

Chapter 8

INTERNATIONAL STUDENT ACHIEVEMENT IN PHYSICS

Chapters 8 through 10 present the results for the physics test given to the subpopulation of students having taken physics. Chapter 8 summarizes achievement on the TIMSS physics test for each of the participating countries. Because resource limitations precluded studying all branches of science at the same level of detail, one was chosen for particular attention. Participating countries in TIMSS chose physics for detailed study because it is the branch of science most closely associated with mathematics, and because for many participants physics came closest to embodying the essential elements of natural science. The physics test was designed to measure learning of physics concepts and knowledge among final-year students having studied physics.

Comparisons are provided for the subpopulations of final-year physics students tested in each country. The relationship between achievement and the population of students tested is examined from several perspectives, because not all countries could provide complete coverage of the entire cohort of school-leaving age students. Comparisons are also provided by gender.

HOW DOES PERFORMANCE COMPARE FOR STUDENTS TESTED IN PHYSICS?

Table 8.1 presents the mean (or average) achievement for 16 countries that participated in the physics study for students in their final year of secondary school.¹ The 11 countries shown in decreasing order of mean achievement in the upper part of the table were judged to have met the TIMSS requirements for testing a representative sample of the final-year students having taken physics as described by their national definitions of this subpopulation.

As explained in the Introduction, in many of the countries not all of the school-leaving age cohort is still attending school, primarily because a number of students have dropped out. Additionally, in many countries, only a relatively small subset of the final-year students have taken the physics courses that would make them eligible for the physics study. Also, some countries, like the Russian Federation where all students in the general secondary schools take physics, defined only those students having taken advanced physics courses. The proportion of the entire school-leaving age cohort that participated in the physics study is indicated by the Physics TIMSS Coverage Index (PTCI). If the PTCI also reflects exclusion of part of the final-year student population, the country is footnoted (i.e., Austria, Cyprus, and the Russian Federation). Although for several countries the PTCI was approximately 15%, it varied from as little as 2% to 3% in the Russian Federation, Latvia (LSS), and Denmark to 33% in Austria and 39% in Slovenia.

¹ The achievement results for physics were derived from all of the physics items scaled together. Chapter 9 contains scaled results for the five physics content areas. See the "IRT Scaling and Data Analysis" section of Appendix B.

Although countries tried very hard to meet the TIMSS sampling requirements, many encountered resistance from schools, teachers, and students, and thus did not have the participation rates for both schools and students of 85% or higher (or a combined rate of 75%) specified in the TIMSS guidelines. Obtaining the voluntary participation of secondary school students who are taking demanding courses is particularly challenging because these students have many calls on their time. Beyond the problem of inducing students to attend the testing sessions, several countries encountered various difficulties in implementing the prescribed methods for sampling schools or students within schools, usually because of the organization of the education system. Because Israel did not clearly document its procedures for sampling schools, its achievement results are presented in Appendix D. Italy's sample size for the physics test was very small and so its results are presented in Appendix D. A full discussion of the sampling procedures and outcomes for each country can be found in Appendix B.

Despite the complications in sampling, the results reveal differences in average physics achievement between the top- and bottom-performing countries, although most countries fell somewhere in the middle ranges. Table 8.1 indicates whether the country averages were significantly above or below the international average of 501. In Norway, Sweden, the Russian Federation, and Denmark, the country average was significantly above the international average, while in six countries, Switzerland, Canada, France, the Czech Republic, Austria, and the United States it was significantly below the international average. Note that the PTCI was low in Norway (8%), and particularly in Denmark (3%), indicating that physics students in these countries are a very select group. In addition, the sampling of physics students in Denmark did not fully comply with the TIMSS sampling guidelines.

To illustrate the broad range of achievement both across and within countries, Table 8.1 graphically represents the distribution of student performance. Achievement for each country is shown for the 25th and 75th percentiles as well as for the 5th and 95th percentiles.² Each percentile point indicates the percentages of students performing below and above that point on the scale. For example, 25% of the students in each country performed below the 25th percentile for that country, and 75% performed above the 25th percentile.

The range between the 25th and 75th percentiles represents performance by the middle half of the students. In contrast, performance at the 5th and 95th percentiles represents the extremes in lower and higher achievement. The dark boxes at the midpoints of the distributions are the 95% confidence intervals around the achievement mean.³

² Tables of the percentile values and standard deviations for all countries are presented in Appendix E.

³ See the "IRT Scaling and Data Analysis" section of Appendix B for more details about calculating standard errors and confidence intervals for the TIMSS statistics.

Comparisons can be made across the means and percentiles. For example, average performance in Norway was comparable to or even exceeded performance at the 75th percentile in the lower-performing countries such as France, the Czech Republic, Austria, and the United States. Also, the differences between the extremes in performance were very large within most countries.

Figure 8.1 allows comparison of overall mean achievement between countries.⁴ It shows whether or not the differences in mean achievement between pairs of countries are statistically significant. Selecting a country of interest and reading across the table, a triangle pointing up indicates significantly higher performance than the country listed across the top, a dot indicates no significant difference, and a triangle pointing down indicates significantly lower performance. Countries shown in italics failed to satisfy one or more guidelines for sample participation rates or student sampling (see Appendix B for details).

In terms of average physics achievement, three clusters of countries can be identified. In the first cluster, Norway and Sweden, each with many triangles pointing up, had performance similar to each other and significantly higher average physics achievement than the other participating countries, although the Russian Federation, with a wide confidence interval for its mean, did not differ significantly from either Sweden or Norway. In the second cluster, there are relatively small differences from one country to the next, with most countries having lower mean achievement than some countries, about the same mean achievement as some countries, and higher mean achievement than other countries. Included in this group are Denmark, Slovenia, Germany, Australia, Cyprus, Switzerland, Latvia (LSS), Greece, and Canada. In the third cluster are France, the Czech Republic, Austria, and the United States. These countries had lower average physics achievement than the other countries. Within this cluster, France had higher achievement than Austria and the United States, and the Czech Republic had higher achievement than the United States. Latvia (LSS), like the Russian Federation, had a wide confidence interval for its mean, and so its mean was not significantly different from that of most other countries.

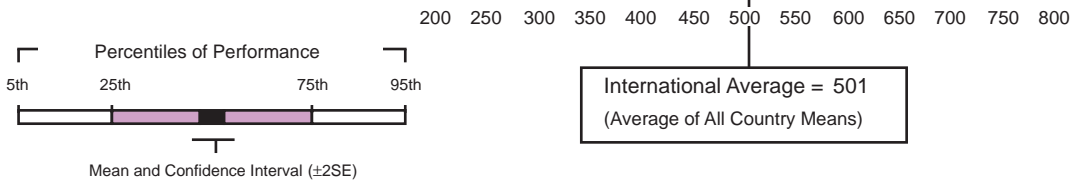
⁴ The significance tests in Figure 8.1 are based on a Bonferroni procedure for multiple comparisons that holds to 5% the probability of erroneously declaring the mean of one country to be different from that of another country.

Table 8.1

**Distributions of Physics Achievement for Students Having Taken Physics
Final Year of Secondary School***

Country	Mean	PTCI [†]	Average Age	Physics Scale Score			
[†] Norway	▲ 581 (6.5)	8%	19.0				
Sweden	▲ 573 (3.9)	16%	18.9				
² Russian Federation	▲ 545 (11.6)	2%	16.9				
[†] Germany	● 522 (11.9)	8%	19.1				
² Cyprus	● 494 (5.8)	9%	17.7				
¹ Latvia (LSS)	● 488 (21.5)	3%	18.0				
Switzerland	▼ 488 (3.5)	14%	19.5				
[†] Greece	● 486 (5.6)	10%	17.7				
Canada	▼ 485 (3.3)	14%	18.6				
France	▼ 466 (3.8)	20%	18.2				
Czech Republic	▼ 451 (6.2)	11%	18.1				
Countries Not Satisfying Guidelines for Sample Participation Rates (See Appendix B for Details)							
Australia	● 518 (6.2)	13%	17.7				
² Austria	▼ 435 (6.4)	33%	19.1				
United States	▼ 423 (3.3)	14%	18.0				
Countries With Unapproved Sampling Procedures and Low Participation Rates (See Appendix B for Details)							
Denmark	▲ 534 (4.2)	3%	19.1				
Slovenia	● 523 (15.5)	39%	18.8				

SOURCE: IEA Third International Mathematics and Science Study (TIMSS), 1995-96.



- ▲ = Country mean significantly higher than international mean
- ▼ = Country mean significantly lower than international mean
- = No statistically significant difference between country mean and international mean

* See Appendix A for characteristics of the students sampled.
[†] The Physics TIMSS Coverage Index (PTCI) is an estimate of the percentage of the school-leaving age cohort covered by the TIMSS final-year physics student sample (see Appendix B for more information).
 Because population coverage falls below 65%, Latvia is annotated LSS for Latvian Speaking Schools only.
[†] Met guidelines for sample participation rates only after replacement schools were included (see Appendix B for details).
¹ National Desired Population does not cover all of International Desired Population (see Table B.4).
² National Defined Population covers less than 90 percent of National Desired Population (see Table B.4).
 () Standard errors appear in parentheses. Because results are rounded to the nearest whole number, some totals may appear inconsistent.

Figure 8.1

Multiple Comparisons of Physics Achievement for Students Having Taken Physics Final Year of Secondary School*

Instructions: Read **across** the row for a country to compare performance with the countries listed in the heading of the chart. The symbols indicate whether the mean 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 two countries.[†]

Country	Norway	Sweden	Russian Federation	Denmark	Slovenia	Germany	Australia	Cyprus	Switzerland	Latvia (LSS)	Greece	Canada	France	Czech Republic	Austria	United States
Norway		●	●	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Sweden	●		●	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
<i>Russian Federation</i>	●	●		●	●	●	●	▲	▲	●	▲	▲	▲	▲	▲	▲
Denmark	▼	▼	●		●	●	●	▲	▲	●	▲	▲	▲	▲	▲	▲
Slovenia	▼	▼	●	●		●	●	●	●	●	●	●	▲	▲	▲	▲
Germany	▼	▼	●	●	●		●	●	●	●	●	▲	▲	▲	▲	▲
Australia	▼	▼	●	●	●	●		●	▲	●	▲	▲	▲	▲	▲	▲
Cyprus	▼	▼	▼	▼	●	●	●		●	●	●	●	▲	▲	▲	▲
Switzerland	▼	▼	▼	▼	●	●	▼	●		●	●	●	▲	▲	▲	▲
Latvia (LSS)	▼	▼	●	●	●	●	●	●	●		●	●	●	●	●	▲
Greece	▼	▼	▼	▼	●	●	▼	●	●	●		●	▲	▲	▲	▲
Canada	▼	▼	▼	▼	●	▼	▼	●	●	●	●		▲	▲	▲	▲
France	▼	▼	▼	▼	▼	▼	▼	▼	▼	●	▼	▼		●	▲	▲
Czech Republic	▼	▼	▼	▼	▼	▼	▼	▼	▼	●	▼	▼	●		●	▲
Austria	▼	▼	▼	▼	▼	▼	▼	▼	▼	●	▼	▼	▼	●		●
United States	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	●	

SOURCE: IEA Third International Mathematics and Science Study (TIMSS), 1995-96.

Countries are ordered by mean achievement across the heading and down the rows.



Mean achievement significantly higher than comparison country



No statistically significant difference from comparison country



Mean achievement significantly lower than comparison country

* See Appendix A for characteristics of the students sampled.

† Statistically significant at .05 level, adjusted for multiple comparisons.

Countries shown in italics did not satisfy one or more guidelines for sample participation rates or student sampling (see Figure B.6). Because population coverage falls below 65%, Latvia is annotated LSS for Latvian Speaking Schools only.

HOW DOES PERFORMANCE IN PHYSICS COMPARE, TAKING DIFFERENCES IN POPULATION COVERAGE INTO ACCOUNT?

Figure 8.2 shows the relationship between physics achievement and the PTCI.⁵ Most countries that took part in the TIMSS physics study considered that between 10% and 20% of the school-leaving age cohort were eligible for testing. The countries with PTCIs in this range showed wide differences in average achievement, with 150 scale-score points separating the average physics scores of Sweden at the high end from the United States at the low end. The six countries with less than 10% of the age cohort having taken physics had average scores at or above the international mean. Of the countries with the largest coverage indices, Slovenia was near the international average, and Austria below it.

Table 8.2 provides another way of examining performance, regardless of whether or not countries may have tested only their elite students. The 90th percentile is the point on the physics scale that divides the higher-performing 10% of the students from the lower-performing 90%. Table 8.2 shows the 90th percentile of performance for each country, and the mean achievement for the top 10% of the students in the entire school-leaving age cohort for each country. This analysis attempts to compare the achievement of the best physics students in each country, regardless of the extent to which the TIMSS test covered the entire cohort.

The 90th percentile provides a useful summary statistic on which to compare performance across countries. It is used instead of the mean in this table because it can be reliably estimated even when scores from some members of the population are not available (that is, those students in the school-leaving age cohort not included in the testing).⁶ As shown by the PTCI, the physics students tested in most countries represented at least 10% of the school-leaving age cohort. Countries where the coverage was less than 10% were excluded from the analysis in Table 8.2.

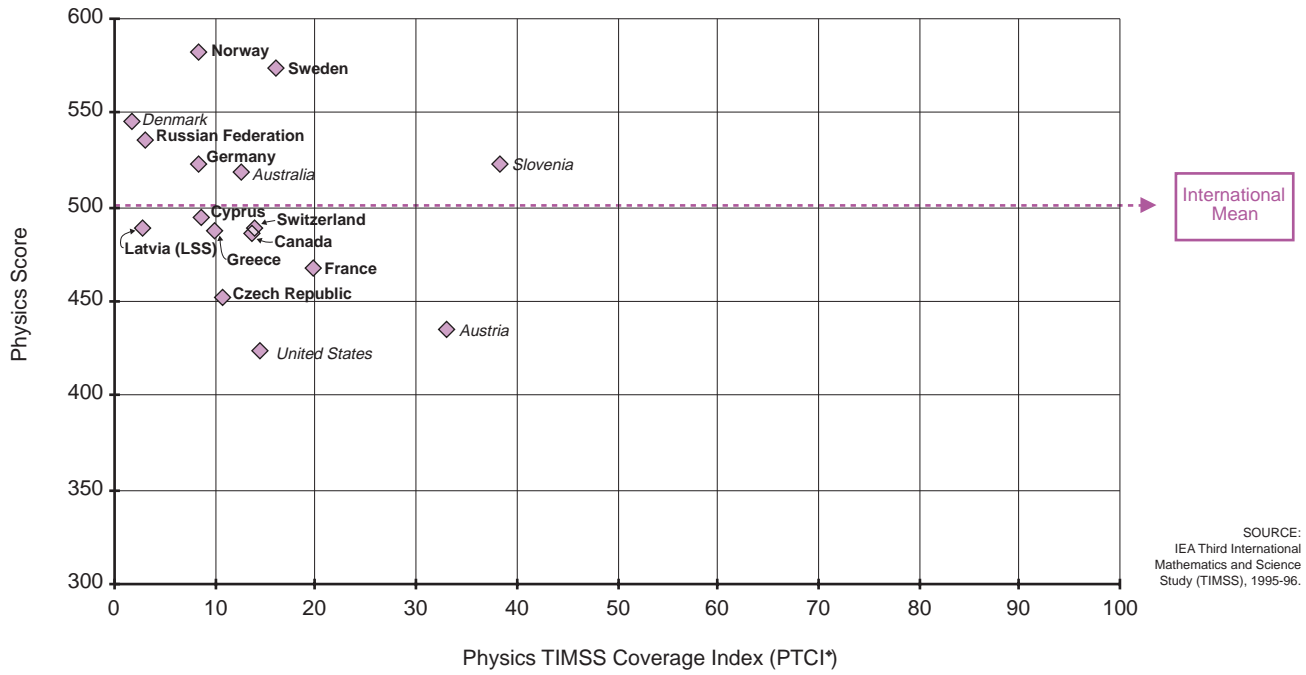
Notwithstanding the additional difficulties in calculating achievement for the entire school-leaving age cohort for each country rather than for the students actually tested, the results for the top 10% of the students in each country appear quite consistent with those obtained from the tested students. However, the countries in Table 8.2 most likely to improve their standing were those with the largest coverage index, since they were least likely to have tested just the elite students. That this proved to be the case is shown in Figure 8.3. Slovenia has joined Sweden at the top of the chart, despite having difficulties with low sampling participation and unapproved sampling procedures. These two countries had higher average physics achievement for the top 10% than any of the other countries. Austria also improved its relative position, moving from the lowest-scoring cluster of countries in Figure 8.1 to the middle group in Figure 8.3. The other countries generally maintained their standing.

