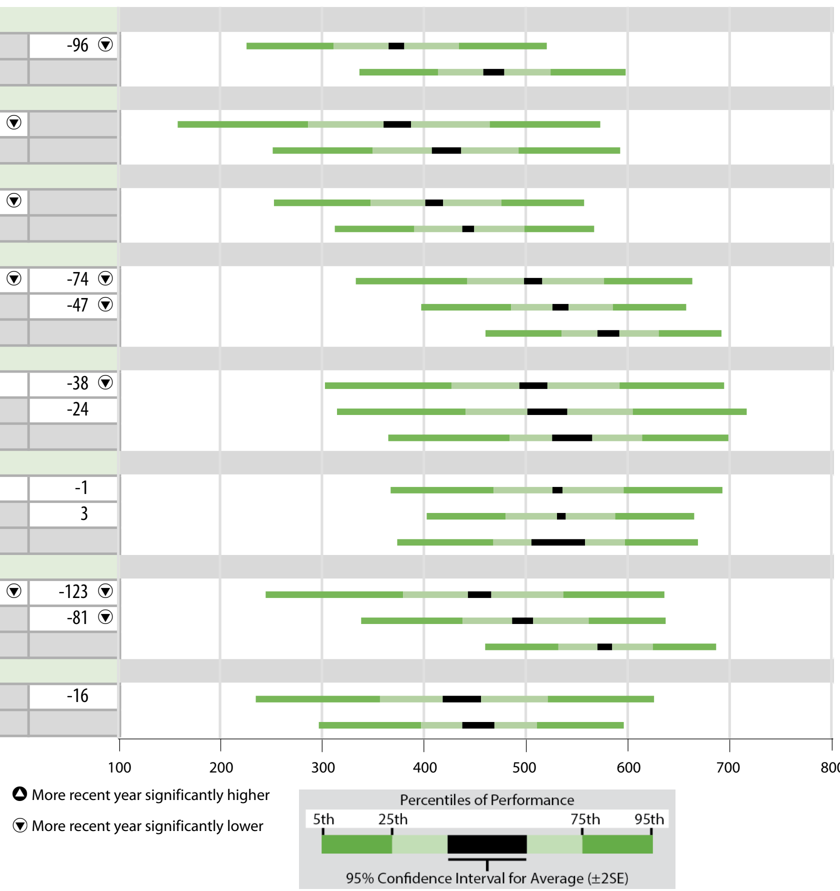
SOURCE: IEA's Trends in International Mathematics and Science Study – TIMSS Advanced 2015

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	Differences Between Years 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)		

Physics Achievement Distribution



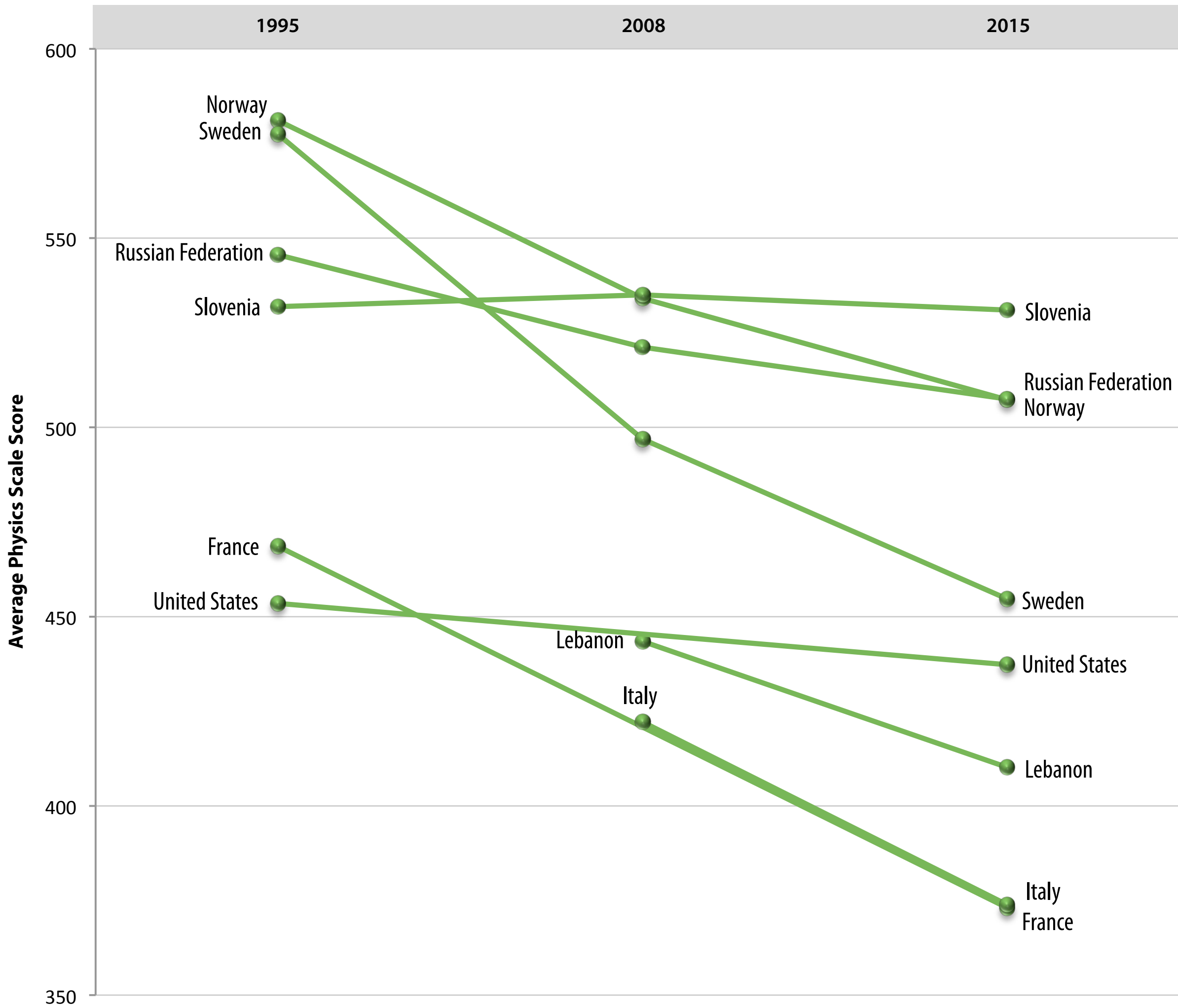
* See Appendix PC.2 for a description of the Physics Coverage Index.

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



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

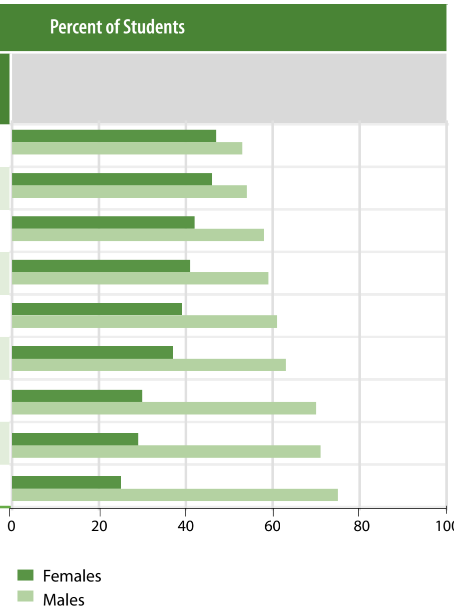
The United States adjusted the 1995 sample to correspond with the course-taking definitions used in 2015, and the 1995 results were recomputed.
A diamond (◊) indicates the country did not participate in this year's assessment.
( ) Standard errors appear in parentheses. Because of rounding some results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

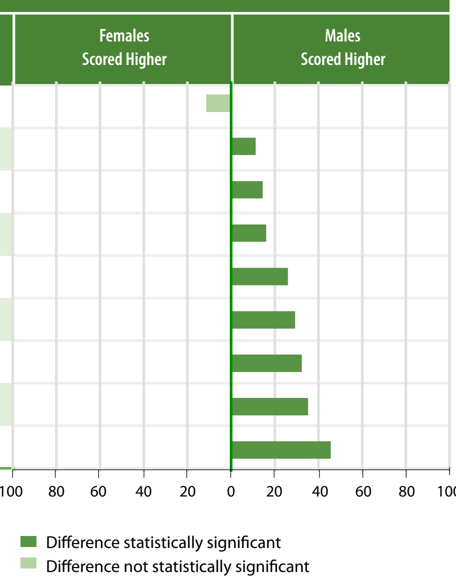
Country	Percent of Students: Females	Percent of Students: Males
France	47 (0.9)	53 (0.9)
Italy	46 (1.1)	54 (1.1)
Russian Federation	42 (1.2)	58 (1.2)
Sweden	41 (1.4)	59 (1.4)
‡ United States	39 (1.6)	61 (1.6)
‡ Lebanon	37 (1.5)	63 (1.5)
Slovenia	30 (1.7)	70 (1.7)
Norway	29 (1.2)	71 (1.2)
Portugal	25 (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 2008	Differences Between Years 1995	Percent of Students	Average Scale Score	Differences Between Years 2008	Differences Between Years 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