⁵ The relationship between physics achievement and the PTCI has a correlation coefficient of -0.28 .

⁶ To compute the 90th percentile, TIMSS assumed that those students in the school-leaving age cohort not tested would score below the 90th percentile, primarily because they had not taken physics. The percentages of these students were added to the lower tail of the distribution before calculating the 90th percentile using the modified distribution.

Figure 8.2

Mean Physics Achievement by TIMSS Coverage Index for Students Having Taken Physics Final Year of Secondary School*



* See Appendix A for characteristics of the students sampled.

* The Physics TIMSS Coverage Index (PTCI) is an estimate of the percentage of the school-leaving age cohort covered by the TIMSS final-year physics student sample (see Appendix B for more information).

Countries shown in italics did not satisfy one or more guidelines for sample participation rates or student sampling (see Figure B.6).

Because population coverage falls below 65%, Latvia is annotated LSS for Latvian Speaking Schools only.

Table 8.2**Physics Achievement for the Top 10 Percent[®] of All Students in the School-Leaving Age Cohort***

Country	90 th Percentile	Mean Achievement of Top 10% of Students (Above 90 th Percentile)	Physics TCI
Sweden	549 (5.5)	630 (3.1)	16%
Switzerland	440 (4.7)	528 (3.8)	14%
Canada	433 (2.7)	522 (3.1)	14%
France	465 (3.4)	518 (3.0)	20%
† Greece	- -	486 (5.6)	10%
Czech Republic	355 (7.0)	464 (6.1)	11%
Countries Not Satisfying Guidelines for Sample Participation Rates (See Appendix B for Details)			
Australia	451 (8.5)	547 (4.6)	13%
† Austria	471 (10.8)	532 (6.1)	33%
United States	394 (3.6)	451 (2.6)	14%
Countries With Unapproved Sampling Procedures and Low Participation Rates (See Appendix B for Details)			
Slovenia	595 (15.1)	652 (13.9)	39%
International Average	462 (2.3)	533 (1.9)	

SOURCE: IEA Third International Mathematics and Science Study (TIMSS), 1995-96.

[®]To compute the 90th percentile, TIMSS assumed that the students in the school-leaving age cohort not tested would have scored below the 90th percentile and added them to the lower tail of the distribution.

* See Appendix A for characteristics of the students sampled.

† Met guidelines for sample participation rates only after replacement schools were included (see Appendix B for details).

¹ National Defined Population covers less than 90 percent of National Desired Population (see Table B.4).

() Standard errors appear in parentheses. Because results are rounded to the nearest whole number, some totals may appear inconsistent. Less than 10% of the students in the Russian Federation, Norway, Germany, Cyprus, Latvia (LSS), and Denmark took the physics test.

A dash (-) indicates data are not available. Because the students tested in Greece covered 10% of the school-leaving age cohort, the 90th percentile could not be estimated with precision.

Because coverage falls below 65%, Latvia is annotated LSS for Latvian Speaking Schools only.

Figure 8.3

Multiple Comparisons of Physics Achievement for the Top 10 Percent[®] of All Students in the School-Leaving Age Cohort^{*}

Instructions: Read **across** the row for a country to compare performance with the countries listed in the heading of the chart. The symbols indicate whether the mean 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 two countries.[†]

Country	<i>Slovenia</i>	Sweden	<i>Australia</i>	<i>Austria</i>	Switzerland	Canada	France	Greece	Czech Republic	<i>United States</i>
<i>Slovenia</i>		●	▲	▲	▲	▲	▲	▲	▲	▲
Sweden	●		▲	▲	▲	▲	▲	▲	▲	▲
<i>Australia</i>	▼	▼		●	▲	▲	▲	▲	▲	▲
<i>Austria</i>	▼	▼	●		●	●	●	▲	▲	▲
Switzerland	▼	▼	▼	●		●	●	▲	▲	▲
Canada	▼	▼	▼	●	●		●	▲	▲	▲
France	▼	▼	▼	●	●	●		▲	▲	▲
Greece	▼	▼	▼	▼	▼	▼	▼		●	▲
Czech Republic	▼	▼	▼	▼	▼	▼	▼	●		●
<i>United States</i>	▼	▼	▼	▼	▼	▼	▼	▼	●	

SOURCE: IEA Third International Mathematics and Science Study (TIMSS), 1995-96.

Countries are ordered by mean achievement across the heading and down the rows.

▲ Mean achievement significantly higher than comparison country

● No statistically significant difference from comparison country

▼ Mean achievement significantly lower than comparison country

[®]To compute the 90th percentile, TIMSS assumed that the students in the school-leaving age cohort not tested would have scored below the 90th percentile and added them to the lower tail of the distribution.

^{*} See Appendix A for characteristics of the students sampled.

[†] Statistically significant at .05 level, adjusted for multiple comparisons.

Countries shown in italics did not satisfy one or more guidelines for sample participation rates or student sampling (see Figure B.6).

Less than 10% of the students in the Russian Federation, Norway, Germany, Cyprus, Latvia (LSS), and Denmark took the physics test.

Because population coverage falls below 65%, Latvia is annotated LSS for Latvian Speaking Schools only.

Table 8.3**Physics Achievement for the Top 5 Percent[®] of All Students in the School-Leaving Age Cohort***

Country	95 th Percentile	Mean Achievement of Top 5% of Students (Above 95 th Percentile)	Physics TCI
Sweden	619 (6.1)	678 (4.2)	16%
† Norway	557 (6.5)	640 (3.4)	8%
Switzerland	512 (7.8)	582 (3.7)	14%
† Germany	498 (16.6)	582 (6.4)	8%
Canada	510 (4.3)	574 (4.8)	14%
† Cyprus	475 (8.8)	562 (5.2)	9%
† Greece	495 (6.9)	555 (3.4)	10%
France	508 (3.1)	550 (3.5)	20%
Czech Republic	448 (6.1)	520 (7.4)	11%
Countries Not Satisfying Guidelines for Sample Participation Rates (See Appendix B for Details)			
Australia	539 (9.5)	598 (6.3)	13%
† Austria	519 (9.1)	572 (7.4)	33%
United States	442 (6.2)	485 (3.2)	14%
Countries With Unapproved Sampling Procedures and Low Participation Rates (See Appendix B for Details)			
Slovenia	641 (25.6)	689 (12.7)	39%
International Average	520 (3.0)	583 (1.7)	

SOURCE: IEA Third International Mathematics and Science Study (TIMSS), 1995-96.

[®] To compute the 95th percentile, TIMSS assumed that the students in the school-leaving age cohort not tested would have scored below the 95th percentile and added them to the lower tail of the distribution.

* See Appendix A for characteristics of the students sampled.

† Met guidelines for sample participation rates only after replacement schools were included (see Appendix B for details).

¹ National Defined Population covers less than 90 percent of National Desired Population (see Table B.4).

() Standard errors appear in parentheses. Because results are rounded to the nearest whole number, some totals may appear inconsistent.

Less than 5% of the students in the Russian Federation, Latvia (LSS), and Denmark took the physics test.

Because population coverage falls below 65%, Latvia is annotated LSS for Latvian Speaking Schools only.

Figure 8.4

Multiple Comparisons of Physics Achievement for the Top 5 Percent[®] of All Students in the School-Leaving Age Cohort*

Instructions: Read **across** the row for a country to compare performance with the countries listed in the heading of the chart. The symbols indicate whether the mean 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 two countries.[†]

Country	<i>Slovenia</i>	Sweden	Norway	<i>Australia</i>	Switzerland	Germany	Canada	<i>Austria</i>	Cyprus	Greece	France	Czech Republic	<i>United States</i>
<i>Slovenia</i>		●	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Sweden	●		▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Norway	▼	▼		▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
<i>Australia</i>	▼	▼	▼		●	●	▲	●	▲	▲	▲	▲	▲
Switzerland	▼	▼	▼	●		●	●	●	▲	▲	▲	▲	▲
Germany	▼	▼	▼	●	●		●	●	●	▲	▲	▲	▲
Canada	▼	▼	▼	▼	●	●		●	●	▲	▲	▲	▲
<i>Austria</i>	▼	▼	▼	●	●	●	●		●	●	●	▲	▲
Cyprus	▼	▼	▼	▼	▼	●	●	●		●	●	▲	▲
Greece	▼	▼	▼	▼	▼	▼	▼	●	●		●	▲	▲
France	▼	▼	▼	▼	▼	▼	▼	●	●	●		▲	▲
Czech Republic	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼		▲
<i>United States</i>	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	▼	

SOURCE: IEA Third International Mathematics and Science Study (TIMSS), 1995-96.

Countries are ordered by mean achievement across the heading and down the rows.



Mean achievement significantly higher than comparison country



No statistically significant difference from comparison country



Mean achievement significantly lower than comparison country

[®]To compute the 95th percentile, TIMSS assumed that the students in the school-leaving age cohort not tested would have scored below the 95th percentile and added them to the lower tail of the distribution.

* See Appendix A for characteristics of the students sampled.

[†] Statistically significant at .05 level, adjusted for multiple comparisons.

Countries shown in italics did not satisfy one or more guidelines for sample participation rates or student sampling (see Figure B.6).

Less than 5% of the students in the Russian Federation, Latvia (LSS), and Denmark took the physics test.

Because population coverage falls below 65%, Latvia is annotated LSS for Latvian Speaking Schools only.

A very similar pattern emerges from a consideration of the top 5% of physics students in each country. Table 8.3 shows the 95th percentile of performance, and the mean achievement for the top 5% of the students in the entire school-leaving age cohort, for each country. Norway and Cyprus are included in this table, since only countries with less than 5% coverage were excluded. As shown in Figure 8.4, Slovenia and Sweden again have higher average physics achievement than the other countries, and the United States has the lowest average achievement.

HOW DOES PERFORMANCE IN PHYSICS COMPARE BY GENDER?

Table 8.4, which shows the differences in physics achievement by gender, reveals that males had significantly higher achievement than females in all but one of the participating countries. The table presents mean physics achievement separately for males and females for each country, as well as the difference between the means. The gender difference for each country, shown by a bar, indicates the amount of the difference, whether the direction of difference favors females or males, and whether the difference is statistically significant (a darkened bar). As can be seen, all of the differences favored males rather than females, and all but one of the differences were statistically significant. Only in Latvia (LSS) was the average physics score for males not significantly greater than that for females, and this may be partly the result of the larger than usual sampling error mentioned earlier.

Although the proportions of males and females taking physics were about equal in Latvia (LSS), Canada, the Russian Federation, Switzerland, and the United States, in several countries males outnumbered females by two or three to one. The disparity was greatest in Denmark, where 80% of the physics students were male and only 20% female. Only in Austria and the Czech Republic were there more female than male physics students. However, as previously observed, the difference in the proportions of males and females taking science courses does not explain, of itself, the gender differences in physics achievement. If it did, gender differences would be expected to be less in countries with greater proportions of female physics students, and that is not supported by the results in Table 8.4.

Table 8.4

Gender Differences in Physics Achievement for Students Having Taken Physics Final Year of Secondary School*

Country	Males		Females		Difference	PTCI	Gender Difference	
	Percent of Students	Mean Achievement	Percent of Students	Mean Achievement				
France	61 (2.0)	478 (4.2)	39 (2.0)	450 (5.6)	28 (7.0)	20%		
² Cyprus	63 (2.5)	509 (8.9)	37 (2.5)	470 (7.1)	40 (11.4)	9%		
¹ Latvia (LSS)	51 (3.7)	509 (19.0)	49 (3.7)	467 (22.6)	42 (29.5)	3%		
Canada	57 (3.2)	506 (6.0)	43 (3.2)	459 (6.3)	47 (8.7)	14%		
[†] Norway	74 (1.8)	594 (6.3)	26 (1.8)	544 (9.3)	51 (11.2)	8%		
Sweden	67 (3.4)	589 (5.1)	33 (3.4)	540 (5.3)	49 (7.4)	16%		
² Russian Federation	54 (2.0)	575 (9.9)	46 (2.0)	509 (15.3)	66 (18.2)	2%		
Czech Republic	38 (2.4)	503 (8.8)	62 (2.4)	419 (3.9)	83 (9.7)	11%		
Switzerland	51 (1.8)	529 (5.2)	49 (1.8)	446 (3.6)	83 (6.3)	14%		
[†] Greece	68 (2.1)	495 (6.1)	32 (2.1)	468 (8.1)	28 (10.1)	10%		
[†] Germany	69 (3.0)	542 (14.3)	31 (3.0)	479 (9.1)	64 (17.0)	8%		
Countries Not Satisfying Guidelines for Sample Participation Rates (See Appendix B for Details)								
Australia	66 (3.8)	532 (6.7)	34 (3.8)	490 (8.4)	42 (10.8)	13%		
² Austria	38 (3.5)	479 (8.1)	62 (3.5)	408 (7.4)	71 (11.0)	33%		
United States	52 (2.4)	439 (4.3)	48 (2.4)	405 (3.1)	33 (5.3)	14%		
Countries With Unapproved Sampling Procedures and Low Participation Rates (See Appendix B for Details)								
Denmark	80 (2.3)	542 (5.2)	20 (2.3)	500 (8.1)	42 (9.6)	3%		
Slovenia	72 (3.7)	546 (16.3)	28 (3.7)	455 (18.7)	91 (24.8)	39%		

International Averages

Males	Females	Difference
523	469	54

(Averages of All Country Means)

Gender difference statistically significant at .05 level.
 Gender difference not statistically significant.

SOURCE: IEA Third International Mathematics and Science Study (TIMSS), 1995-96.

* See Appendix A for characteristics of the students sampled.

Because population coverage falls below 65%, Latvia is annotated LSS for Latvian Speaking Schools only.

[†] Met guidelines for sample participation rates only after replacement schools were included (see Appendix B for details).

¹ National Desired Population does not cover all of International Desired Population (see Table B.4).

² National Defined Population covers less than 90 percent of National Desired Population (see Table B.4).

() Standard errors appear in parentheses. Because results are rounded to the nearest whole number, some differences may appear inconsistent.

HOW WELL DID STUDENTS HAVING TAKEN PHYSICS PERFORM IN MATHEMATICS AND SCIENCE LITERACY?

The PTCI provides one indicator of the percentage of a country's school-leaving age cohort that has taken physics, and confirms that in most of the TIMSS countries, physics in upper secondary school is taken by only a small proportion of students. Table 8.5 provides further information on these students by comparing their performance on the science literacy test, and on the composite mathematics and science literacy test, with the performance of final-year students in general. It is clear from this table that students having taken physics generally come from the high end of the achievement continuum. As might be expected, there was a tendency for achievement differences to be greatest in countries where the coverage index was least. The science literacy difference ranged from 49 in Slovenia (PTCI of 39%) to 124 in Norway (PTCI of 8%).

Table 8.5**Comparison Between All Students in Their Final Year of Secondary School and Final-Year Students Having Taken Physics in Mathematics and Science Literacy**

Country	Mean Achievement				Overall TCI	Physics TCI
	Mathematics and Science Literacy		Science Literacy			
	All Students	Physics Students	All Students	Physics Students		
Canada	526 (2.6)	594 (5.5)	532 (2.6)	596 (5.5)	70%	14%
¹ Cyprus	447 (2.5)	521 (6.1)	448 (3.0)	526 (6.2)	48%	9%
Czech Republic	476 (10.5)	582 (7.2)	487 (8.8)	591 (6.8)	78%	11%
France	505 (4.9)	572 (5.0)	487 (5.1)	553 (4.9)	84%	20%
[†] Germany	496 (5.4)	591 (7.3)	497 (5.1)	586 (7.5)	75%	8%
[†] Norway	536 (4.0)	658 (6.7)	544 (4.1)	668 (8.0)	84%	8%
Sweden	555 (4.3)	664 (3.7)	559 (4.4)	668 (4.1)	71%	16%
Switzerland	531 (5.4)	618 (4.2)	523 (5.3)	617 (4.5)	82%	14%
Countries Not Satisfying Guidelines for Sample Participation Rates (See Appendix B for Details)						
Australia	525 (9.5)	610 (7.7)	527 (9.8)	610 (8.9)	68%	13%
¹ Austria	519 (5.4)	567 (5.9)	520 (5.6)	570 (6.2)	76%	33%
United States	471 (3.1)	548 (5.2)	480 (3.3)	553 (5.7)	63%	14%
Countries With Unapproved Sampling Procedures and Low Participation Rates (See Appendix B for Details)						
Denmark	528 (3.2)	610 (6.7)	509 (3.6)	592 (7.3)	58%	3%
Slovenia	514 (8.2)	563 (8.0)	517 (8.2)	566 (8.7)	88%	39%
International Average	510 (1.6)	592 (1.7)	510 (1.6)	592 (1.8)		

SOURCE: IEA Third International Mathematics and Science Study (TIMSS), 1995-96.

[†] Met guidelines for sample participation rates only after replacement schools were included (see Appendix B for details).

¹ National Defined Population covers less than 90 percent of National Desired Population (see Table B.4).

() Standard errors appear in parentheses. Because results are rounded to the nearest whole number, some totals may appear inconsistent.

The procedures used by Latvia (LSS) and Russian Federation do not permit estimating literacy achievement for students taking physics.

Greece did not test the population of all students in their final year of secondary school.

Because population coverage falls below 65%, Latvia is annotated LSS for Latvian Speaking Schools only.

Chapter 9

ACHIEVEMENT IN PHYSICS CONTENT AREAS

TIMSS measured achievement in different content areas of physics in order to gather more information about what each country's population of physics students know and can do than an overall physics score would provide. The physics test for final year students was designed to enable reporting by five content areas.¹ These are:

- Mechanics
- Electricity and magnetism
- Heat
- Wave phenomena
- Modern physics: particle, quantum and astrophysics, and relativity

This chapter summarizes student performance across countries in the five physics content areas, and goes on to provide further information about the type of items in each area, including six example items and the percentage of correct responses on those items for each TIMSS country.

HOW DOES PERFORMANCE COMPARE ACROSS CONTENT AREAS?

As well as scaling the complete physics item pool to obtain an overall physics scale, TIMSS scaled each of the five content areas separately to facilitate analyses at the content level. Table 9.1 summarizes the country means and standard errors on each content scale for each country, and also provides the Physics TIMSS Coverage Index. The international averages of each of the subscales was arbitrarily set to be 500.² In general, countries' performance in the physics content areas resembles their performance on the test overall, although few countries performed equally well or poorly in all five areas. Among the highest performers, Norway and Sweden fell above the international average in all five physics content areas. In contrast, Austria and the United States performed below the international mean in all five. Every other country except Latvia (LSS) scored significantly above or below the international mean in at least one content area, and about at the mean in others.

Figure 9.1 graphically depicts each country's strengths and weaknesses in the physics content areas compared with their average performance across all five content areas. The horizontal line indicates each country's overall average achievement in physics, and the five darkened boxes indicate the 95% confidence intervals around the mean achievement in each of the five content areas. If the darkened box is below the line, then the country performed significantly less well in that content area than it did overall. Similarly, if the darkened box is above the line, then the

¹ See the "Test Development" section of Appendix B for more information about the process used to develop the TIMSS tests. Appendix C provides an analysis of the match between the test and curriculum in the different TIMSS countries and the effect of this match on the TIMSS results.

² Final revisions of the data resulted in international averages of 501 for some of the physics scales.

Table 9.1

Achievement in Physics Content Areas for Students Having Taken Physics Final Year of Secondary School*

Country	PTCI	Physics Content Areas Mean Achievement Scale Scores				
		Mechanics (16 items)	Electricity and Magnetism (16 items)	Heat (9 items)	Wave Phenomena (10 items)	Modern Physics: Particle, Quantum and Astrophysics, and Relativity (14 items)
Canada	14%	▼ 473 (3.6)	▼ 485 (3.7)	● 508 (4.2)	▼ 488 (3.2)	● 494 (2.7)
² Cyprus	9%	▲ 530 (6.6)	● 502 (6.3)	▼ 476 (6.7)	● 507 (6.5)	▼ 434 (5.2)
Czech Republic	11%	▼ 469 (6.0)	▼ 465 (5.5)	● 488 (4.7)	▼ 447 (5.4)	▼ 453 (4.9)
France	20%	▼ 457 (4.3)	● 494 (4.1)	● 491 (3.4)	▼ 463 (3.6)	▼ 474 (3.4)
[†] Germany	8%	● 495 (9.4)	● 512 (9.9)	● 496 (6.4)	▲ 530 (10.3)	▲ 545 (13.1)
[†] Greece	10%	● 514 (6.5)	● 520 (6.6)	● 481 (7.2)	▼ 453 (5.3)	▼ 447 (4.9)
[†] Latvia (LSS)	3%	● 489 (18.1)	● 485 (17.4)	● 504 (21.4)	● 498 (17.6)	● 488 (19.0)
[†] Norway	8%	▲ 572 (6.4)	▲ 565 (6.2)	▲ 536 (4.3)	▲ 560 (5.4)	▲ 576 (5.3)
² Russian Federation	2%	▲ 537 (9.3)	▲ 549 (9.2)	▲ 530 (10.4)	● 515 (9.4)	▲ 542 (9.9)
Sweden	16%	▲ 563 (4.0)	▲ 570 (3.3)	▲ 522 (4.3)	▲ 560 (4.7)	▲ 560 (3.5)
Switzerland	14%	▼ 482 (3.5)	▼ 480 (4.5)	● 509 (3.6)	● 498 (3.1)	▼ 488 (3.8)
Countries Not Satisfying Guidelines for Sample Participation Rates (See Appendix B for Details)						
Australia	13%	● 507 (6.1)	● 512 (4.4)	▲ 517 (4.3)	● 519 (6.9)	▲ 521 (5.8)
² Austria	33%	▼ 420 (4.9)	▼ 432 (6.3)	▼ 445 (5.6)	▼ 468 (7.3)	▼ 480 (6.0)
United States	14%	▼ 420 (2.8)	▼ 420 (3.0)	▼ 477 (3.0)	▼ 451 (2.2)	▼ 456 (2.5)
Countries With Unapproved Sampling Procedures and Low Participation Rates (See Appendix B for Details)						
Denmark	3%	▲ 529 (4.9)	● 513 (3.8)	● 512 (4.3)	▲ 537 (5.5)	▲ 544 (4.9)
Slovenia	39%	▲ 552 (17.3)	● 509 (14.6)	● 521 (10.4)	● 514 (11.5)	● 511 (15.1)
International Average		501 (2.1)	501 (2.0)	501 (2.0)	500 (1.9)	501 (2.1)

SOURCE: IEA Third International Mathematics and Science Study (TIMSS), 1995-96.

▲ = Country average significantly higher than the international average for the scale

● = No significant difference between country average and international average for the scale

▼ = Country average significantly lower than the international average for the scale

* See Appendix A for characteristics of the students sampled.

Because population coverage falls below 65%, Latvia is annotated LSS for Latvian Speaking Schools only.

[†] Met guidelines for sample participation rates only after replacement schools were included (see Appendix B for details).¹ National Desired Population does not cover all of International Desired Population (see Table B.4).² National Defined Population covers less than 90 percent of National Desired Population (see Table B.4).

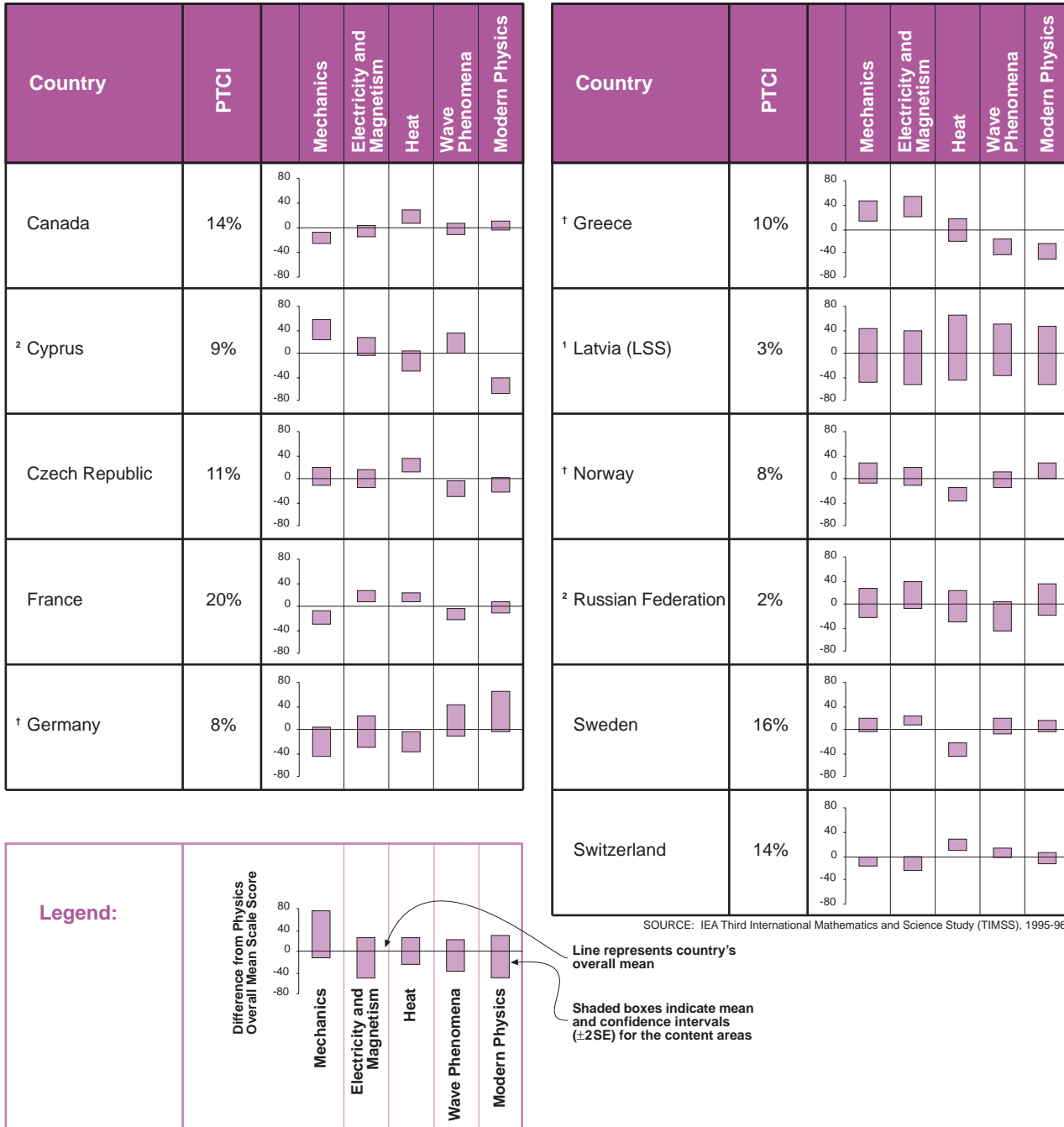
() Standard errors appear in parentheses. Because results are rounded to the nearest whole number, some totals may appear inconsistent.

country performed significantly better in that content area than it did overall. Most countries did relatively better in some areas and less well in others. Students in Canada performed relatively less well in mechanics and relatively better in heat than they did on the physics test as a whole. In Cyprus, students performed better in mechanics and wave phenomena, and less well in modern physics. Students in the Czech Republic performed relatively better in heat, and relatively less well in wave phenomena than they did on the test overall. French students performed relatively better in electricity and magnetism and heat, and relatively less well in mechanics and in wave phenomena, whereas students in Germany performed relatively less well in heat. Students in Greece performed better in mechanics and electricity and magnetism, and less well in wave phenomena and modern physics. Whereas students in Norway and Sweden, both countries with high average performance on the physics test, had a relative weakness in heat, students in Switzerland had a relative strength in this area. Students in Norway performed relatively better in modern physics, whereas students in Sweden did relatively better in electricity and magnetism. Students in Switzerland had relatively lower achievement in mechanics and electricity and magnetism. Austrian students showed relative strengths in wave phenomena and modern physics, and relative weakness in mechanics. Students in Denmark also had relatively higher achievement in modern physics, but relatively lower achievement in electricity and magnetism and heat. Compared with their overall mean achievement, students in the United States performed better in heat, wave phenomena, and modern physics, and less well in mechanics, and electricity and magnetism. For Latvia (LSS), the Russian Federation, Australia, and Slovenia, performance in the individual content areas was not significantly different from their overall physics scores.

It was evident from Chapter 8 that male students outperformed female students on the overall physics test in all countries but one. Table 9.2 provides further information on this issue by presenting gender differences for each country on each physics content area scale. The international average for males was significantly higher than the average for females on each of the content area scales, with the difference between males and females ranging from 31 scale points in electricity and magnetism to 58 scale point in mechanics. Significant gender differences favoring males were found in more countries in the areas of mechanics (15 countries), wave phenomena (11 countries), and modern physics (12 countries) than in electricity and magnetism (8 countries) or heat (7 countries). Apart from Latvia (LSS), which showed no significant gender differences on any content scale, the countries with significant gender differences on the fewest content scales were Cyprus, Greece, and Denmark. Significant gender differences on all five content scales were shown in the Czech Republic, Switzerland, and Austria.

Figure 9.1

Profiles of Performance in Physics Content Areas for Students Having Taken Physics Final Year of Secondary School*



SOURCE: IEA Third International Mathematics and Science Study (TIMSS), 1995-96.

* See Appendix A for characteristics of students sampled.

Because population coverage falls below 65%, Latvia is annotated LSS for Latvia Speaking School only.

[†] Met guidelines for sample participation rates only after replacement schools were included (see Appendix B for details).

¹ National Desired Population does not cover all of International Desired Population (see Table B.4).

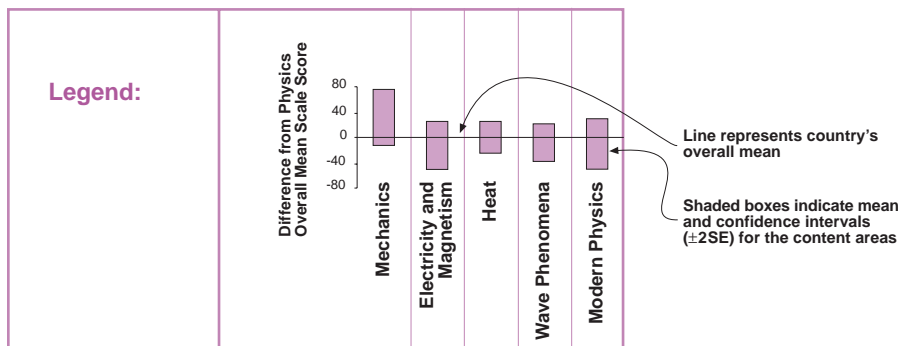
² National Defined Population covers less than 90 percent of National Desired Population (see Table B.4).

Figure 9.1 (Continued)

Profiles of Performance in Physics Content Areas for Students Having Taken Physics Final Year of Secondary School*



SOURCE: IEA Third International Mathematics and Science Study (TIMSS), 1995-96.



* See Appendix A for characteristics of students sampled.

† Met guidelines for sample participation rates only after replacement schools were included (see Appendix B for details).

¹ National Desired Population does not cover all of International Desired Population (see Table B.4).

² National Defined Population covers less than 90 percent of National Desired Population (see Table B.4).