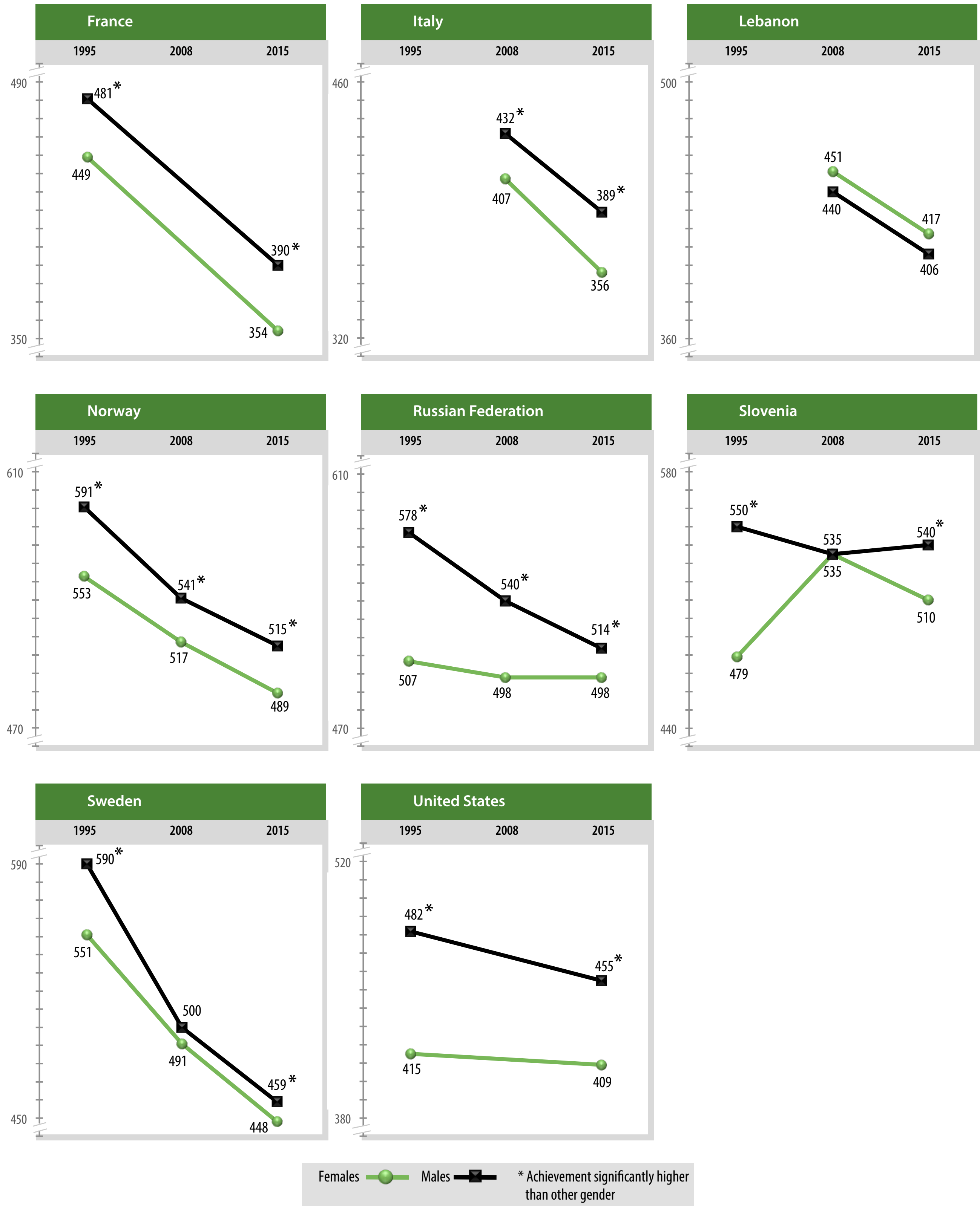
▼ More recent year significantly lower

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



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.

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

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

TIMSS Advanced 2015

CHAPTER P2: PERFORMANCE AT INTERNATIONAL BENCHMARKS

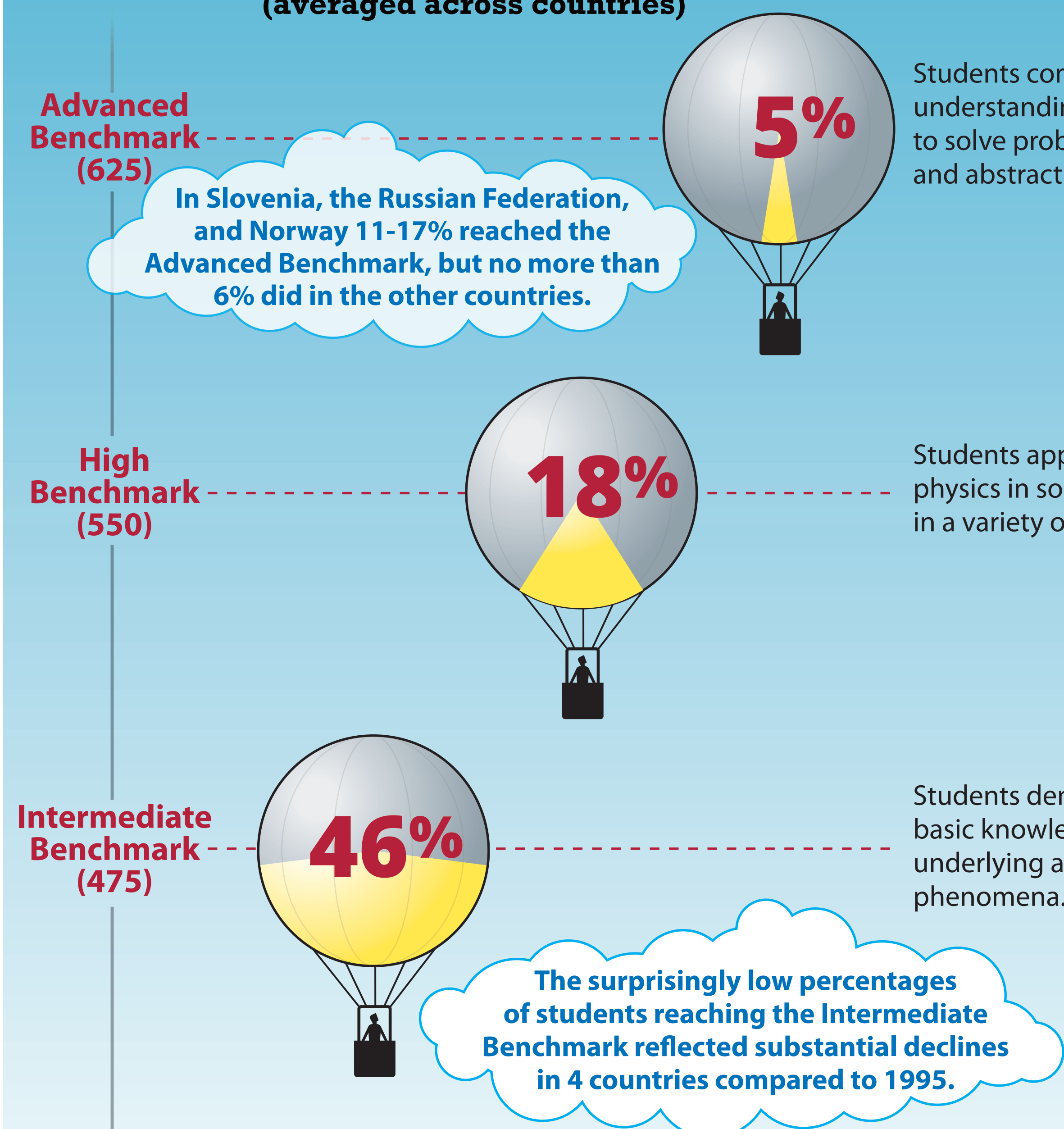
TIMSS ADVANCED 2015 INTERNATIONAL RESULTS IN ADVANCED MATHEMATICS AND PHYSICS

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

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.

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.

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

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

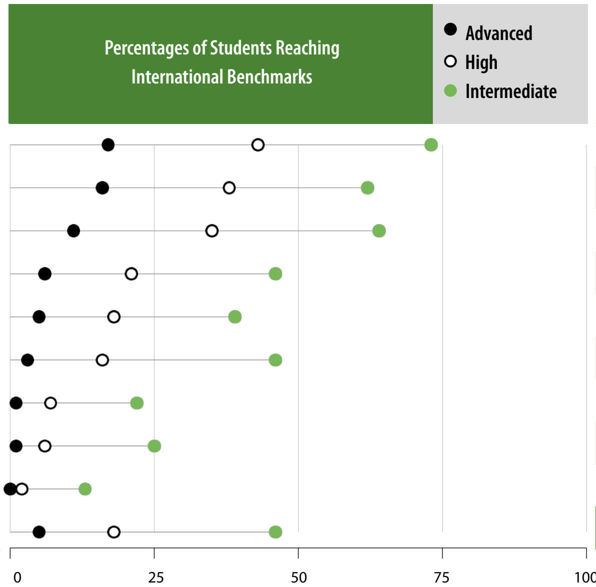
Students apply basic laws of physics in solving problems in a variety of situations. They apply knowledge of forces and motion, communicate understanding of the laws of conservation of energy and momentum, and apply knowledge of heat and temperature to solve problems. Students apply knowledge of Ohm's 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



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) Percent of Students			High International Benchmark (550) Percent of Students			Intermediate International Benchmark (475) 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

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

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

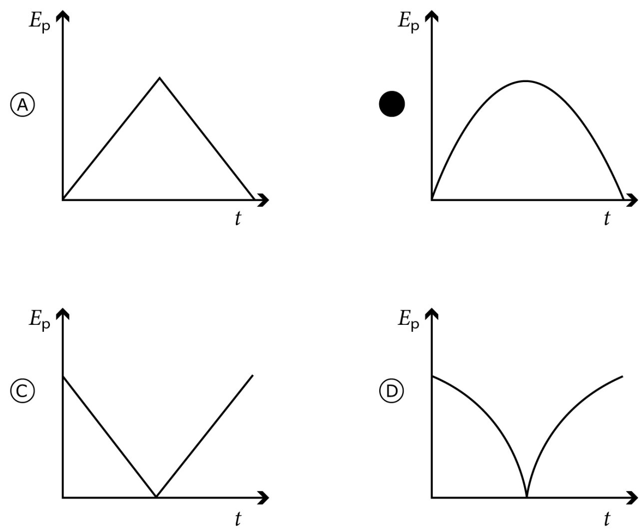
Country	Percent Correct	
Slovenia	64 (2.5)	▲
Sweden	61 (1.6)	▲
Portugal	60 (2.3)	
‡ Lebanon	60 (3.8)	
‡ United States	60 (2.0)	
Norway	58 (1.8)	
International Avg.	57 (0.8)	
France	57 (1.6)	
Italy	51 (1.7)	▼
Russian Federation	45 (2.6)	▼

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?