Table 9.2

Achievement in Physics Content Areas by Gender for Students Having Taken Physics Final Year of Secondary School*

Country	PTCI	Physics Content Areas Mean Achievement Scale Scores					
		Mechanics (16 items)		Electricity and Magnetism (16 items)		Heat (9 items)	
		Females	Males	Females	Males	Females	Males
Canada	14%	440 (5.7)	▲ 499 (6.6)	468 (6.5)	▲ 497 (6.2)	492 (8.1)	520 (5.2)
² Cyprus	9%	496 (10.3)	▲ 551 (9.6)	494 (7.4)	507 (8.5)	461 (11.2)	484 (9.8)
Czech Republic	11%	440 (4.8)	▲ 514 (8.4)	443 (3.3)	▲ 501 (8.7)	472 (4.5)	▲ 513 (6.6)
France	20%	437 (5.5)	▲ 470 (5.6)	491 (5.2)	495 (4.2)	487 (5.7)	496 (4.0)
[†] Germany	8%	453 (10.6)	▲ 515 (9.6)	491 (7.7)	522 (12.1)	461 (10.6)	▲ 513 (6.3)
[†] Greece	10%	489 (7.2)	▲ 525 (7.0)	515 (11.0)	522 (6.5)	460 (10.5)	490 (8.1)
¹ Latvia (LSS)	3%	468 (19.8)	509 (15.2)	474 (18.4)	496 (16.8)	484 (23.4)	523 (17.8)
[†] Norway	8%	523 (9.0)	▲ 589 (6.1)	549 (10.0)	570 (6.2)	511 (7.0)	▲ 545 (4.4)
² Russian Federation	2%	507 (12.3)	▲ 563 (7.4)	519 (12.9)	▲ 575 (7.7)	501 (14.8)	▲ 555 (7.5)
Sweden	16%	517 (4.4)	▲ 586 (4.6)	551 (4.7)	▲ 579 (4.8)	507 (5.3)	529 (5.8)
Switzerland	14%	444 (3.5)	▲ 519 (5.3)	452 (4.5)	▲ 507 (7.1)	480 (5.7)	▲ 538 (4.3)
Countries Not Satisfying Guidelines for Sample Participation Rates (See Appendix B for Details)							
Australia	13%	474 (6.8)	▲ 524 (7.8)	488 (8.3)	▲ 525 (6.7)	503 (6.2)	524 (5.0)
² Austria	33%	399 (6.3)	▲ 459 (6.6)	409 (6.9)	▲ 468 (9.1)	420 (6.8)	▲ 485 (8.0)
United States	14%	393 (2.8)	▲ 446 (3.5)	409 (3.6)	▲ 430 (3.5)	474 (2.7)	480 (4.2)
Countries With Unapproved Sampling Procedures and Low Participation Rates (See Appendix B for Details)							
Denmark	3%	483 (10.2)	▲ 540 (5.5)	498 (7.8)	515 (4.5)	487 (9.6)	517 (5.3)
Slovenia	39%	487 (21.7)	▲ 576 (17.5)	470 (13.8)	522 (16.6)	470 (18.7)	▲ 538 (13.1)
International Average		466 (2.6)	▲ 524 (2.2)	483 (2.3)	▲ 514 (2.2)	479 (2.7)	▲ 516 (2.0)

SOURCE: IEA Third International Mathematics and Science Study (TIMSS), 1994-95.

▲ = Difference from other gender statistically significant at .05 level, adjusted for multiple comparisons

* See Appendix A for characteristics of the students sampled.

Because population coverage falls below 65%, Latvia is annotated LSS for Latvian Speaking Schools only.

[†] Met guidelines for sample participation rates only after replacement schools were included (see Appendix B for details).¹ National Desired Population does not cover all of International Desired Population (see Table B.4).² National Defined Population covers less than 90 percent of National Desired Population (see Table B.4).

() Standard errors appear in parentheses. Because results are rounded to the nearest whole number, some totals may appear inconsistent.

Table 9.2 (Continued)**Achievement in Physics Content Areas by Gender for Students Having Taken Physics Final Year of Secondary School***

Country	PTCI	Physics Content Areas Mean Achievement Scale Scores			
		Wave Phenomena (10 items)		Modern Physics: Particle, Quantum and Astrophysics, and Relativity (14 items)	
		Females	Males	Females	Males
Canada	14%	476 (6.4)	497 (4.3)	471 (5.1)	▲ 513 (6.0)
² Cyprus	9%	486 (8.4)	519 (10.4)	411 (9.9)	▲ 450 (7.7)
Czech Republic	11%	419 (4.9)	▲ 491 (7.2)	425 (4.6)	▲ 498 (6.9)
France	20%	448 (4.6)	▲ 475 (5.6)	457 (4.1)	▲ 485 (4.3)
[†] Germany	8%	485 (10.1)	▲ 551 (12.7)	508 (13.5)	561 (15.3)
[†] Greece	10%	444 (7.2)	457 (7.4)	426 (5.7)	▲ 456 (6.4)
¹ Latvia (LSS)	3%	480 (16.2)	515 (17.3)	470 (20.8)	505 (16.6)
[†] Norway	8%	519 (10.2)	▲ 575 (4.9)	549 (9.9)	▲ 585 (5.0)
² Russian Federation	2%	487 (12.4)	▲ 539 (7.9)	520 (13.9)	561 (7.9)
Sweden	16%	528 (5.9)	▲ 576 (6.1)	538 (6.2)	▲ 570 (3.3)
Switzerland	14%	460 (4.4)	▲ 533 (4.8)	457 (4.4)	▲ 519 (5.8)
Countries Not Satisfying Guidelines for Sample Participation Rates (See Appendix B for Details)					
Australia	13%	498 (7.2)	529 (9.0)	497 (7.8)	▲ 533 (6.7)
² Austria	33%	444 (9.7)	▲ 506 (7.3)	465 (6.1)	▲ 505 (9.9)
United States	14%	442 (3.0)	▲ 460 (2.6)	446 (2.3)	▲ 466 (3.6)
Countries With Unapproved Sampling Procedures and Low Participation Rates (See Appendix B for Details)					
Denmark	3%	493 (10.0)	▲ 547 (6.3)	529 (7.4)	546 (6.0)
Slovenia	39%	446 (13.4)	▲ 538 (11.9)	458 (14.1)	▲ 528 (18.7)
International Average		472 (2.3)	▲ 519 (2.2)	477 (2.4)	▲ 518 (2.3)

SOURCE: IEA Third International Mathematics and Science Study (TIMSS), 1994-95.

▲ = Difference from other gender statistically significant at .05 level, adjusted for multiple comparisons

* See Appendix A for characteristics of the students sampled.

Because population coverage falls below 65%, Latvia is annotated LSS for Latvian Speaking Schools only.

[†] Met guidelines for sample participation rates only after replacement schools were included (see Appendix B for details).¹ National Desired Population does not cover all of International Desired Population (see Table B.4).² National Defined Population covers less than 90 percent of National Desired Population (see Table B.4).

() Standard errors appear in parentheses. Because results are rounded to the nearest whole number, some totals may appear inconsistent.

WHAT ARE SOME EXAMPLES OF PERFORMANCE IN PHYSICS?

This section presents six example items from the physics test, including the performance on each item for each TIMSS country. The example items were chosen to illustrate the topics covered within each content area and to show the range of difficulty. Example Item 1, presented in Table 9.3, requires students to indicate why boiling a small volume of water produces a large volume of steam. On average across countries, about two-thirds of the students having taken courses in physics selected the correct answer to this question, demonstrating an understanding of the relationship between the increased volume and the relative distance between water molecules in the liquid and gaseous states. Three-fourths or more of the students in Norway, Sweden, Australia, Denmark, and Slovenia answered this question correctly.

Example Item 2, from modern physics, asked students to apply their knowledge of special relativity to determine the length of a spaceship traveling at close to the speed of light as seen by a stationary observer. In order to solve this problem, students needed to correctly apply the mathematical equation for relativistic length contraction ($L = L_0(1 - v^2/c^2)^{1/2}$). As shown in Table 9.4, fewer than half of the students on average internationally responded correctly. There was considerable variation in performance across countries, with the proportion of students responding correctly ranging from about one-fourth to nearly three-fourths. More than 60% of the students in Norway, the Russian Federation, and Sweden answered this item correctly. An additional 20% of students internationally selected option A, indicating some knowledge that the length of the moving spaceship would appear contracted relative to its length at rest, but made an incorrect calculation by omitting the square-root operation.

Example Item 3, from wave phenomena, proved more difficult for students internationally. This item required an understanding of the refraction of light as it passes through a semicircular glass block into air. As presented in Table 9.5, about 37% of the students internationally, on average, correctly identified the direction in which the refracted ray of light would travel after leaving the glass block. The highest performance was in Norway, the Russian Federation, and Sweden, where slightly more than half of the students chose the correct answer; the lowest performance was in Greece, where fewer than 20% chose the correct answer. Internationally, about one-fourth of the students, on average, selected option C, showing the refracted beam that would occur if the ray of light were traveling from air into glass rather than glass into air. The selection of this option indicates some understanding of refraction at a glass/air interface but an incorrect application to the problem presented.

Example Item 4, from the content area electricity and magnetism, was also difficult for most students. Students were provided with a diagram representing electrons moving at a given velocity and entering a perpendicular uniform electric field, and were asked to identify the path taken by the electrons in the electric field. About one-third of students on average identified the correct path, showing deflection of the electron away from the negative charge and toward the positive charge in the electric field (see Table 9.6). The highest performance was in France, Norway, and Sweden, where the majority of students chose the correct answer, and the lowest was in the Czech Republic, Austria, and the United States, each with less than 15% correct. Another third of students internationally selected the incorrect option B,

showing deflection of the electron in the opposite direction, toward the negative charge. In fact, this was the most frequent response chosen in several countries. This response indicates some understanding that the path of the electrons will be deflected in an electric field but a misinterpretation of the direction of negative and positive charges as shown by the electric field vector in the diagram.

Example Item 5, from mechanics, was quite difficult for students in most countries. In this item, students were shown a pictorial representation of an amusement park ride in which a rider is pressed against the wall of a rotating cylinder. As seen in Table 9.7, only 20% of the students on average could correctly identify the three real forces acting on the rider. The wall exerts a centripetal force inward toward the center that keeps the rider moving in a circular path, while two balanced vertical forces (gravitational and frictional) keep the rider stationary with respect to the wall. Cyprus was the only country where as many as half of the students identified the correct answer. The item was most difficult for students in the Czech Republic, Germany, and Austria, where fewer than 10% of the students selected the correct response. Internationally, more than half of the students selected option B, indicating the commonly held misconception that centrifugal force resulting from rotation pushes the rider outward from the center.

The final example, Item 6, was a free-response item from modern physics related to the Rutherford scattering experiment. Students were asked to explain why most of a stream of alpha particles directed at a very thin sheet of gold will pass through it. Table 9.8 presents the percentage of students in each country that provided partially and fully correct answers. A fully correct response to this item required the student to explain that alpha particles may be scattered or deflected only by interacting with the nuclei in the gold atoms, and that the distance between the gold nuclei (diameter of a gold atom) is very large compared to the diameter of the nucleus or of an alpha particle. Although on average only 10% of students internationally provided fully correct answers, a further 14% provided at least a partially correct response referencing the general idea of relative size or empty space within the gold atom. The highest percentages of fully correct answers were from Germany and Slovenia (more than 20%). In more than half of the countries, however, 25% or more of the students received partial or full credit, and in Germany, Norway, and Australia, the proportion of students with partial or full credit was more than one-third.

Figure 9.2 shows the relationship between performance on the TIMSS international physics scale and achievement on the six example items from the physics test.³ The international achievement on each example item is indicated both by the average percentage of fully correct responses across all countries, and by the international physics scale value, or item difficulty level. Since the scale was based on the performance of students in all countries, the international scale values apply to all countries. As illustrated by the example items, the physics test was relatively difficult for students in a number of countries. Students achieving below the international average were unlikely to provide fully correct responses to many of the items.

³ The three-digit item label shown in the lower right corner of the box locating each example item on the item difficulty map refers to the original item identification number used in the student test booklets.

Table 9.3 Physics

Percent Correct for Example Item 1 for Students Having Taken Physics Final Year of Secondary School*

Country	Percent Correct	PTCI	Example 1
			Volume of steam. Content Category: Heat
Canada	73 (3.0)	14%	<p>When a small volume of water is boiled, a large volume of steam is produced. Why?</p> <p>(A.) The molecules are further apart in steam than in water.</p> <p>B. Water molecules expand when heated and make the molecules bigger than the water molecules.</p> <p>C. The change from water to steam causes the number of molecules to increase.</p> <p>D. Atmospheric pressure works more on water molecules than on steam molecules.</p> <p>E. Water molecules repel each other when heated.</p>
² Cyprus	54 (4.5)	9%	
Czech Republic	39 (3.0)	11%	
France	50 (3.0)	20%	
[†] Germany	64 (5.7)	8%	
[†] Greece	62 (5.2)	10%	
¹ Latvia (LSS)	43 (8.3)	3%	
[†] Norway	81 (2.1)	8%	
² Russian Federation	68 (5.0)	2%	
Sweden	83 (2.8)	16%	
Switzerland	66 (3.8)	14%	
Countries Not Satisfying Guidelines for Sample Participation Rates (See Appendix B for Details):			
Australia	80 (3.4)	13%	
² Austria	40 (4.8)	33%	
United States	60 (2.3)	14%	
Countries with Unapproved Sampling Procedures and Low Participation Rates (See Appendix B for Details):			
Denmark	79 (3.2)	3%	
Slovenia	89 (3.1)	39%	
International Average Percent Correct	64 (1.1)		

SOURCE: IEA Third International Mathematics and Science Study (TIMSS), 1994-95.

* See Appendix A for characteristics of the students sampled.

Because population coverage falls below 65%, Latvia is annotated LSS for Latvian Speaking Schools only.

[†] Met guidelines for sample participation rates only after replacement schools were included (see Appendix B for details).

¹ National Desired Population does not cover all of International Desired Population (see Table B.4).

² National Defined Population covers less than 90 percent of National Desired Population (see Table B.4).

() Standard errors appear in parentheses. Because results are rounded to the nearest whole number, some totals may appear inconsistent.

Table 9.4 Physics

Percent Correct for Example Item 2 for Students Having Taken Physics Final Year of Secondary School*

Country	Percent Correct	PTCI	Example 2
			Length of spaceship in flight. Content Category: Modern Physics: Particle, Quantum and Astrophysics, and Relativity
Canada	47 (3.5)	14%	<p>A spaceship passes an observer at a speed of $0.9c$. The observer knows that the length of the spaceship, measured at rest before it took off, was 100 m.</p> <p>What is the length of the spaceship in flight as seen by the observer?</p> <p>A. 19 m <input checked="" type="radio"/> B. 44 m C. 229 m D. 526 m</p>
² Cyprus	25 (4.0)	9%	
Czech Republic	53 (3.4)	11%	
France	25 (3.1)	20%	
[†] Germany	45 (4.5)	8%	
[†] Greece	28 (4.4)	10%	
[†] Latvia (LSS)	55 (4.8)	3%	
[†] Norway	67 (2.8)	8%	
² Russian Federation	62 (5.1)	2%	
Sweden	73 (3.4)	16%	
Switzerland	35 (3.8)	14%	
Countries Not Satisfying Guidelines for Sample Participation Rates (See Appendix B for Details):			
Australia	36 (5.3)	13%	
² Austria	32 (3.6)	33%	
United States	34 (2.3)	14%	
Countries with Unapproved Sampling Procedures and Low Participation Rates (See Appendix B for Details):			
Denmark	38 (4.5)	3%	
Slovenia	56 (6.3)	39%	
International Average Percent Correct	44 (1.0)		

SOURCE: IEA Third International Mathematics and Science Study (TIMSS), 1994-95.

* See Appendix A for characteristics of the students sampled.

Because population coverage falls below 65%, Latvia is annotated LSS for Latvian Speaking Schools only.

[†] Met guidelines for sample participation rates only after replacement schools were included (see Appendix B for details).

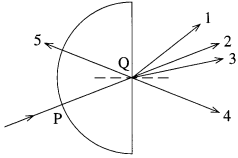
¹ National Desired Population does not cover all of International Desired Population (see Table B.4).

² National Defined Population covers less than 90 percent of National Desired Population (see Table B.4).

() Standard errors appear in parentheses. Because results are rounded to the nearest whole number, some totals may appear inconsistent.

Table 9.5 Physics

Percent Correct for Example Item 3 for Students Having Taken Physics Final Year of Secondary School*

Country	Percent Correct	PTCI	Example 3
			Direction refracted ray of light.
			Content Category: Wave Phenomena
Canada	42 (3.6)	14%	<p>This item refers to the following diagram.</p>  <p>A ray of light passes from P to Q through a semicircular glass block in air.</p> <p>Which arrow shows the direction in which the refracted ray of light would travel after leaving Q?</p> <p>(A) 1 B. 2 C. 3 D. 4 E. 5</p>
² Cyprus	47 (6.2)	9%	
Czech Republic	34 (4.0)	11%	
France	24 (2.6)	20%	
[†] Germany	40 (4.6)	8%	
[†] Greece	18 (3.5)	10%	
[†] Latvia (LSS)	41 (6.0)	3%	
[†] Norway	52 (2.9)	8%	
² Russian Federation	51 (3.0)	2%	
Sweden	53 (5.6)	16%	
Switzerland	34 (4.3)	14%	
Countries Not Satisfying Guidelines for Sample Participation Rates (See Appendix B for Details):			
Australia	42 (4.9)	13%	
² Austria	29 (4.2)	33%	
United States	27 (2.8)	14%	
Countries with Unapproved Sampling Procedures and Low Participation Rates (See Appendix B for Details):			
Denmark	32 (3.8)	3%	
Slovenia	30 (5.7)	39%	
International Average Percent Correct	37 (1.1)		

SOURCE: IEA Third International Mathematics and Science Study (TIMSS), 1994-95.

* See Appendix A for characteristics of the students sampled.

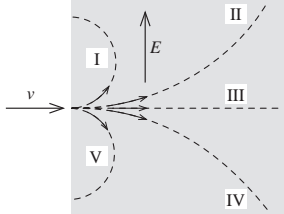
Because population coverage falls below 65%, Latvia is annotated LSS for Latvian Speaking Schools only.

[†] Met guidelines for sample participation rates only after replacement schools were included (see Appendix B for details).¹ National Desired Population does not cover all of International Desired Population (see Table B.4).² National Defined Population covers less than 90 percent of National Desired Population (see Table B.4).

() Standard errors appear in parentheses. Because results are rounded to the nearest whole number, some totals may appear inconsistent.

Table 9.6 Physics

Percent Correct for Example Item 4 for Students Having Taken Physics Final Year of Secondary School*

Country	Percent Correct	PTCI	Example 4
			Path of electrons in electric field. Content Category: Electricity & Magnetism
Canada	17 (2.1)	14%	<p>Electrons enter a uniform electric field E with a velocity v as shown in the figure. The velocity v is perpendicular to the electric field E.</p>  <p>Which one of the dashed paths (I, II, III, IV or V) best represents the path of the electrons in the electric field?</p> <p>A. I B. II C. III <input checked="" type="radio"/> D. IV E. V</p>
² Cyprus	24 (4.3)	9%	
Czech Republic	12 (2.2)	11%	
France	54 (4.4)	20%	
[†] Germany	35 (5.1)	8%	
[†] Greece	49 (5.9)	10%	
[†] Latvia (LSS)	23 (8.6)	3%	
[†] Norway	50 (3.4)	8%	
² Russian Federation	32 (3.3)	2%	
Sweden	52 (3.6)	16%	
Switzerland	30 (3.7)	14%	
Countries Not Satisfying Guidelines for Sample Participation Rates (See Appendix B for Details):			
Australia	25 (6.3)	13%	
² Austria	11 (2.7)	33%	
United States	12 (1.6)	14%	
Countries with Unapproved Sampling Procedures and Low Participation Rates (See Appendix B for Details):			
Denmark	41 (4.8)	3%	
Slovenia	40 (7.5)	39%	
International Average Percent Correct	32 (1.2)		

SOURCE: IEA Third International Mathematics and Science Study (TIMSS), 1994-95.

* See Appendix A for characteristics of the students sampled.

Because population coverage falls below 65%, Latvia is annotated LSS for Latvian Speaking Schools only.

[†] Met guidelines for sample participation rates only after replacement schools were included (see Appendix B for details).

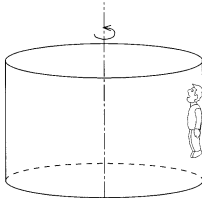
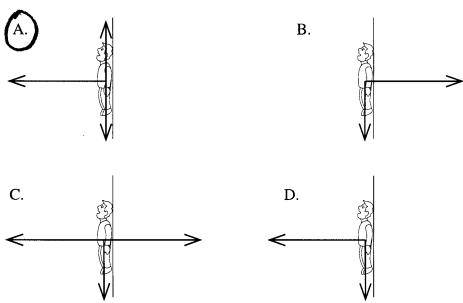
¹ National Desired Population does not cover all of International Desired Population (see Table B.4).

² National Defined Population covers less than 90 percent of National Desired Population (see Table B.4).

() Standard errors appear in parentheses. Because results are rounded to the nearest whole number, some totals may appear inconsistent.

Table 9.7 Physics

Percent Correct for Example Item 5 for Students Having Taken Physics Final Year of Secondary School*

Country	Percent Correct	PTCI	Example 5
			Direction of forces in amusement park ride. Content Category: Mechanics
Canada	21 (2.7)	14%	<p>The figure below shows a special sort of amusement park ride. As the ride starts to rotate about its central vertical axis the floor drops slowly but the rider does not. The rider is pressed against the rough inside wall of the rotating cylinder and remains at rest with respect to the wall. The rider's feet are not in contact with the floor.</p>  <p>Which one of the following diagrams best represents the real forces acting on the rider?</p> 
² Cyprus	51 (4.3)	9%	
Czech Republic	8 (4.3)	11%	
France	14 (2.2)	20%	
[†] Germany	9 (3.0)	8%	
[†] Greece	20 (3.0)	10%	
¹ Latvia (LSS)	18 (5.7)	3%	
[†] Norway	29 (3.4)	8%	
² Russian Federation	13 (3.1)	2%	
Sweden	28 (3.3)	16%	
Switzerland	15 (3.7)	14%	
Countries Not Satisfying Guidelines for Sample Participation Rates (See Appendix B for Details):			
Australia	27 (4.9)	13%	
² Austria	5 (1.4)	33%	
United States	15 (2.2)	14%	
Countries with Unapproved Sampling Procedures and Low Participation Rates (See Appendix B for Details):			
Denmark	23 (3.7)	3%	
Slovenia	22 (6.0)	39%	
International Average Percent Correct	20 (0.9)		

SOURCE: IEA Third International Mathematics and Science Study (TIMSS), 1994-95.

* See Appendix A for characteristics of the students sampled.

Because population coverage falls below 65%, Latvia is annotated LSS for Latvian Speaking Schools only.

[†] Met guidelines for sample participation rates only after replacement schools were included (see Appendix B for details).

¹ National Desired Population does not cover all of International Desired Population (see Table B.4).

² National Defined Population covers less than 90 percent of National Desired Population (see Table B.4).

() Standard errors appear in parentheses. Because results are rounded to the nearest whole number, some totals may appear inconsistent.

Table 9.8 Physics

Percent Correct for Example Item 6 for Students Having Taken Physics Final Year of Secondary School*

Country	Percent Partially Correct	Percent Fully Correct	PTCI	Example 6
				Alpha particles passing through gold.
				Content Category: Modern Physics: Particle, Quantum and Astrophysics, and Relativity
Canada	19 (3.2)	12 (2.6)	14%	<p>A stream of alpha particles is directed at a thin sheet of gold 80 atoms thick.</p> <p>Explain why most of the alpha particles pass through the sheet.</p> <p>most alpha particles pass through the sheet because, of the size of the alpha particle, compared to the nucleus is very small. Because there is a vast amount of space between the nucleus and the electrons orbiting it, there is lots of room for alpha particles to simply pass through.</p> <p>Even if some of the alpha particles hit the edge of the nucleus, they would deflect off with an angle, but still pass through.</p>
² Cyprus	18 (2.4)	7 (2.4)	9%	
Czech Republic	7 (2.0)	1 (0.8)	11%	
France	11 (2.0)	5 (1.8)	20%	
[†] Germany	11 (3.8)	24 (4.2)	8%	
[†] Greece	4 (1.8)	2 (0.7)	10%	
[†] Latvia (LSS)	11 (3.2)	8 (2.2)	3%	
[†] Norway	23 (3.1)	17 (2.6)	8%	
² Russian Federation	8 (2.0)	17 (3.1)	2%	
Sweden	23 (3.9)	7 (2.1)	16%	
Switzerland	15 (2.4)	13 (1.9)	14%	
Countries Not Satisfying Guidelines for Sample Participation Rates (See Appendix B for Details):				
Australia	29 (4.4)	8 (3.2)	13%	
² Austria	17 (3.3)	5 (1.5)	33%	
United States	11 (1.7)	2 (0.7)	14%	
Countries with Unapproved Sampling Procedures and Low Participation Rates (See Appendix B for Details):				
Denmark	8 (1.7)	7 (2.2)	3%	
Slovenia	4 (1.9)	21 (6.7)	39%	
International Average Percent Correct	14 (0.7)	10 (0.7)		

SOURCE: IEA Third International Mathematics and Science Study (TIMSS), 1994-95.

* See Appendix A for characteristics of the students sampled.

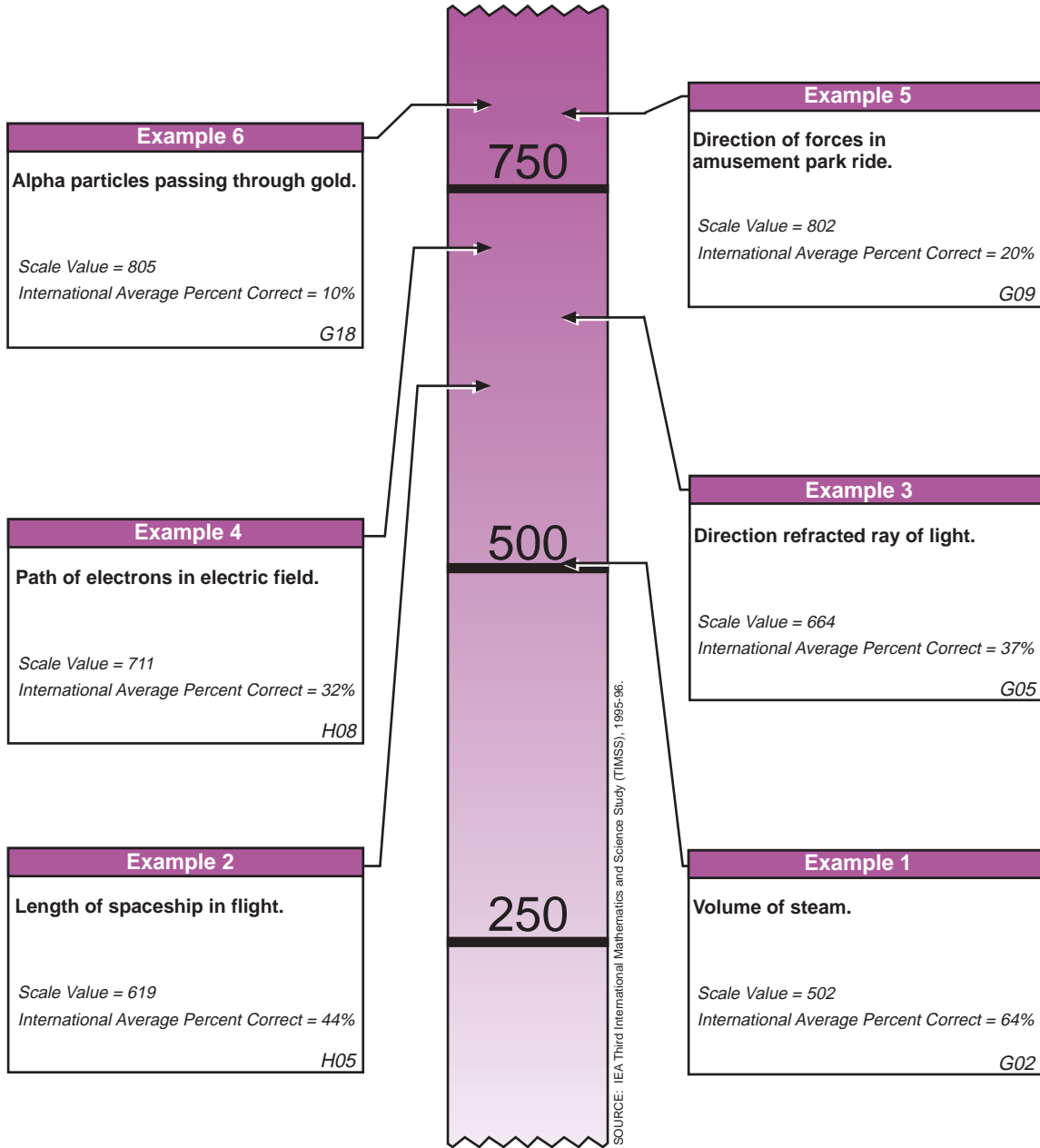
Because population coverage falls below 65%, Latvia is annotated LSS for Latvian Speaking Schools only.

[†] Met guidelines for sample participation rates only after replacement schools were included (see Appendix B for details).¹ National Desired Population does not cover all of International Desired Population (see Table B.4).² National Defined Population covers less than 90 percent of National Desired Population (see Table B.4).

() Standard errors appear in parentheses. Because results are rounded to the nearest whole number, some totals may appear inconsistent.

Figure 9.2

International Difficulty Map for Physics Example Items for Students Having Taken Physics Final Year of Secondary School*



* See Appendix A for characteristics of students sampled.

Note: Items are shown at the point on the TIMSS physics scale where students with that level of proficiency had a 65 percent probability of providing a correct response.

Chapter 10

CONTEXTS FOR PHYSICS ACHIEVEMENT

Physics is often considered to be among the most demanding of the sciences, and, because of its reliance on mathematical models and methods, the science most closely allied to mathematics. The students who take courses in physics at the end of upper secondary school are frequently also those who take advanced mathematics at that time. In countries with clearly defined tracks at the upper secondary level, the mathematics and physics tracks are often one and the same. This chapter focuses on the instructional experiences of final-year physics students, including the amount of instruction and homework they receive each week, the kinds of activities they engage in in physics class, and their use of calculators. In addition, this chapter presents physics students' reports on the educational level of their parents, and on their plans for future study.

WHAT ARE THE INSTRUCTIONAL PRACTICES IN PHYSICS CLASSES?

The amount of physics instruction received by students in physics classes in their final year varied considerably across countries, but in general was less than five hours per week (see Table 10.1). Students in Australia, the Russian Federation, and the United States mostly reported between three and five hours of physics instruction per week, while in Canada, about half of the students then taking physics reported having five hours or more of physics instruction each week. In Cyprus, Denmark, Greece, and Norway, almost all physics students reported between three and four hours of instruction per week, whereas less than three hours was the norm for students in the Czech Republic, Germany, Latvia (LSS), Sweden, and Switzerland.

Significant percentages of students who met the TIMSS definition for a physics student in Austria, Canada, Slovenia, Switzerland, and the United States reported that they were not taking physics at the time of testing. For example, in Switzerland and other European countries, physics instruction is distributed across three to four years of secondary education (e.g., two lessons a week for three years). In the United States, physics can be taken before the final year of school. Also, in some countries, courses are scheduled by semesters rather than full years. Thus, there are several reasons why students may have completed their physics instruction before the TIMSS testing. Further it should be noted that such different instructional arrangements for secondary school physics also will influence the results in Table 10.1. The relationship between physics achievement and amount of instruction also varied across countries; the most common was a curvilinear relationship, with the highest achievement associated with between three and five hours of instruction.