▲ 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.

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

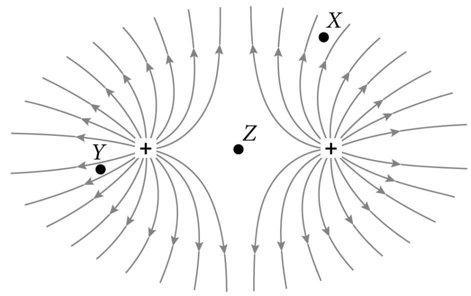
Country	Percent Full Credit	
Portugal	77 (2.2)	▲
France	76 (1.2)	▲
Norway	75 (1.5)	▲
Russian Federation	73 (2.0)	▲
‡ United States	68 (2.3)	
International Avg.	68 (0.8)	
Slovenia	67 (3.1)	
Italy	66 (1.9)	
Sweden	66 (1.3)	
‡ Lebanon	41 (3.8)	▼

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.

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)

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

* No Response.

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

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

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

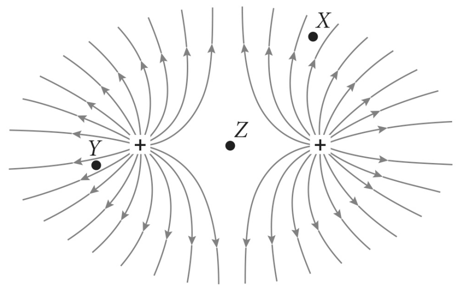
Country	Percent Full Credit	
Portugal	69 (2.8)	▲
Slovenia	58 (2.7)	▲
France	54 (2.0)	▲
International Avg.	50 (0.8)	
‡ Lebanon	50 (3.2)	
Russian Federation	50 (2.3)	
Norway	47 (1.7)	▼
Sweden	46 (1.4)	▼
‡ United States	43 (3.4)	▼
Italy	35 (1.9)	▼

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.

▲ 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.

▲ 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.

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

Scoring Guide

Code	Response	Item: PA23088
	Correct Response	
10	All six numbers correct:	

Isotope	Number of protons	Number of neutrons
^{4}He	**2**	**2**
^{14}C	**6**	**8**
^{14}N	**7**	**7**

Code	Response
	Incorrect Response
70	All protons correct, all neutrons wrong
71	Any five numbers correct
79	Other incorrect (including crossed out, erased, stray marks, illegible, or off task)
	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	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.

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.

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

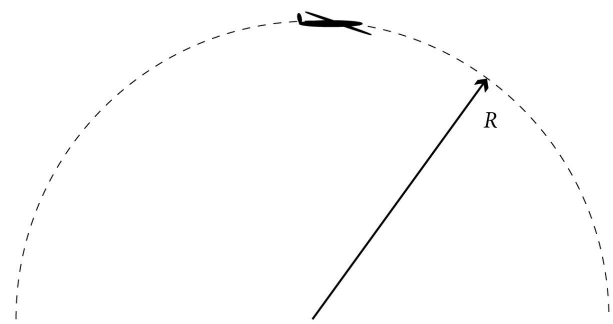
Country	Percent Correct	
Russian Federation	74 (1.7)	▲
Norway	68 (2.0)	▲
Slovenia	59 (2.7)	▲
Portugal	55 (2.5)	▲
International Avg.	49 (0.8)	
‡ United States	43 (3.2)	▼
Italy	39 (2.0)	▼
Sweden	38 (2.3)	▼
‡ Lebanon	34 (2.7)	▼
France	28 (1.5)	▼

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

● $\sqrt{gR}$

Ⓒ $\frac{g}{R}$

Ⓓ $\sqrt{\frac{g}{R}}$

Ⓔ $2gR$

▲ 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.

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.

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	

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	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.

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

$Q = Cm\Delta T$

$= (4.2)(.5)(37-4)$

$= 69\,kJ$

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.

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: • $Q = c \cdot m \cdot \Delta T = (4.2\ \text{kJ/kg} \cdot °\text{C}) \cdot (0.50\ \text{kg}) \cdot (33\ °\text{C}) = 69\ \text{kJ}$	
	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.

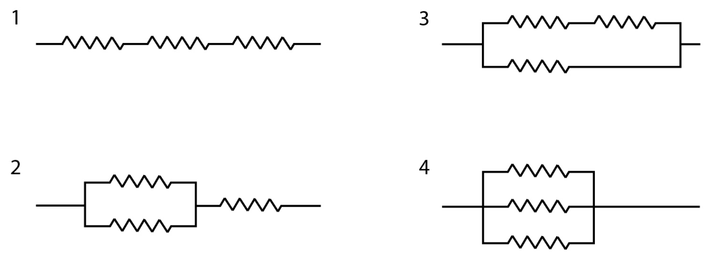
Exhibit P2.5.4: High International Benchmark – Example Item 4

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.

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

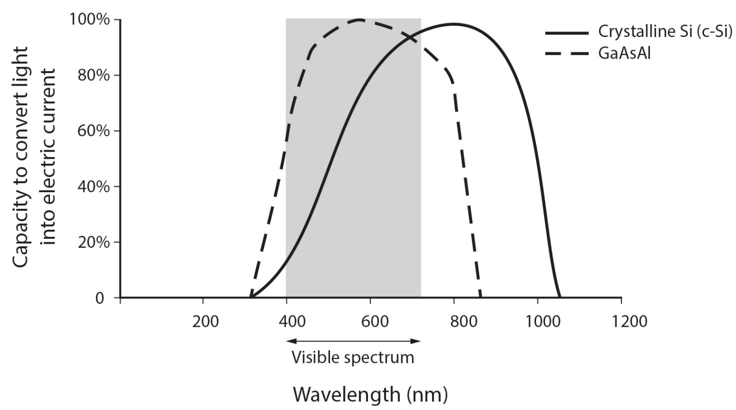
Country	Percent Full Credit	
Slovenia	57 (2.4)	▲
Portugal	54 (2.7)	▲
‡ United States	51 (2.3)	▲
Norway	50 (1.8)	▲
France	45 (1.6)	
International Avg.	44 (0.7)	
Sweden	42 (2.1)	
Russian Federation	39 (1.9)	▼
‡ Lebanon	35 (2.5)	▼
Italy	27 (2.0)	▼

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.

▲ 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.

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

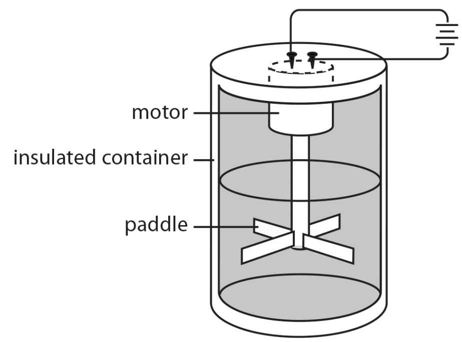
Country	Percent Full Credit	
Slovenia	59 (2.5)	▲
Portugal	47 (3.1)	▲
Sweden	32 (1.7)	
International Avg.	31 (0.7)	
‡ United States	31 (2.2)	
Norway	31 (1.6)	
Russian Federation	28 (2.3)	
Italy	26 (1.4)	▼
France	18 (1.3)	▼
‡ Lebanon	9 (1.6)	▼

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.

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	

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

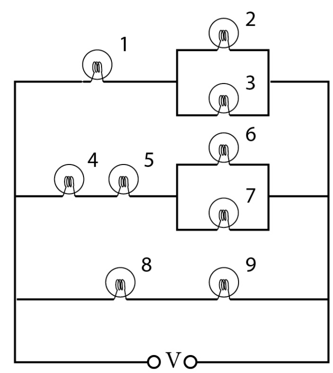
Country	Percent Correct	
Slovenia	59 (1.9)	▲
Sweden	51 (1.5)	▲
Norway	50 (1.9)	▲
‡ Lebanon	50 (2.4)	▲
International Avg.	44 (0.7)	
‡ United States	43 (2.4)	
Russian Federation	41 (2.4)	
Italy	36 (1.5)	▼
Portugal	36 (3.2)	▼
France	28 (1.5)	▼

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.

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.

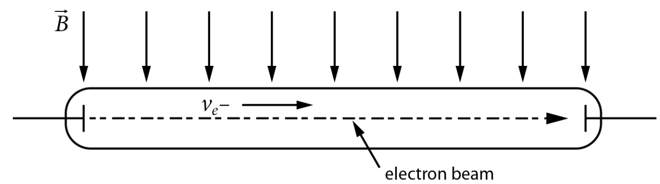
SOURCE: IEA's Trends in International Mathematics and Science Study – TIMSS Advanced 2015

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.

▲ 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.

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

Scoring Guide

Code	Response	Item: PA23066
	Correct Response	
10	3 neutrons (standard notation): $3\,{}^{1}_{0}n$	
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.