The assignment of homework to final-year physics students is also something that varies considerably from country to country, as may be seen in Table 10.2. On one hand, most students taking physics in Austria, the Czech Republic, Latvia (LSS), and Slovenia reported that they were assigned physics homework less than once a week, while on the other, most students in Australia, Canada, Cyprus, Greece,

Table 10.1

Physics Students' Reports on the Amount of Physics Instruction They Are Currently Receiving Each Week – Physics Final Year of Secondary School*

Country	Not Currently Taking Physics		Amount of Physics Instruction Per Week ¹							
			Less Than 3 Hours		3 to Less Than 4 Hours		4 to Less Than 5 Hours		5 Hours or More	
	Percent of Students	Mean Achievement	Percent of Students	Mean Achievement	Percent of Students	Mean Achievement	Percent of Students	Mean Achievement	Percent of Students	Mean Achievement
<i>Australia</i>	2 (0.6)	~ ~	1 (0.6)	~ ~	39 (4.9)	507 (9.5)	46 (5.4)	530 (9.1)	13 (2.1)	551 (10.0)
<i>Austria</i>	44 (2.6)	413 (7.5)	- -	- -	- -	- -	- -	- -	- -	- -
Canada	31 (2.2)	463 (5.3)	4 (0.8)	465 (18.6)	22 (3.0)	507 (9.7)	23 (3.0)	516 (13.1)	52 (3.6)	487 (5.2)
Cyprus	0 (0.0)	~ ~	1 (0.4)	~ ~	92 (1.6)	496 (6.6)	3 (1.1)	483 (17.9)	5 (1.0)	464 (28.9)
Czech Republic	r 9 (3.9)	436 (11.9)	81 (3.1)	448 (6.0)	17 (2.9)	529 (22.9)	1 (0.6)	~ ~	0 (0.4)	~ ~
² <i>Denmark</i>	r 0 (0.0)	~ ~	0 (0.0)	~ ~	100 (0.0)	535 (5.0)	0 (0.0)	~ ~	0 (0.0)	~ ~
France	0 (0.0)	~ ~	- -	- -	- -	- -	- -	- -	- -	- -
Germany	8 (4.1)	421 (20.5)	52 (5.2)	489 (8.1)	42 (5.0)	580 (8.6)	6 (1.5)	558 (10.6)	1 (0.5)	~ ~
Greece	r 0 (0.0)	~ ~	0 (0.0)	~ ~	100 (0.0)	492 (5.8)	0 (0.0)	~ ~	0 (0.0)	~ ~
Latvia (LSS)	2 (1.1)	~ ~	53 (7.6)	453 (11.2)	10 (5.4)	599 (27.1)	33 (5.0)	501 (14.2)	5 (3.8)	494 (12.6)
Norway	0 (0.2)	~ ~	0 (0.2)	~ ~	98 (0.5)	585 (6.3)	0 (0.0)	~ ~	1 (0.4)	~ ~
Russian Federation	0 (0.1)	~ ~	22 (3.9)	485 (21.7)	23 (3.9)	527 (15.5)	44 (5.3)	569 (12.4)	11 (2.7)	610 (14.7)
<i>Slovenia</i>	17 (4.0)	394 (9.5)	42 (8.8)	527 (15.0)	53 (8.3)	567 (17.4)	3 (1.2)	578 (135.2)	2 (0.5)	~ ~
Sweden	0 (0.1)	~ ~	65 (3.5)	579 (4.3)	26 (3.2)	568 (7.5)	7 (1.5)	569 (19.1)	2 (0.5)	~ ~
Switzerland	22 (3.9)	452 (8.4)	72 (4.2)	485 (5.5)	24 (4.1)	535 (10.4)	3 (0.8)	544 (13.7)	0 (0.1)	~ ~
<i>United States</i>	23 (2.3)	421 (5.1)	9 (0.8)	396 (6.8)	26 (4.9)	429 (8.3)	49 (4.6)	425 (5.7)	17 (2.9)	423 (3.5)

SOURCE: IEA Third International Mathematics and Science Study (TIMSS), 1995-96.

* See Appendix A for characteristics of the students sampled.

¹ Percentages based only on those students reporting that they are currently taking physics. Hours of instruction computed from lessons per week and minutes per lesson.² Data for Denmark obtained from ministry.

Countries shown in italics did not satisfy one or more guidelines for sample participation rates or student sampling (see Figure B.6).

Because population coverage falls below 65%, Latvia is annotated LSS for Latvian Speaking Schools only.

() Standard errors appear in parentheses. Because results are rounded to the nearest whole number, some totals may appear inconsistent.

An "r" indicates a 70-84% student response rate.

A dash (-) indicates data are not available. A tilde (~) indicates insufficient data to report achievement.

Norway, the Russian Federation, and the United States reported physics homework assignments three or more times a week. No clear relationship between amount of homework assigned and physics achievement was evident across countries. In several countries the highest achievement was associated with a modest amount of homework; possibly in these countries homework is primarily a remedial device assigned to those who need it.

To provide information about instructional practices, students were asked how often in their physics lessons they are asked to do reasoning tasks, apply science to everyday problems, conduct laboratory experiments, and use computers to do exercises or solve problems. As shown in Table 10.3, virtually all students in every country except Austria reported being asked to do reasoning tasks in at least some lessons. Whereas the students in advanced mathematics classes who reported doing reasoning tasks most frequently were those with the highest achievement, the relationship between physics achievement and frequency of doing reasoning tasks was not consistent; only in a few countries was the average achievement highest among those asked to do such tasks every day.

Students reported that applying science to everyday problems is a frequent activity in physics classes. As may be seen in Table 10.4, most students in every country reported that they are asked to do this in some or most lessons. The practice was reportedly least common in Sweden, where 30% of physics students reported that they were never, or almost never, asked in class to apply science to everyday problems. This approach to physics instruction was most common in the United States, where 23% of the physics students reported being asked to apply science to everyday problems during every lesson. In many countries, the relationship between physics achievement and frequency of applying science to everyday problems was curvilinear, with the highest average achievement shown by those applying science to everyday problems in some or most lessons.

Although experimentation is the cornerstone of at least some branches of physics and might be expected to play a central role in physics classes for students in the final year of upper secondary school, students' reports indicate a wide range of approaches (see Table 10.5). In Austria, Germany, and Greece, the majority of the students reported that they never or almost never conduct laboratory experiments, whereas one-fourth or more of the students in Canada, Cyprus, Denmark, France, Switzerland, and the United States reported conducting experiments in most or all lessons. In about half of the countries, the majority of students reported conducting experiments in some lessons. There was no consistent relationship between frequency of conducting laboratory experiments in class and physics achievement.

The use of computers to do exercises or solve problems is reportedly no more common in physics classes than in advanced mathematics classes. In eight countries, Australia, Austria, the Czech Republic, Latvia (LSS), Norway, the Russian Federation, Sweden, and Switzerland, 80% or more of the students reported never or almost never using computers in physics classes (see Table 10.6). Only in Cyprus and Slovenia did more than 20% of the physics students report using a computer in every lesson. There was no consistent relationship between computer use in class and physics achievement.

Table 10.2

Physics Students' Reports on How Often They Are Assigned Physics Homework
Physics
Final Year of Secondary School*

Country	Not Currently Taking Physics		How Often Physics Homework Is Assigned ¹					
			Less Than Once a Week		Once or Twice a Week		3 or More Times a Week	
	Percent of Students	Mean Achievement	Percent of Students	Mean Achievement	Percent of Students	Mean Achievement	Percent of Students	Mean Achievement
<i>Australia</i>	2 (0.6)	~ ~	12 (2.8)	529 (14.5)	27 (2.6)	525 (10.6)	60 (3.8)	518 (7.7)
<i>Austria</i>	44 (2.6)	413 (7.5)	97 (1.2)	450 (9.1)	3 (1.2)	454 (21.7)	0 (0.3)	~ ~
Canada	31 (2.2)	463 (5.3)	6 (1.3)	535 (16.0)	25 (3.1)	514 (9.1)	68 (3.9)	487 (4.9)
Cyprus	0 (0.0)	~ ~	2 (0.5)	~ ~	6 (1.1)	508 (24.9)	92 (1.0)	493 (6.9)
Czech Republic	r 9 (3.9)	436 (11.9)	84 (2.5)	459 (7.9)	15 (2.4)	480 (12.2)	1 (0.4)	~ ~
<i>Denmark</i>	r 0 (0.0)	~ ~	7 (1.4)	531 (13.4)	45 (3.0)	525 (7.3)	48 (3.4)	545 (8.4)
France	0 (0.0)	~ ~	- -	- -	- -	- -	- -	- -
Germany	8 (4.1)	421 (20.5)	41 (4.7)	507 (13.4)	40 (3.3)	538 (6.7)	18 (3.3)	579 (15.6)
Greece	0 (0.0)	~ ~	8 (1.9)	465 (20.5)	10 (1.4)	488 (17.0)	82 (2.2)	496 (5.6)
Latvia (LSS)	2 (1.1)	~ ~	53 (4.8)	482 (23.0)	30 (3.4)	497 (20.2)	17 (3.3)	473 (16.9)
Norway	0 (0.2)	~ ~	10 (2.1)	595 (20.8)	15 (2.6)	589 (7.8)	75 (3.6)	581 (6.9)
Russian Federation	0 (0.1)	~ ~	6 (1.1)	554 (22.8)	20 (2.6)	541 (24.2)	74 (2.9)	546 (12.6)
<i>Slovenia</i>	17 (4.0)	394 (9.5)	67 (4.6)	559 (15.3)	29 (4.1)	535 (20.2)	3 (1.1)	506 (37.6)
Sweden	0 (0.1)	~ ~	33 (3.8)	569 (7.2)	64 (3.8)	577 (4.9)	3 (0.9)	551 (18.5)
Switzerland	22 (3.9)	452 (8.4)	41 (3.1)	475 (7.4)	51 (2.9)	514 (6.0)	7 (1.2)	529 (15.3)
<i>United States</i>	23 (2.3)	421 (5.1)	13 (2.2)	418 (7.6)	36 (2.3)	422 (4.6)	51 (2.7)	425 (4.8)

SOURCE: IEA Third International Mathematics and Science Study (TIMSS), 1995-96.

* See Appendix A for characteristics of the students sampled.

¹ Percentages based only on those students reporting that they are currently taking physics.

Countries shown in italics did not satisfy one or more guidelines for sample participation rates or student sampling (see Figure B.6).

Because population coverage falls below 65%, Latvia is annotated LSS for Latvian Speaking Schools only.

() Standard errors appear in parentheses. Because results are rounded to the nearest whole number, some totals may appear inconsistent.

An "r" indicates a 70-84% student response rate.

A dash (-) indicates data are not available. A tilde (~) indicates insufficient data to report achievement.

Table 10.3

**Physics Students' Reports on How Often They Are Asked to Do Reasoning Tasks
in Their Physics Lessons[†] – Physics
Final Year of Secondary School***

Country	Never or Almost Never		Some Lessons		Most Lessons		Every Lesson	
	Percent of Students	Mean Achievement	Percent of Students	Mean Achievement	Percent of Students	Mean Achievement	Percent of Students	Mean Achievement
<i>Australia</i>	0 (0.3)	~ ~	22 (1.6)	504 (10.8)	57 (2.8)	531 (9.4)	21 (2.1)	514 (9.2)
<i>Austria</i>	15 (3.3)	418 (25.5)	42 (3.4)	445 (10.9)	33 (3.3)	467 (10.1)	11 (2.0)	466 (11.8)
Canada	1 (0.2)	~ ~	16 (1.0)	495 (10.6)	56 (2.1)	496 (6.6)	28 (2.0)	501 (5.7)
Cyprus	1 (0.5)	~ ~	8 (1.5)	498 (30.0)	42 (2.3)	499 (10.6)	49 (2.8)	490 (6.3)
Czech Republic	r 0 (0.1)	~ ~	16 (1.7)	440 (9.9)	53 (3.2)	466 (11.2)	31 (3.5)	473 (7.6)
<i>Denmark</i>	r 2 (0.7)	~ ~	23 (2.9)	515 (7.4)	65 (2.9)	538 (6.6)	11 (1.6)	557 (14.1)
France	1 (0.4)	~ ~	14 (1.2)	459 (6.4)	52 (1.6)	470 (4.7)	33 (1.4)	465 (4.6)
Germany	1 (0.2)	~ ~	19 (1.5)	506 (13.7)	57 (2.1)	541 (9.5)	23 (2.3)	535 (16.6)
Greece	1 (0.4)	~ ~	8 (1.5)	463 (10.6)	45 (2.7)	492 (7.7)	46 (3.2)	500 (7.6)
Latvia (LSS)	3 (0.9)	482 (36.7)	52 (3.3)	476 (20.2)	41 (3.4)	495 (21.3)	5 (0.9)	490 (15.9)
Norway	1 (0.3)	~ ~	48 (1.9)	571 (8.6)	45 (2.0)	596 (6.3)	6 (0.8)	594 (16.7)
Russian Federation	1 (0.3)	~ ~	26 (2.3)	517 (11.6)	54 (1.8)	551 (12.7)	19 (1.5)	568 (16.8)
<i>Slovenia</i>	2 (0.8)	~ ~	43 (4.3)	546 (26.5)	43 (4.1)	552 (11.6)	12 (1.6)	577 (12.9)
Sweden	0 (0.2)	~ ~	26 (1.9)	576 (8.9)	58 (2.1)	571 (4.2)	16 (1.6)	581 (8.2)
Switzerland	2 (0.5)	~ ~	16 (1.4)	480 (15.3)	57 (2.1)	504 (7.0)	26 (2.4)	506 (7.2)
<i>United States</i>	1 (0.2)	~ ~	13 (1.2)	428 (7.1)	50 (1.8)	424 (4.6)	36 (1.8)	420 (4.1)

SOURCE: IEA Third International Mathematics and Science Study (TIMSS), 1995-96.

[†] Based on most frequent response for: explain reasoning behind an idea; represent and analyze relationships using tables, charts, or graphs; work on problems for which there is no immediately obvious method solution; write equations to represent relationships; and put events or objects in order and give a reason for their organization. Percentages based only on those students reporting that they are currently taking physics.

* See Appendix A for characteristics of the students sampled.

Countries shown in italics did not satisfy one or more guidelines for sample participation rates or student sampling (see Figure B.6).

Because population coverage falls below 65%, Latvia is annotated LSS for Latvian Speaking Schools only.

() Standard errors appear in parentheses. Because results are rounded to the nearest whole number, some totals may appear inconsistent.

An "r" indicates a 70-84% student response rate.

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

Table 10.4

Physics Students' Reports on How Often They Are Asked to Apply Science to Everyday Problems in Their Physics Lessons[†] – Physics
Final Year of Secondary School*

Country	Never or Almost Never		Some Lessons		Most Lessons		Every Lesson	
	Percent of Students	Mean Achievement	Percent of Students	Mean Achievement	Percent of Students	Mean Achievement	Percent of Students	Mean Achievement
<i>Australia</i>	7 (1.4)	493 (16.6)	40 (3.2)	514 (9.0)	38 (3.4)	536 (8.8)	14 (1.8)	521 (12.4)
<i>Austria</i>	25 (2.8)	436 (14.6)	40 (3.8)	461 (7.8)	26 (2.9)	459 (13.6)	9 (2.6)	422 (18.6)
Canada	8 (0.8)	451 (17.1)	35 (1.8)	504 (7.8)	39 (2.4)	498 (4.7)	17 (2.5)	501 (10.4)
Cyprus	14 (1.6)	491 (25.1)	41 (2.3)	489 (9.7)	35 (2.5)	505 (7.9)	11 (1.5)	480 (21.1)
Czech Republic	r 13 (1.4)	448 (10.6)	49 (2.0)	461 (8.5)	31 (1.7)	470 (9.8)	7 (2.5)	478 (16.3)
<i>Denmark</i>	r 10 (1.5)	497 (12.3)	40 (2.7)	531 (7.5)	45 (2.7)	544 (7.1)	6 (1.3)	540 (22.4)
France	16 (1.2)	449 (7.6)	44 (1.1)	473 (4.6)	30 (1.3)	469 (5.7)	10 (1.1)	463 (8.0)
Germany	16 (2.0)	519 (11.1)	57 (2.4)	529 (10.7)	22 (1.8)	551 (15.4)	5 (0.9)	523 (21.2)
Greece	22 (2.4)	485 (11.5)	51 (2.9)	488 (8.4)	20 (2.2)	505 (9.0)	7 (1.4)	514 (13.8)
Latvia (LSS)	29 (3.6)	485 (21.0)	55 (4.1)	484 (21.0)	12 (1.3)	480 (19.2)	3 (0.8)	472 (19.2)
Norway	26 (1.6)	565 (7.6)	57 (1.6)	588 (7.2)	16 (1.0)	597 (8.8)	1 (0.4)	~ ~
Russian Federation	22 (2.0)	522 (14.8)	50 (1.5)	546 (13.6)	25 (2.0)	562 (10.3)	3 (0.6)	555 (24.3)
<i>Slovenia</i>	15 (2.4)	513 (18.3)	52 (2.8)	554 (15.5)	28 (2.4)	565 (20.9)	5 (1.2)	560 (19.8)
Sweden	30 (1.9)	564 (8.6)	54 (1.7)	577 (4.4)	14 (1.3)	577 (10.1)	2 (0.6)	~ ~
Switzerland	16 (1.3)	464 (11.2)	49 (1.5)	504 (7.1)	31 (1.8)	508 (6.4)	4 (0.8)	522 (21.7)
<i>United States</i>	6 (0.9)	412 (7.0)	31 (1.4)	422 (4.7)	40 (1.7)	421 (4.2)	23 (2.1)	430 (6.6)

SOURCE: IEA Third International Mathematics and Science Study (TIMSS), 1995-96.