TIMSS Advanced 2015

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

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

Relative Weakness

3 Countries
Norway, Lebanon, and France

Electricity and Magnetism

Relative Strength

2 Countries
Russian Federation and Italy

Relative Weakness

3 Countries
Portugal, the United States, and France

Wave Phenomena and Atomic/Nuclear Physics

Relative Strength

2 Countries
Lebanon and France

Relative Weakness

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

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

Relative Weakness

2 Countries
Slovenia and Lebanon

Applying

Relative Strength

2 Countries
Slovenia and Lebanon

Relative Weakness

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

Reasoning

Relative Strength

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

Relative Weakness

3 Countries
Slovenia, Russian Federation, and Lebanon

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

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 P3.2: 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

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

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

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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TIMSS Advanced 2015

CHAPTER P4: HOME ENVIRONMENT AND FUTURE PLANS

TIMSS ADVANCED 2015 INTERNATIONAL RESULTS IN ADVANCED MATHEMATICS AND PHYSICS

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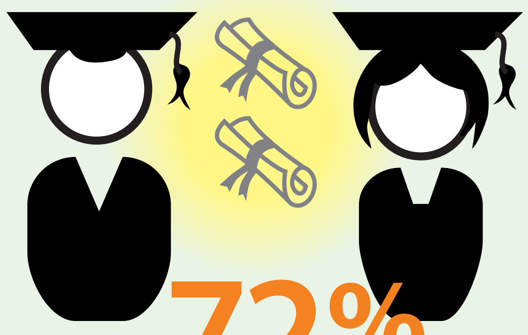
Students' Plans for Future Study

Nearly all the Physics students planned to continue their education after finishing secondary school and the vast majority intend to obtain advanced degrees.

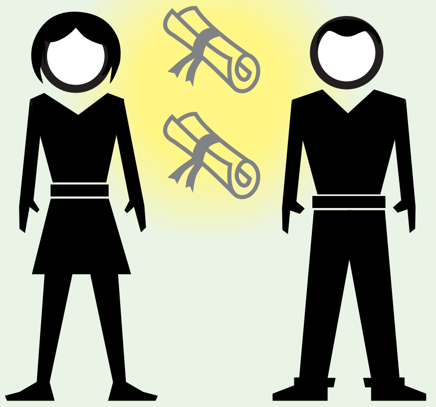


72%

of students expect to obtain an advanced degree

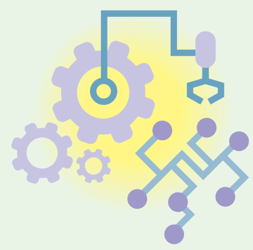
Higher percentages of the Females taking physics than of the Males expect to obtain an advanced degree.

76% **70%**



The most popular areas of future study included:

Engineering/ Technnology

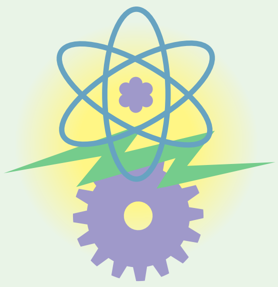


48%

Biological/ Biomedical

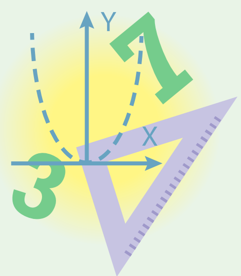
24%

Physics



22%

Mathematics



22%

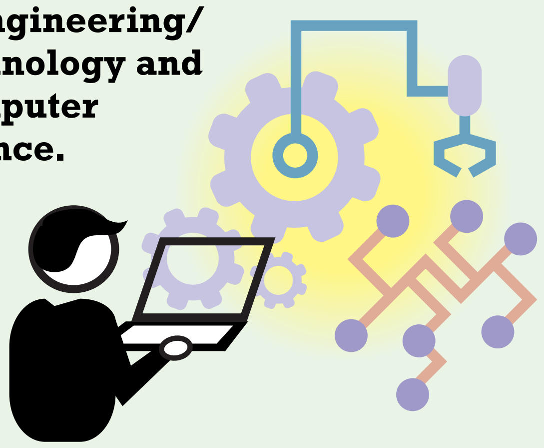
Education trailed behind (7%) as a future area of study.

Students' Plans for Future Professions

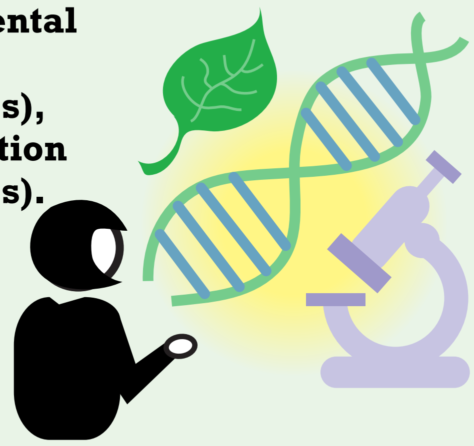
Students who studied physics in secondary school reported considering a number of professions.

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)

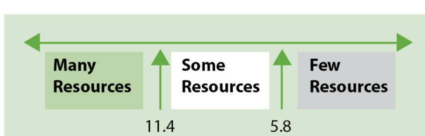


Exhibit P4.2: Students Working at a Paid Job on a Regular Basis During the School Year

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%	PERCENT OF STUDENTS 26%	PERCENT OF STUDENTS 17%
Average Achievement 468	Average Achievement 436	Average Achievement 424
Attended schools with more affluent than disadvantaged students	Attended schools with neither more affluent nor more disadvantaged students	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/

IEA

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

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.

TIMSS Advanced 2015

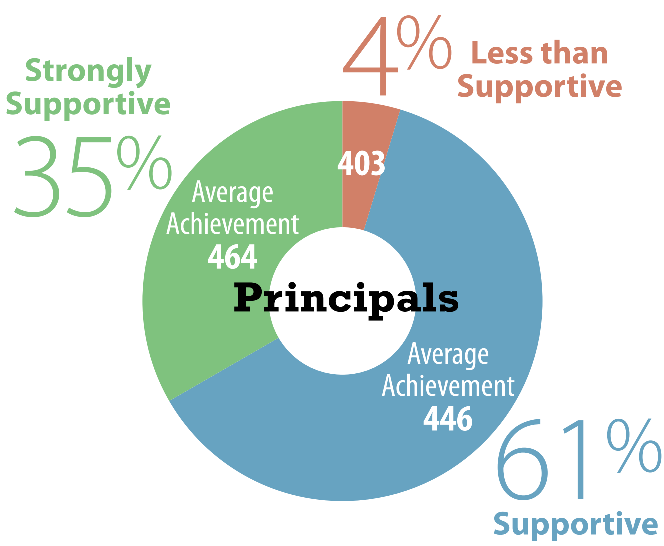
CHAPTER M6: SCHOOL CLIMATE

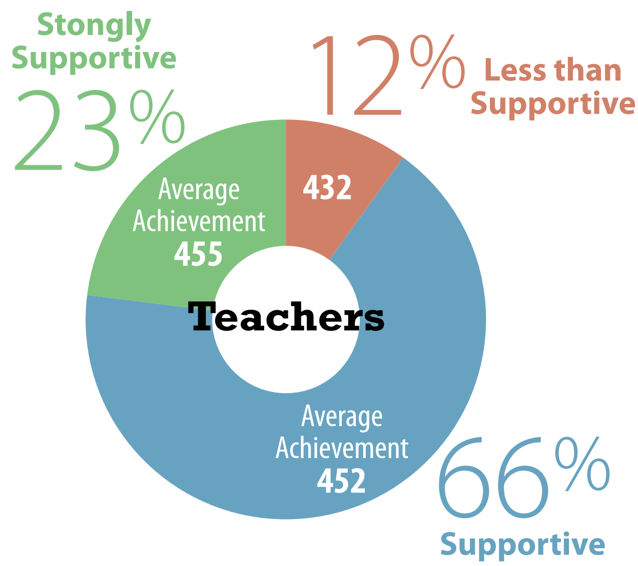
TIMSS ADVANCED 2015 INTERNATIONAL RESULTS IN ADVANCED MATHEMATICS AND PHYSICS

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

Schools Have Positive Environments

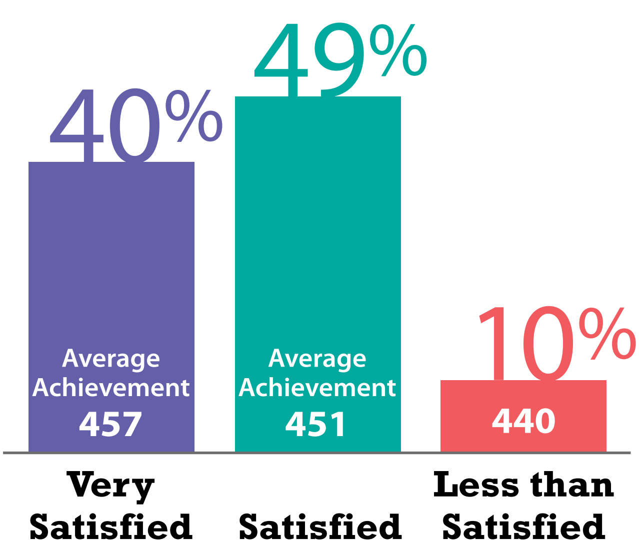
Generally, students taking physics courses are in positive school environments, and the more positive the school environment the higher the average achievement.



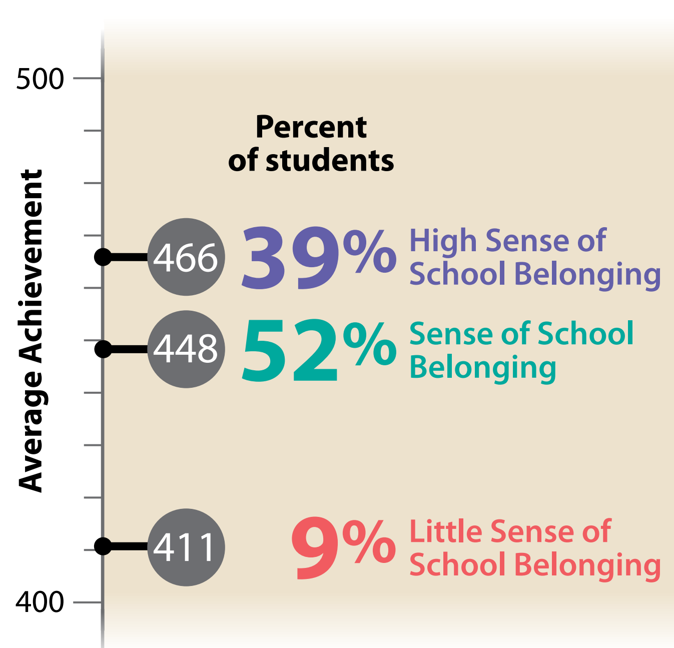


Principals and teachers agree that high percentages of TIMSS Advanced students attend schools that support physics education, although the principals have more positive attitudes than the teachers.

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	◯	◯	◯	◯

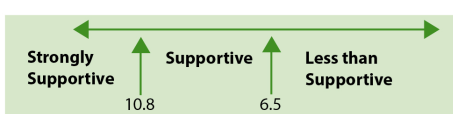

Exhibit P6.3: School Supports Advanced Mathematics and Physics Education – Teacher Version

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	◯	◯	◯	◯

Strongly Supportive ← 11.6 → **Supportive** ← 7.5 → **Less than Supportive**

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	◯	◯	◯	◯

Very Satisfied | 10.6 | **Satisfied** | 7.4 | **Less than Satisfied**

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	○	○	○	○

High Sense of School Belonging | 10.5 | **Sense of School Belonging** | 7.6 | **Little Sense of School Belonging**

TIMSS Advanced 2015

CHAPTER P7: SCHOOL SAFETY

TIMSS ADVANCED 2015 INTERNATIONAL RESULTS IN ADVANCED MATHEMATICS AND PHYSICS

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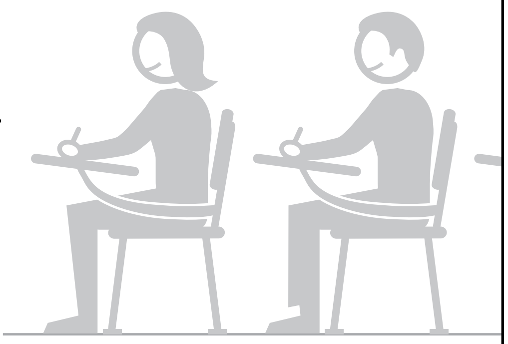
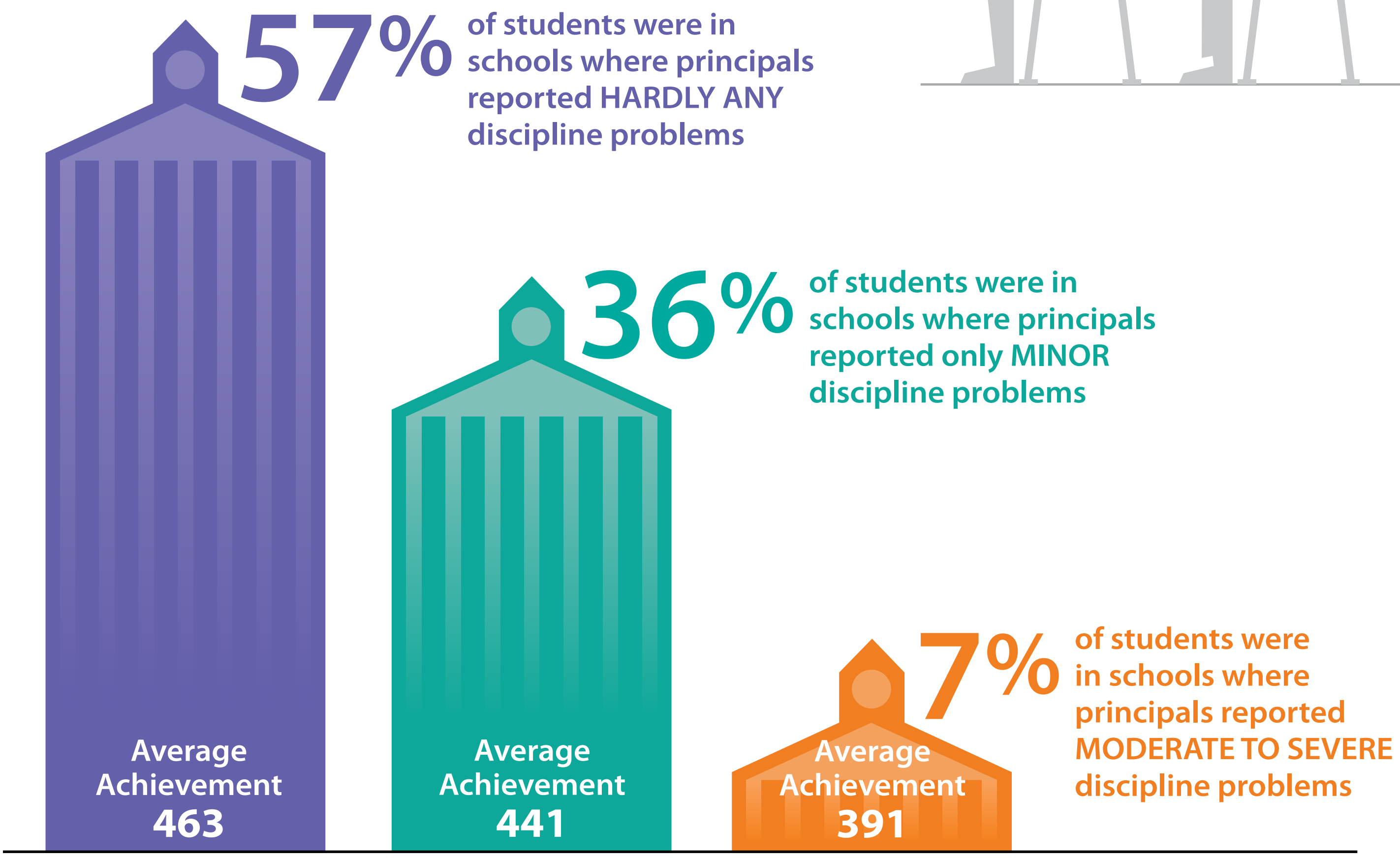
Students Are in Safe Schools

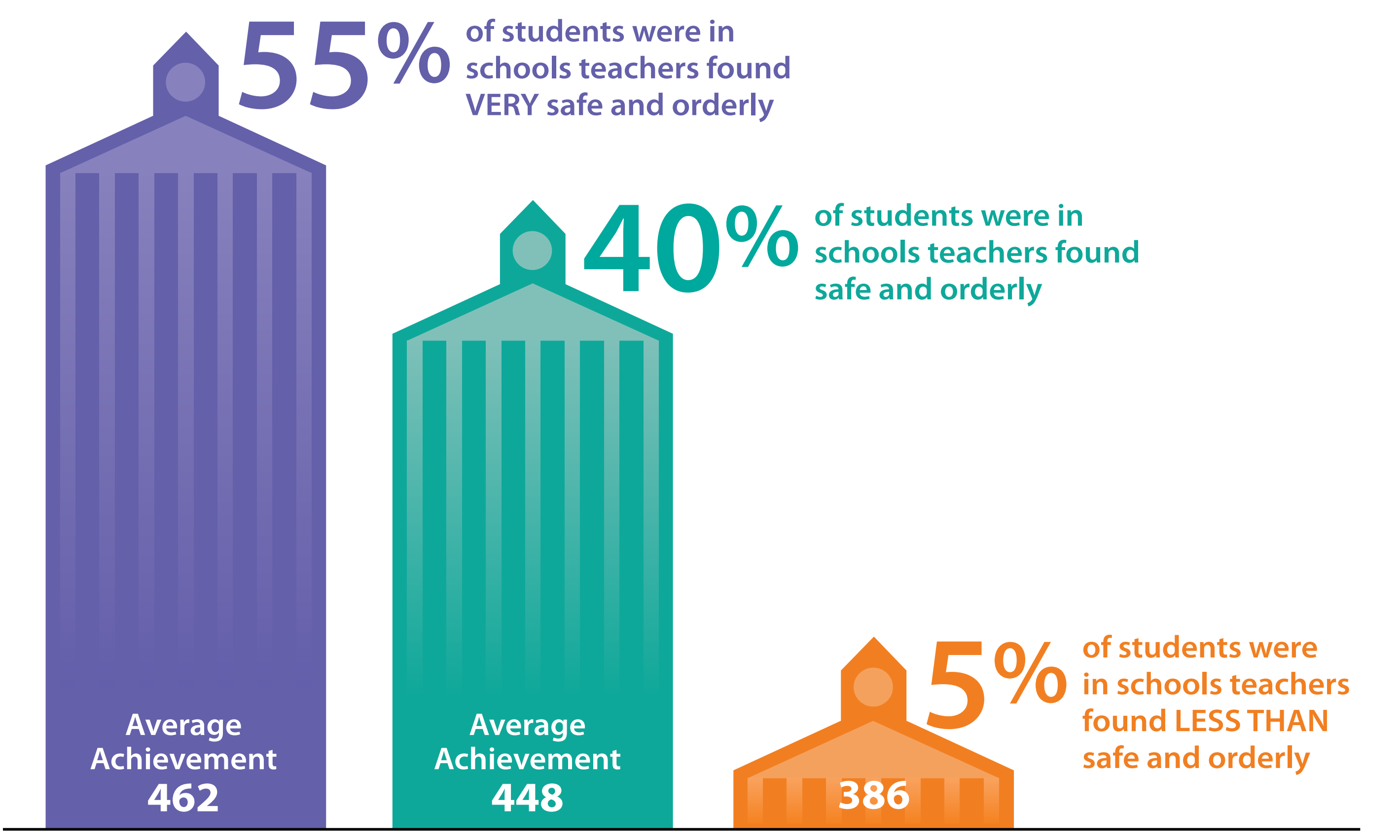
Principals and teachers agreed that ALMOST ALL the TIMSS Advanced students were in safe school environments.