[†] Percentages based only on those students reporting that they are currently taking physics.

* See Appendix A for characteristics of the students sampled.

Countries shown in italics did not satisfy one or more guidelines for sample participation rates or student sampling (see Figure B.6).

Because population coverage falls below 65%, Latvia is annotated LSS for Latvian Speaking Schools only.

() Standard errors appear in parentheses. Because results are rounded to the nearest whole number, some totals may appear inconsistent.

An "r" indicates a 70-84% student response rate.

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

Table 10.5

Physics Students' Reports on How Often They Are Asked to Conduct Laboratory Experiments in Their Physics Lessons[†] – Physics
Final Year of Secondary School*

Country	Never or Almost Never		Some Lessons		Most Lessons		Every Lesson	
	Percent of Students	Mean Achievement	Percent of Students	Mean Achievement	Percent of Students	Mean Achievement	Percent of Students	Mean Achievement
<i>Australia</i>	12 (1.7)	508 (16.0)	80 (2.2)	523 (6.0)	8 (1.9)	524 (28.3)	0 (0.3)	~ ~
<i>Austria</i>	52 (4.8)	434 (10.6)	33 (4.3)	465 (10.8)	10 (1.9)	476 (25.2)	6 (4.0)	469 (21.1)
Canada	8 (1.1)	496 (11.9)	65 (2.5)	493 (7.5)	24 (2.8)	506 (15.4)	3 (0.4)	504 (12.5)
Cyprus	7 (1.1)	541 (36.1)	68 (2.2)	489 (7.5)	19 (1.9)	487 (12.1)	6 (1.1)	513 (32.4)
Czech Republic	r 33 (2.9)	449 (9.0)	58 (3.1)	470 (9.1)	8 (1.4)	480 (14.5)	1 (0.8)	~ ~
<i>Denmark</i>	r 4 (1.2)	505 (20.3)	48 (3.0)	537 (6.8)	48 (3.2)	535 (7.6)	0 (0.0)	~ ~
France	5 (1.0)	449 (14.9)	62 (2.1)	471 (3.9)	30 (2.3)	464 (5.6)	3 (0.5)	446 (8.8)
Germany	62 (3.2)	515 (9.6)	33 (3.2)	556 (16.8)	4 (1.2)	551 (21.6)	1 (0.4)	~ ~
Greece	78 (2.7)	500 (5.7)	17 (2.3)	468 (13.0)	4 (1.2)	453 (29.6)	2 (0.6)	~ ~
Latvia (LSS)	17 (3.6)	450 (27.4)	77 (3.2)	489 (16.6)	6 (1.4)	512 (28.5)	0 (0.2)	~ ~
Norway	3 (0.9)	583 (23.2)	93 (1.6)	584 (6.3)	4 (0.9)	575 (19.9)	0 (0.3)	~ ~
Russian Federation	9 (1.6)	539 (13.3)	72 (1.9)	545 (13.9)	18 (1.7)	544 (13.4)	2 (0.3)	~ ~
<i>Slovenia</i>	14 (2.9)	532 (23.3)	68 (3.9)	560 (18.6)	16 (3.4)	531 (14.9)	2 (0.9)	~ ~
Sweden	4 (1.0)	581 (20.6)	79 (1.8)	576 (4.4)	16 (1.4)	562 (6.5)	1 (0.7)	~ ~
Switzerland	31 (4.4)	477 (10.8)	36 (2.1)	512 (6.9)	28 (2.9)	507 (8.6)	5 (1.7)	503 (15.4)
<i>United States</i>	4 (0.6)	410 (11.2)	49 (2.6)	425 (4.1)	37 (2.2)	423 (5.3)	10 (1.1)	414 (6.9)

SOURCE: IEA Third International Mathematics and Science Study (TIMSS), 1995-96.

[†] Percentages based only on those students reporting that they are currently taking physics.

* See Appendix A for characteristics of the students sampled.

Countries shown in italics did not satisfy one or more guidelines for sample participation rates or student sampling (see Figure B.6).

Because population coverage falls below 65%, Latvia is annotated LSS for Latvian Speaking Schools only.

() Standard errors appear in parentheses. Because results are rounded to the nearest whole number, some totals may appear inconsistent.

An "r" indicates a 70-84% student response rate. A tilde (~) indicates insufficient data to report achievement.

As discussed in Chapter 7, calculators are used very frequently by final-year advanced mathematics students. A similar situation is shown in Table 10.7 for physics students. In Australia, Canada, Cyprus, Denmark, France, Norway, Slovenia, and Sweden, 80% or more of the students reported using a calculator at least daily, and in several other countries more than half of the students reported this level of use. The lowest levels of calculator use among physics students were reported in the Czech Republic and Greece, where about one-fourth of the students reported using a calculator once a month or less. Like final-year students in general and students of advanced mathematics, the students with the highest average physics achievement were those who reported the highest level of calculator use in most countries. Although the relationship was less pronounced than for students having taken advanced mathematics, in most countries students who reported daily calculator use performed better on the TIMSS physics test than those who reported less frequent use.

Like the advanced mathematics students, and final-year students in general, physics students also were given the option of using a calculator when completing the TIMSS tests. As shown in Table 10.8, during the testing session physics students reported using a calculator slightly less than did advanced mathematics students. However, most physics students in every country made moderate use (for up to ten questions) of a calculator on the TIMSS test. In Austria, Greece, Latvia (LSS), and the Russian Federation, more than one-third of the students reported not using a calculator at all. The extent of calculator use was not consistently related to achievement in every country, but physics students who reported that they did not use a calculator on the test did less well than those who reported using one.

Table 10.6

Physics Students' Reports on How Often in Physics Lessons They Are Asked to Use Computers to Solve Exercises or Problems[†] – Physics
Final Year of Secondary School*

Country	Never or Almost Never		Some Lessons		Most Lessons		Every Lesson	
	Percent of Students	Mean Achievement	Percent of Students	Mean Achievement	Percent of Students	Mean Achievement	Percent of Students	Mean Achievement
<i>Australia</i>	80 (3.5)	518 (6.0)	16 (3.5)	528 (16.3)	3 (1.1)	573 (30.1)	1 (0.5)	~ ~
<i>Austria</i>	87 (3.0)	441 (9.0)	8 (2.2)	511 (17.7)	3 (1.1)	542 (20.2)	2 (0.6)	~ ~
Canada	72 (3.0)	501 (6.4)	20 (2.8)	488 (9.0)	6 (1.9)	485 (43.6)	1 (0.4)	~ ~
Cyprus	54 (2.8)	509 (6.5)	9 (2.1)	455 (25.5)	15 (1.8)	479 (15.2)	22 (2.3)	481 (14.2)
Czech Republic	r 91 (1.7)	462 (8.3)	7 (1.5)	481 (19.1)	1 (0.4)	~ ~	1 (0.8)	~ ~
<i>Denmark</i>	r 46 (3.3)	534 (7.3)	42 (2.2)	540 (7.3)	12 (2.0)	528 (12.6)	0 (0.2)	~ ~
France	69 (2.7)	468 (4.5)	25 (2.3)	465 (5.3)	4 (1.0)	466 (9.9)	1 (0.4)	~ ~
Germany	77 (3.1)	519 (9.0)	20 (3.0)	575 (14.9)	3 (0.9)	553 (22.1)	1 (0.6)	~ ~
Greece	r 63 (3.0)	499 (6.3)	22 (2.3)	482 (9.8)	11 (1.5)	468 (16.7)	4 (1.3)	507 (23.0)
Latvia (LSS)	88 (1.6)	480 (17.4)	9 (1.5)	522 (32.0)	3 (0.6)	464 (26.8)	0 (0.3)	~ ~
Norway	88 (2.5)	583 (6.5)	11 (2.4)	603 (19.6)	1 (0.4)	~ ~	1 (0.6)	~ ~
Russian Federation	83 (2.1)	542 (10.2)	12 (1.5)	577 (29.9)	3 (1.0)	533 (30.3)	1 (0.4)	~ ~
<i>Slovenia</i>	13 (1.9)	567 (12.4)	21 (2.4)	559 (17.7)	44 (3.0)	551 (22.7)	22 (2.2)	535 (15.4)
Sweden	83 (2.6)	571 (4.3)	17 (2.5)	585 (7.4)	0 (0.2)	~ ~	0 (0.2)	~ ~
Switzerland	80 (3.0)	489 (6.2)	17 (2.5)	545 (12.0)	2 (0.7)	~ ~	0 (0.2)	~ ~
<i>United States</i>	58 (4.5)	418 (4.2)	30 (3.6)	431 (5.6)	8 (1.7)	425 (8.7)	4 (1.5)	435 (22.7)

SOURCE: IEA Third International Mathematics and Science Study (TIMSS), 1995-96.

[†] Percentages based only on those students reporting that they are currently taking physics.

* See Appendix A for characteristics of the students sampled.

Countries shown in italics did not satisfy one or more guidelines for sample participation rates or student sampling (see Figure B.6).

Because population coverage falls below 65%, Latvia is annotated LSS for Latvian Speaking Schools only.

() Standard errors appear in parentheses. Because results are rounded to the nearest whole number, some totals may appear inconsistent.

An "r" indicates a 70-84% student response rate.

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

Table 10.7

Physics Students' Reports on How Often They Use a Calculator at School, Home, or Anywhere Else – Physics
Final Year of Secondary School*

Country	Rarely or Never		Monthly		Weekly		Daily	
	Percent of Students	Mean Achievement	Percent of Students	Mean Achievement	Percent of Students	Mean Achievement	Percent of Students	Mean Achievement
<i>Australia</i>	1 (0.4)	~ ~	0 (0.2)	~ ~	5 (1.3)	496 (22.5)	94 (1.4)	520 (5.9)
<i>Austria</i>	4 (1.1)	394 (14.8)	4 (0.8)	407 (17.5)	34 (2.2)	442 (7.7)	58 (2.7)	435 (7.6)
Canada	1 (0.9)	~ ~	1 (0.4)	~ ~	10 (1.3)	483 (13.5)	88 (1.1)	488 (3.7)
Cyprus	1 (0.5)	~ ~	1 (0.5)	~ ~	7 (1.3)	528 (22.9)	91 (1.7)	493 (5.6)
Czech Republic	11 (1.5)	417 (8.3)	14 (2.2)	429 (9.4)	44 (1.9)	442 (5.2)	31 (3.1)	487 (9.4)
<i>Denmark</i>	r 0 (0.0)	~ ~	0 (0.1)	~ ~	9 (1.5)	488 (13.0)	91 (1.5)	539 (5.4)
France	2 (0.4)	~ ~	2 (0.6)	~ ~	16 (1.4)	462 (5.7)	80 (1.7)	469 (3.8)
Germany	2 (0.6)	~ ~	0 (0.3)	~ ~	20 (1.7)	495 (14.5)	78 (1.8)	531 (13.1)
Greece	18 (1.8)	457 (9.9)	7 (1.1)	452 (19.8)	26 (2.1)	482 (10.7)	49 (2.5)	507 (5.8)
Latvia (LSS)	13 (1.8)	456 (19.2)	6 (1.1)	468 (26.5)	44 (2.0)	487 (19.9)	38 (2.4)	500 (22.7)
Norway	0 (0.1)	~ ~	1 (0.4)	~ ~	7 (0.9)	559 (8.8)	91 (1.0)	586 (6.4)
Russian Federation	10 (2.0)	494 (22.3)	4 (0.7)	532 (22.8)	30 (1.4)	537 (14.5)	57 (2.6)	559 (11.3)
<i>Slovenia</i>	1 (0.4)	~ ~	1 (0.6)	~ ~	18 (2.1)	513 (18.5)	80 (2.3)	523 (16.8)
Sweden	0 (0.1)	~ ~	1 (0.4)	~ ~	11 (1.5)	558 (12.7)	88 (1.5)	576 (3.7)
Switzerland	1 (0.3)	~ ~	1 (0.2)	~ ~	25 (2.1)	458 (5.4)	74 (2.0)	499 (4.0)
<i>United States</i>	4 (0.7)	385 (5.7)	3 (0.5)	402 (9.0)	14 (1.6)	401 (5.4)	79 (1.6)	429 (3.2)

SOURCE: IEA Third International Mathematics and Science Study (TIMSS), 1995-96.

* See Appendix A for characteristics of the students sampled.

Countries shown in italics did not satisfy one or more guidelines for sample participation rates or student sampling (see Figure B.6).

Because population coverage falls below 65%, Latvia is annotated LSS for Latvian Speaking Schools only.

() Standard errors appear in parentheses. Because results are rounded to the nearest whole number, some totals may appear inconsistent.

An "r" indicates a 70-84% student response rate.

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

Table 10.8

**Physics Students' Reports on the Frequency of Calculator Use During the TIMSS Test
Physics
Final Year of Secondary School***

Country	Did Not Use a Calculator		Used a Calculator Very Little (<5 Questions)		Used a Calculator Somewhat (5-10 Questions)		Used a Calculator Quite a Lot (>10 Questions)	
	Percent of Students	Mean Achievement	Percent of Students	Mean Achievement	Percent of Students	Mean Achievement	Percent of Students	Mean Achievement
<i>Australia</i>	9 (1.7)	448 (12.3)	66 (2.3)	528 (6.2)	23 (1.9)	514 (10.0)	2 (0.8)	~ ~
<i>Austria</i>	34 (2.7)	421 (8.3)	49 (2.3)	440 (6.8)	15 (1.6)	456 (15.0)	1 (0.4)	~ ~
Canada	10 (1.6)	451 (10.3)	61 (1.8)	479 (3.8)	27 (1.6)	507 (7.4)	3 (0.4)	548 (19.9)
Cyprus	23 (2.5)	476 (10.9)	60 (2.6)	500 (6.4)	15 (1.9)	510 (17.5)	2 (0.8)	~ ~
Czech Republic	18 (1.8)	425 (11.8)	62 (3.1)	449 (5.3)	19 (2.1)	485 (11.0)	1 (0.4)	~ ~
<i>Denmark</i>	11 (1.4)	512 (9.8)	66 (1.8)	537 (5.0)	21 (1.8)	541 (9.4)	2 (0.6)	~ ~
France	17 (1.4)	447 (4.6)	63 (1.5)	471 (4.5)	18 (1.7)	471 (7.4)	1 (0.4)	~ ~
Germany	17 (2.1)	475 (19.2)	64 (2.5)	528 (12.1)	18 (2.2)	546 (12.7)	1 (0.5)	~ ~
Greece	75 (2.8)	475 (6.0)	22 (2.7)	530 (9.6)	3 (0.9)	494 (32.1)	1 (0.6)	~ ~
Latvia (LSS)	38 (4.5)	471 (24.2)	49 (3.3)	490 (23.0)	11 (2.1)	514 (15.6)	1 (0.3)	~ ~
Norway	4 (0.8)	558 (17.0)	56 (1.8)	572 (7.7)	37 (1.8)	597 (6.8)	3 (0.6)	616 (18.1)
Russian Federation	36 (2.8)	543 (12.1)	49 (2.2)	551 (11.9)	14 (1.3)	570 (15.5)	1 (0.4)	~ ~
<i>Slovenia</i>	17 (2.2)	476 (15.2)	65 (2.4)	532 (16.6)	16 (1.5)	562 (17.5)	2 (1.0)	~ ~
Sweden	3 (0.6)	526 (26.5)	53 (2.6)	562 (5.1)	38 (2.5)	588 (5.8)	5 (0.7)	611 (16.6)
Switzerland	13 (1.5)	461 (8.8)	62 (1.6)	493 (3.9)	23 (1.3)	496 (7.6)	2 (0.4)	~ ~
<i>United States</i>	19 (1.3)	391 (4.0)	64 (1.4)	427 (3.5)	16 (1.1)	443 (4.8)	1 (0.3)	~ ~

SOURCE: IEA Third International Mathematics and Science Study (TIMSS), 1995-96.