Principals' Reports



Teachers' Reports



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	◯	◯	◯	◯

Hardly Any Problems | 10.0 | **Minor Problems** | 7.2 | **Moderate to Severe Problems**

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

Reported by Physics Teachers

Students were scored according to their teachers' degree of agreement with eight statements on the *Safe and Orderly School* scale. Students in **Very Safe and Orderly** schools had a score on the scale of at least 9.8, which corresponds to their teachers "agreeing a lot" with four of the eight qualities of a safe and orderly school and "agreeing a little" with the other four, on average. Students in **Less than Safe and Orderly** schools had a score no higher than 6.4, which corresponds to their teachers "disagreeing a little" with four of the eight qualities and "agreeing a little" with the other four, on average. All other students attended **Safe and Orderly** schools.

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)	

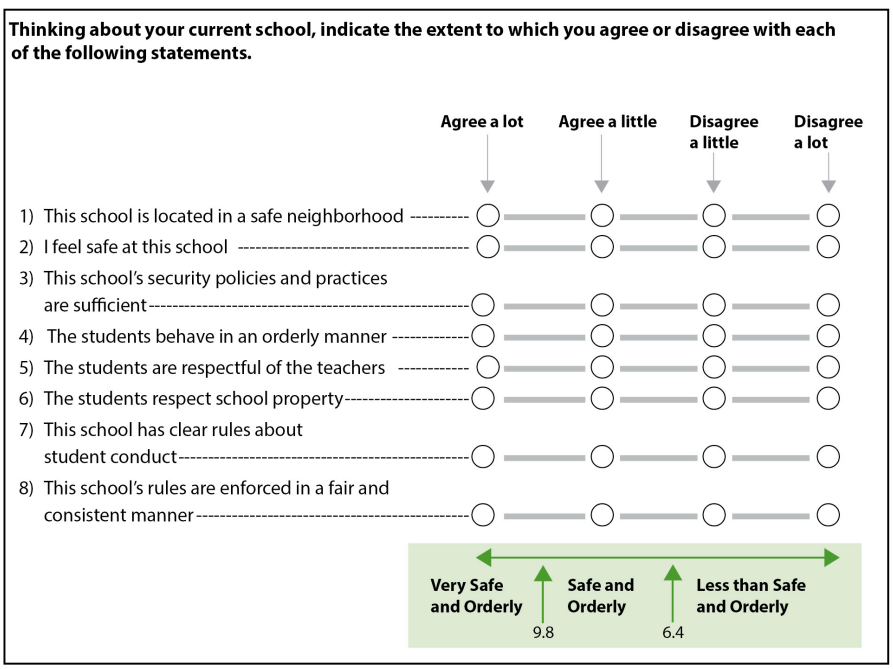
SOURCE: IEA's Trends in International Mathematics and Science Study – TIMSS Advanced 2015

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.



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CHAPTER P8: TEACHERS' AND PRINCIPALS' PREPARATION

TIMSS ADVANCED 2015 INTERNATIONAL RESULTS IN ADVANCED MATHEMATICS AND PHYSICS

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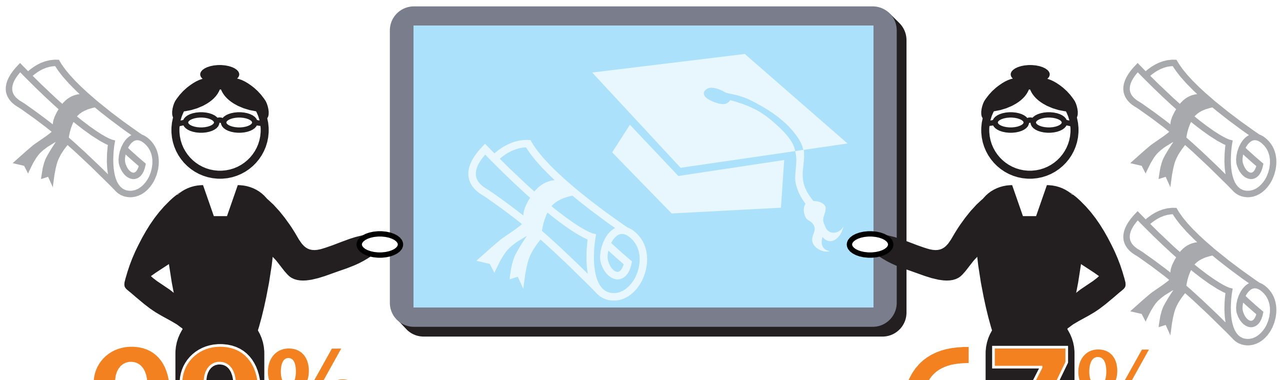
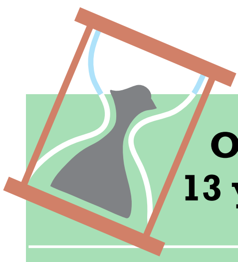
Students Have Well Qualified Teachers and Principals

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



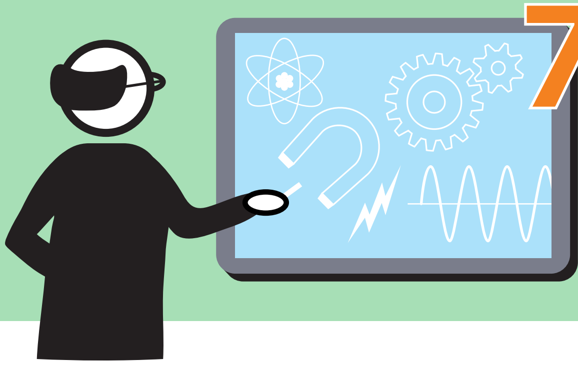
99% of students were taught by physics teachers with at least a Bachelor's degree

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

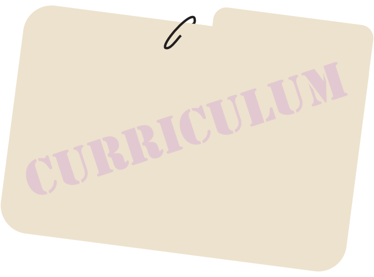
IEA
TIMSS & PIRLS International Study Center
Lynch School of Education, Boston College

Instruction in Physics Classes

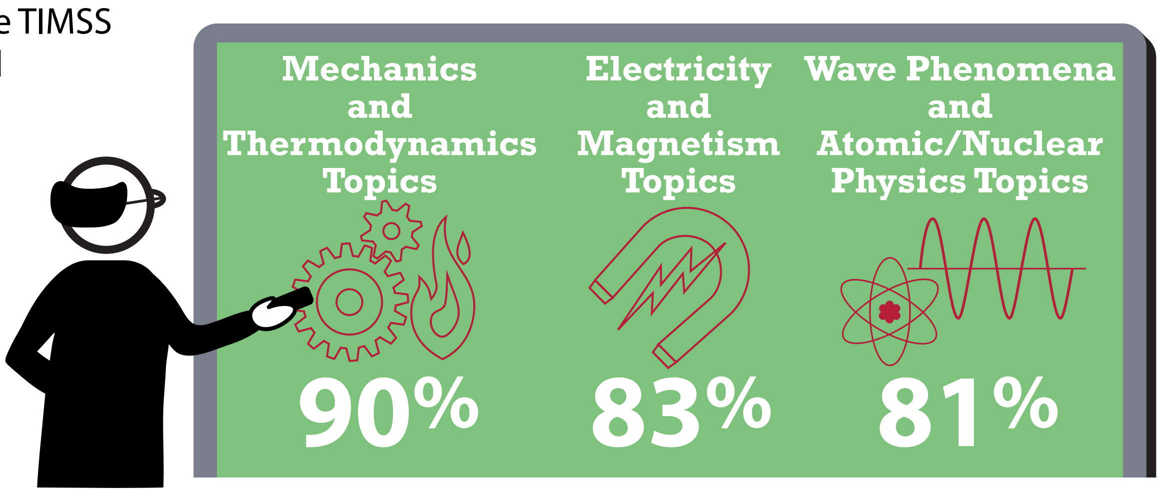
Curriculum

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.



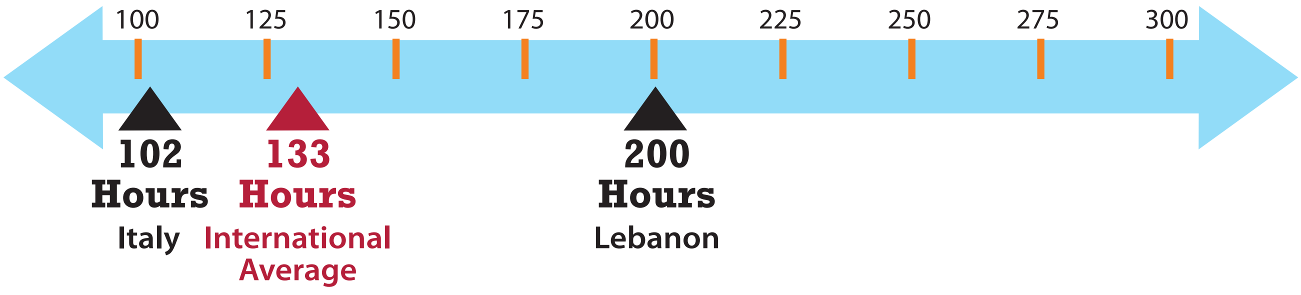
There was variation in topic coverage within content domains. However, according to their teachers, on average, most Physics students had been taught the TIMSS Advanced topics.



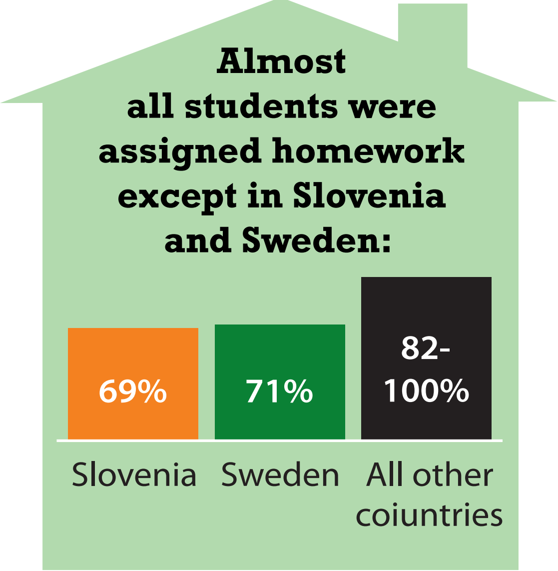
Instructional Time

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:



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

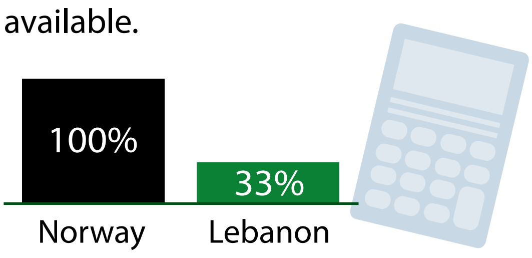
52% attended tutoring in the Russian Federation.

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.

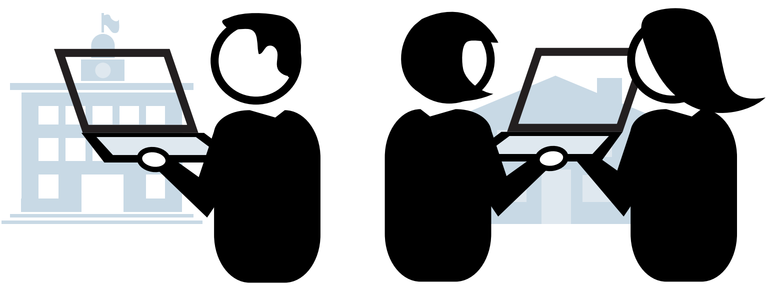


Teachers have students use their digital devices primarily to process and analyze data (71%), draw graphs of functions (67%), look up ideas and information (66%), and do scientific procedures or experiments (62%).

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

Find information about physics concepts or solve problems

Collaborate with classmates on physics assignements or projects



72-74% **64%**

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

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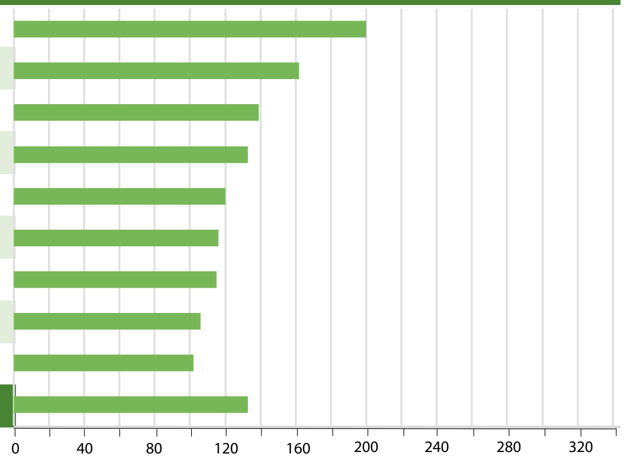
Lynch School of Education, Boston College

Exhibit 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.

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 = (Teacher Reports of Weekly Physics Instructional Hours / 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

TIMSS Advanced 2015 Physics

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)

* 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 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

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

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.

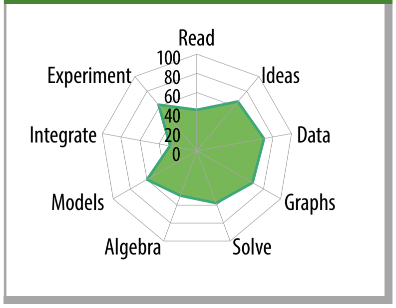
SOURCE: IEA's Trends in International Mathematics and Science Study – TIMSS Advanced 2015

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

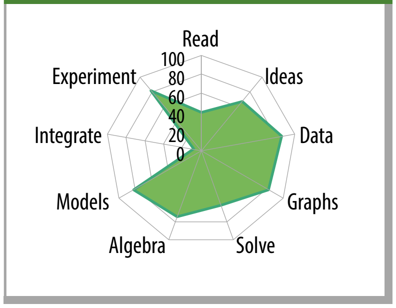
Reported by Physics Teachers

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.

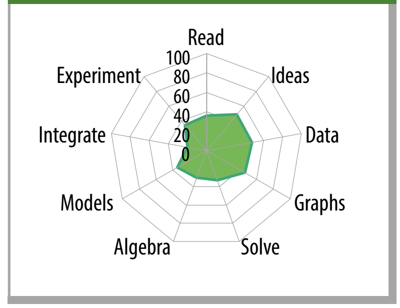
International Avg.



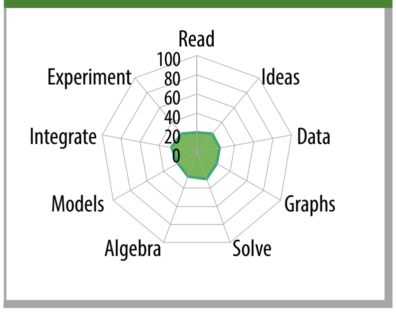
France



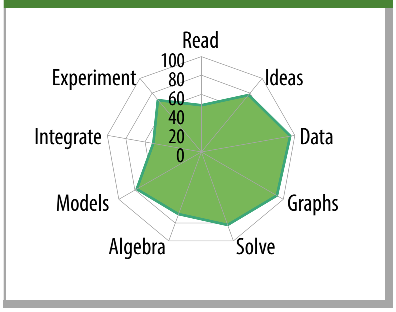
Italy



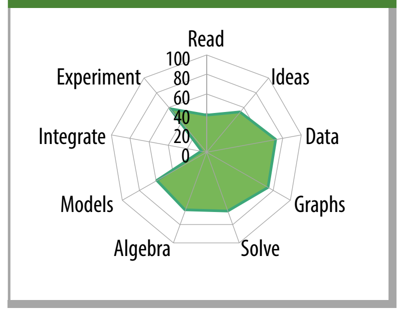
Lebanon



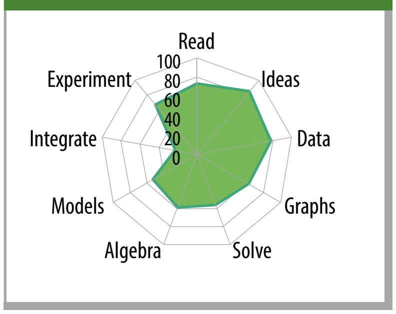
Norway



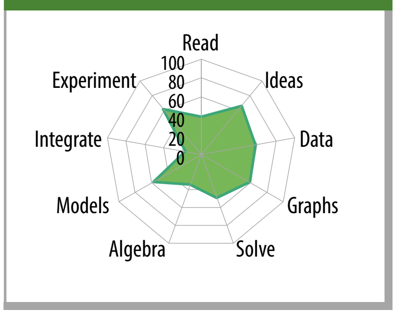
Portugal



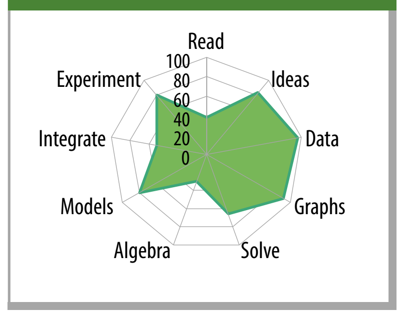
Russian Federation



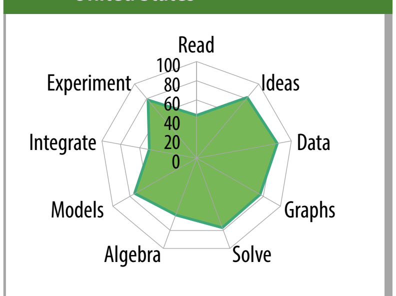
Slovenia



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

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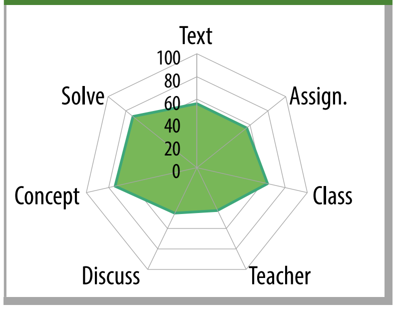
Lynch School of Education, Boston College

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

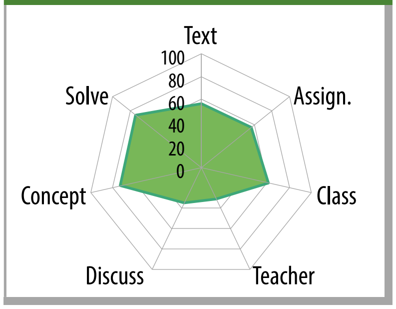
Reported by Physics Students

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.

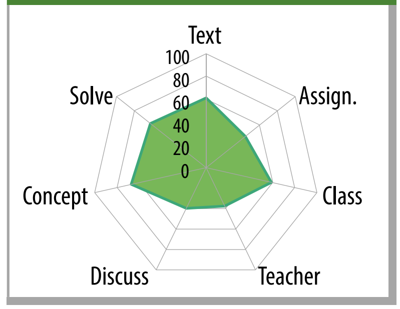
International Avg.



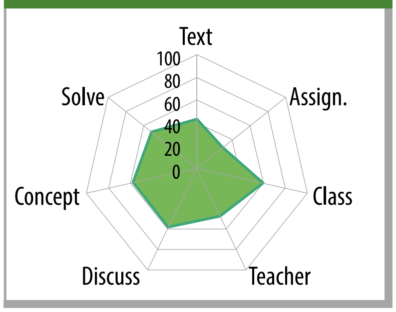
France



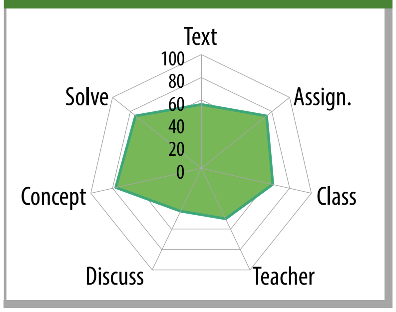
Italy



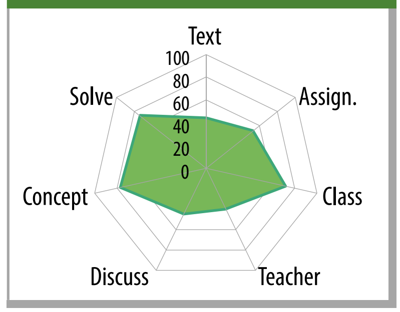
Lebanon



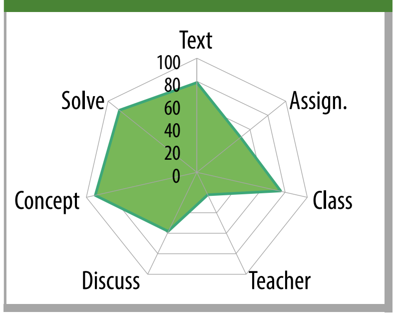
Norway



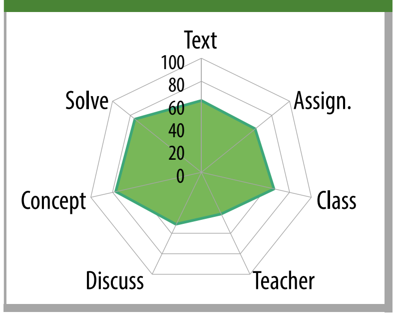
Portugal



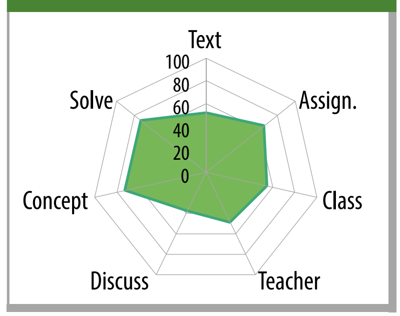
Russian Federation



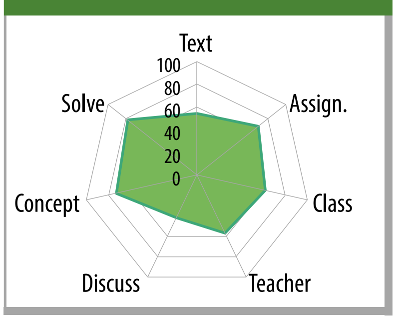
Slovenia



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

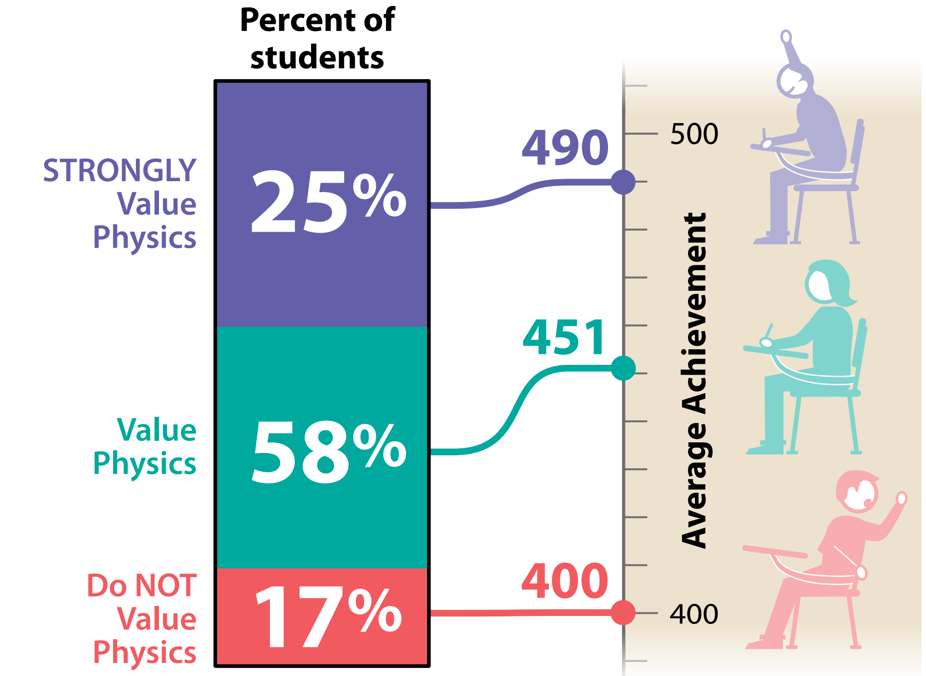
TIMSS ADVANCED 2015 INTERNATIONAL RESULTS IN ADVANCED MATHEMATICS AND PHYSICS

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

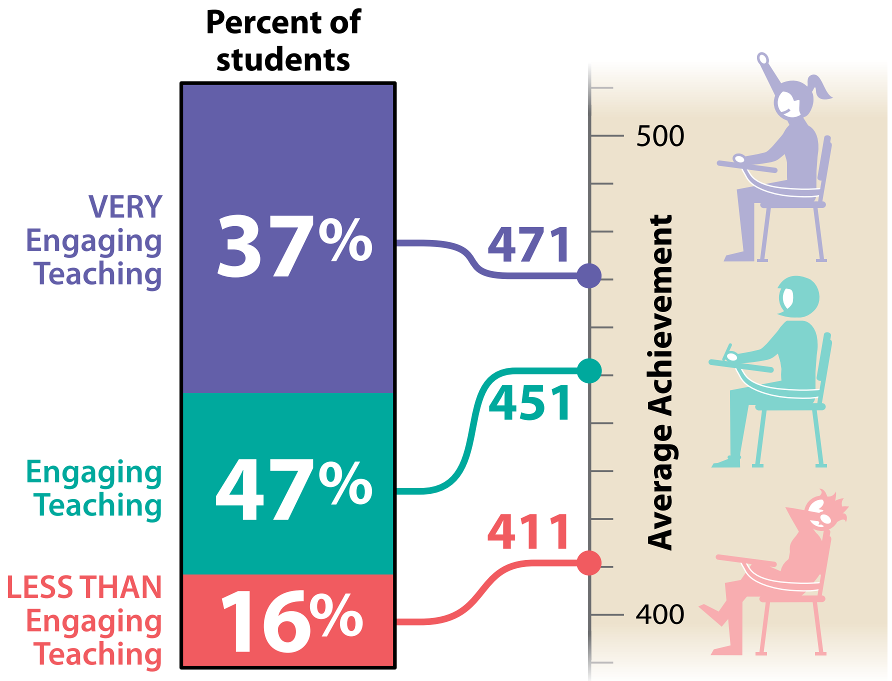
Students' Attitudes Toward Physics

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

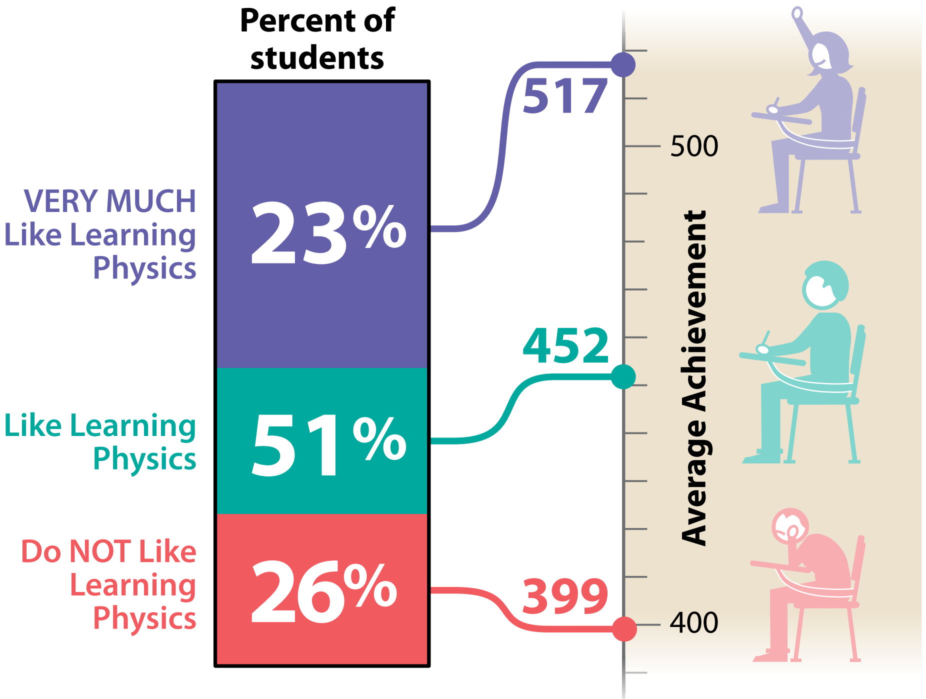
Most students (83%) STRONGLY value or value physics.



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

Very Engaging Teaching | 10.6 | Engaging Teaching | 8.2 | Less than Engaging Teaching

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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)	

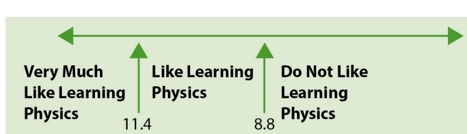
This TIMSS Advanced questionnaire scale was established in 2015 based on the combined response distribution of all countries that participated in TIMSS Advanced 2015. To provide a point of reference for country comparisons, the scale centerpoint of 10 was located at the mean of the combined distribution. 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



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

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

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( ) 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

Strongly Value Physics | 11.3 | Value Physics | 8.2 | Do Not Value Physics

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

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( ) 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
Advanced
2015

PHYSICS APPENDICES

TIMSS ADVANCED 2015 INTERNATIONAL RESULTS IN ADVANCED MATHEMATICS AND PHYSICS

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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

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

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.

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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