* See Appendix A for characteristics of the students sampled.

Countries shown in italics did not satisfy one or more guidelines for sample participation rates or student sampling (see Figure B.6).

Because population coverage falls below 65%, Latvia is annotated LSS for Latvian Speaking Schools only.

() Standard errors appear in parentheses. Because results are rounded to the nearest whole number, some totals may appear inconsistent.

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

WHAT ARE SECONDARY SCHOOL STUDENTS' EDUCATIONAL RESOURCES AND PLANS?

The relationship between parental education and achievement among final-year students was described in Chapter 4 for final-year students in general, and in Chapter 7 for those students having taken advanced mathematics. The results for final-year students having taken physics are again given for the same three educational levels: finished university, finished upper secondary school but not university, and finished primary school but not upper secondary school (see Table 10.9). The modifications that some countries made in the categories are those that are described in Figure 4.6. The clear positive relationship between parents' education and achievement that was described in the earlier chapters is also apparent in Table 10.9 for students having taken physics. Physics students' reports of level of parental education were very similar to the reports of advanced mathematics students, with more than 30% of them reporting that at least one parent had finished university in every country except Austria. More than half the physics students in Canada, Germany, Latvia (LSS), the Russian Federation, and the United States reported that at least one parent had completed university.

Like the plans for further education of final-year students having taken advanced mathematics, those of final-year physics students center mainly on university. The students planning to attend university, as reported in Table 10.10, are in the majority in every country; and in 11 countries, Australia, Canada, Cyprus, the Czech Republic, Greece, Latvia (LSS), the Russian Federation, Slovenia, Sweden, Switzerland, and the United States, the percentage planning a university career exceeded 80%. The percentage of physics and mathematics students planning to attend university was very similar in every country except Denmark and Slovenia, where greater percentages of physics students reported plans to attend university. The percentage planning to choose a vocationally oriented program, low among advanced mathematics students, was even lower among physics students. Only in Norway and Germany did more than 15% of physics students report such intentions. Very few of the physics students reported that they did not plan to continue their education. Only in Austria and Denmark did at least 10% of students indicate that this was their plan. In nearly every country, the students planning to attend university had higher average physics achievement than any other group.

Table 10.9

Physics Students' Reports on the Highest Level of Education of Either Parent[†]
Physics
Final Year of Secondary School*

Country	Finished University ¹		Finished Upper Secondary but Not University ²		Finished Primary but Not Upper Secondary ³		Do Not Know	
	Percent of Students	Mean Achievement	Percent of Students	Mean Achievement	Percent of Students	Mean Achievement	Percent of Students	Mean Achievement
<i>Australia</i>	42 (3.3)	539 (8.3)	34 (3.0)	511 (8.1)	19 (2.1)	481 (9.7)	5 (1.5)	533 (24.8)
<i>Austria</i>	19 (2.0)	447 (10.0)	71 (2.0)	434 (7.5)	8 (1.5)	409 (11.7)	2 (0.6)	~ ~
Canada	51 (1.6)	502 (4.5)	37 (1.3)	472 (4.7)	7 (0.8)	481 (11.0)	6 (1.1)	444 (21.8)
Cyprus	44 (1.8)	507 (7.5)	36 (2.6)	488 (9.5)	17 (1.9)	481 (12.0)	3 (0.9)	477 (23.7)
Czech Republic	48 (1.9)	469 (9.1)	41 (1.8)	440 (5.7)	11 (1.1)	425 (6.1)	0 (0.0)	~ ~
<i>Denmark</i>	r 36 (2.1)	554 (9.8)	54 (2.3)	525 (4.8)	6 (1.2)	527 (20.7)	5 (1.1)	506 (30.2)
France	30 (2.1)	488 (4.9)	43 (2.1)	464 (4.0)	22 (2.3)	444 (8.4)	5 (0.7)	466 (12.5)
Germany	52 (3.2)	537 (13.4)	46 (3.1)	507 (13.3)	2 (0.6)	~ ~	- -	- -
Greece	34 (2.4)	510 (8.4)	42 (2.3)	479 (7.2)	21 (2.7)	472 (10.6)	3 (1.2)	449 (39.0)
Latvia (LSS)	52 (5.1)	508 (25.0)	44 (5.1)	467 (14.0)	2 (0.8)	~ ~	2 (0.5)	~ ~
Norway	43 (2.5)	599 (7.4)	45 (2.2)	575 (7.9)	7 (1.1)	559 (11.8)	5 (0.8)	555 (14.4)
Russian Federation	65 (2.2)	559 (10.4)	35 (2.2)	518 (15.7)	0 (0.1)	~ ~	0 (0.2)	~ ~
<i>Slovenia</i>	39 (3.0)	548 (23.5)	53 (2.1)	507 (12.9)	8 (1.3)	481 (15.3)	0 (0.2)	~ ~
Sweden	41 (2.0)	587 (6.2)	41 (2.0)	565 (7.4)	8 (1.6)	571 (11.1)	9 (1.3)	551 (9.4)
Switzerland	34 (1.4)	490 (4.9)	59 (1.8)	489 (4.7)	5 (1.0)	473 (10.5)	1 (0.4)	~ ~
<i>United States</i>	55 (2.5)	440 (3.9)	41 (2.4)	407 (4.1)	3 (0.5)	387 (6.8)	2 (0.3)	~ ~

SOURCE: IEA Third International Mathematics and Science Study (TIMSS), 1995-96.

[†] The response categories were defined by each country to conform to their own educational system and may not be strictly comparable across countries. See Figure 4.5 for country modifications to the definitions of educational levels.

* See Appendix A for characteristics of the students sampled.

¹ In most countries, defined as completion of at least a 4-year degree program at a university or an equivalent institute of higher education.

² Finished upper secondary school with or without some tertiary education not equivalent to a university degree. In most countries, finished secondary corresponds to completion of an upper secondary track terminating after 11 to 13 years of schooling.

³ Finished primary or some secondary school not equivalent to completion of upper secondary.

Countries shown in italics did not satisfy one or more guidelines for sample participation rates or student sampling (see Figure B.6).

Because population coverage falls below 65%, Latvia is annotated LSS for Latvian Speaking Schools only.

() Standard errors appear in parentheses. Because results are rounded to the nearest whole number, some totals may appear inconsistent.

An "r" indicates a 70-84% student response rate.

A dash (-) indicates data are not available. A tilde (~) indicates insufficient data to report achievement.

Table 10.10

Physics Students' Reports on Their Plans for Future Education[†] – Physics Final Year of Secondary School*

Country	University ¹		Vocationally Oriented Programs ²		Other Postsecondary Education ³		Does Not Intend to Continue Education	
	Percent of Students	Mean Achievement	Percent of Students	Mean Achievement	Percent of Students	Mean Achievement	Percent of Students	Mean Achievement
<i>Australia</i>	89 (1.6)	524 (7.0)	4 (1.0)	460 (13.4)	2 (0.8)	~ ~	4 (1.3)	455 (9.4)
<i>Austria</i>	68 (2.0)	444 (7.1)	12 (1.5)	413 (12.8)	6 (1.0)	417 (12.6)	14 (1.6)	421 (13.1)
Canada	82 (1.6)	488 (4.7)	5 (1.2)	462 (10.3)	12 (1.8)	485 (12.6)	1 (0.9)	~ ~
Cyprus	91 (1.5)	500 (5.1)	6 (1.3)	454 (26.3)	2 (0.7)	~ ~	1 (0.7)	~ ~
Czech Republic	93 (1.0)	456 (6.5)	5 (0.7)	396 (8.9)	1 (0.3)	~ ~	2 (0.5)	~ ~
<i>Denmark</i>	r 74 (2.0)	555 (6.6)	5 (1.1)	453 (15.8)	10 (1.4)	490 (13.4)	10 (1.5)	518 (15.5)
France	75 (1.7)	471 (4.4)	12 (1.2)	453 (5.6)	12 (1.0)	457 (6.9)	1 (0.4)	~ ~
Germany	76 (5.5)	540 (9.6)	17 (4.6)	456 (17.9)	3 (0.9)	493 (22.1)	3 (0.8)	501 (15.1)
Greece	86 (1.9)	499 (5.2)	5 (1.3)	430 (19.7)	8 (1.2)	432 (15.4)	2 (0.7)	~ ~
Latvia (LSS)	85 (1.4)	491 (21.1)	7 (0.8)	478 (17.7)	8 (1.0)	447 (30.9)	1 (0.4)	~ ~
Norway	75 (2.2)	595 (6.4)	19 (1.9)	554 (10.8)	5 (0.9)	535 (11.5)	1 (0.3)	~ ~
Russian Federation	89 (2.2)	554 (10.7)	9 (1.9)	473 (24.2)	2 (0.5)	~ ~	0 (0.1)	~ ~
<i>Slovenia</i>	92 (1.6)	526 (16.5)	5 (1.3)	485 (20.4)	1 (0.5)	~ ~	1 (0.6)	~ ~
Sweden	92 (0.8)	580 (3.7)	3 (0.7)	503 (24.8)	4 (0.6)	508 (15.2)	2 (0.5)	~ ~
Switzerland	90 (1.1)	492 (3.7)	2 (0.5)	~ ~	4 (0.5)	454 (11.5)	4 (1.0)	465 (17.5)
<i>United States</i>	92 (0.7)	425 (3.4)	3 (0.4)	383 (6.7)	5 (0.7)	391 (6.4)	0 (0.0)	~ ~

SOURCE: IEA Third International Mathematics and Science Study (TIMSS), 1995-96.

[†] Educational options were defined by each country to conform to their national systems and may not be comparable across countries. See Figure 4.2 for definitions and any national adaptations of the international options in each category.

* See Appendix A for characteristics of the students sampled.

¹ In most countries, defined as at least a 3-year degree program at a university or an equivalent institute of higher education.

² Defined in most countries as vocational or technical courses at a tertiary institution not equivalent to a university degree program (e.g., trade or business school, junior or community college, and other shorter vocational programs), but may also include higher-level upper secondary vocational programs in some countries

³ Includes other postsecondary education defined in each country. Includes categories such as academic courses at junior or community college, short university or polytechnic courses, and college-preparatory courses.

Countries shown in italics did not satisfy one or more guidelines for sample participation rates or student sampling (see Figure B.6).

Because population coverage falls below 65%, Latvia is annotated LSS for Latvian Speaking Schools only.

() Standard errors appear in parentheses. Because results are rounded to the nearest whole number, some totals may appear inconsistent.

An "r" indicates a 70-84% student response rate.

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

Students who have studied physics in upper secondary school are well positioned to continue their education in the sciences or in areas of scientific application. Table 10.11 presents students' reports of their choices for study after secondary school from a range of areas where students with advanced preparation in physics might seek further education. The areas include physics or chemistry, biological or earth science, health sciences or related occupations, mathematics or computer/information sciences, engineering, and business. An "other" category was provided for students whose preferred area of study was not included. Although choice of study area varied considerably across countries, the most popular were engineering, mathematics or computer/information sciences, health sciences or related occupations, and business. Engineering was the most popular area overall, and was the area chosen by the most physics students in Australia, Denmark, Norway, and Sweden. Health sciences or related occupations were most popular in Austria, Canada, Cyprus, France, Switzerland, and the United States. Business was the area of choice for the most students in the Czech Republic, Germany, Latvia (LSS), and the Russian Federation. Mathematics or computer/information sciences are the most popular choice for physics students only in Greece and Slovenia. Neither of the science options (physics or chemistry, or biological or earth science) was the preferred choice in any country, although biological or earth science was among the more popular choices in France. Relatively few physics students chose physics or chemistry as their preferred area of future study; only in Denmark, France, Greece, and Norway did as many as 10% of students indicate this as their choice. In Austria, the Czech Republic, and Switzerland, students most often reported that they planned to study some area other than the choices provided.

Table 10.11

Physics Students' Reports on the Area They Intend to Study After Secondary School[†]
Physics
Final Year of Secondary School*

Country	Percent of Students						
	Physics or Chemistry	Biological or Earth Sciences	Health Sciences or Related Occupations	Mathematics or Computer / Information Sciences	Engineering	Business	Other
<i>Australia</i>	8 (1.4)	8 (1.2)	21 (2.2)	15 (2.8)	27 (3.0)	8 (1.2)	12 (2.1)
<i>Austria</i>	s 4 (1.0)	5 (1.3)	20 (1.9)	5 (1.2)	8 (1.6)	15 (1.8)	43 (2.7)
Canada	8 (1.0)	9 (1.3)	27 (1.5)	10 (0.7)	22 (1.9)	10 (1.3)	15 (1.0)
Cyprus	7 (1.5)	5 (1.3)	25 (2.4)	19 (1.8)	22 (1.7)	4 (1.1)	19 (1.6)
Czech Republic	2 (0.5)	14 (1.5)	13 (1.1)	12 (1.3)	3 (0.6)	20 (1.8)	37 (3.3)
<i>Denmark</i>	r 10 (1.5)	5 (1.3)	12 (1.6)	12 (1.5)	29 (2.7)	11 (1.5)	22 (2.7)
France	10 (1.3)	18 (1.8)	19 (1.3)	18 (1.2)	15 (1.6)	7 (1.1)	14 (1.3)
Germany	8 (1.7)	4 (0.8)	7 (1.8)	13 (2.2)	18 (1.5)	26 (3.9)	24 (2.6)
Greece	13 (1.9)	2 (0.9)	0 (0.3)	36 (2.1)	28 (2.1)	2 (0.9)	18 (1.8)
Latvia (LSS)	3 (0.6)	5 (0.8)	8 (1.2)	12 (1.6)	6 (0.9)	35 (2.3)	32 (2.6)
Norway	12 (1.0)	4 (0.9)	20 (1.3)	13 (1.5)	30 (1.7)	7 (1.1)	15 (0.9)
Russian Federation	6 (1.0)	3 (0.8)	6 (1.3)	29 (2.3)	9 (1.0)	30 (1.9)	17 (1.5)
<i>Slovenia</i>	7 (1.6)	5 (0.9)	12 (2.2)	21 (3.3)	18 (3.6)	18 (2.0)	19 (2.9)
Sweden	8 (1.2)	7 (1.1)	11 (1.9)	12 (2.2)	42 (3.6)	4 (0.7)	17 (2.1)
Switzerland	5 (0.7)	7 (1.0)	18 (1.4)	4 (0.7)	8 (1.1)	14 (1.6)	46 (1.7)
<i>United States</i>	3 (0.6)	7 (0.7)	23 (1.5)	7 (0.7)	15 (1.3)	16 (1.2)	29 (1.9)

SOURCE: IEA Third International Mathematics and Science Study (TIMSS), 1995-96.

[†] Percentages based only on those students reporting that they intend to continue their education after secondary school.

* See Appendix A for characteristics of the students sampled.

Countries shown in italics did not satisfy one or more guidelines for sample participation rates or student sampling (see Figure B.6).

Because population coverage falls below 65%, Latvia is annotated LSS for Latvian Speaking Schools only.

() Standard errors appear in parentheses. Because results are rounded to the nearest whole number, some totals may appear inconsistent.

An "r" indicates a 70-84% student response rate. An "s" indicates a 50-69% student response rate.

As was also reported in Chapter 7 for advanced mathematics students, there were considerable differences between male and female physics students in their choice of area for further study (see Table 10.12). Among students choosing health sciences or related occupations, and to a lesser extent biological or earth sciences, there were proportionately more females than males in many countries. However, in engineering, and in mathematics or computer/information sciences, males often outnumbered females by a substantial margin. As was found in the case of advanced mathematics students, a substantially higher percentage of females than males in most countries plan to pursue future studies in other areas not listed in Table 10.12.

Table 10.12

**Physics Students' Reports on the Area They Intend to Study After Secondary School
by Gender – Physics
Final Year of Secondary School***

Country	Percent of Students							
	Physics or Chemistry		Biological or Earth Sciences		Health Sciences or Related Occupations		Mathematics or Computer/Information Sciences	
	Males	Females	Males	Females	Males	Females	Males	Females
<i>Australia</i>	7 (1.8)	9 (2.5)	6 (1.5)	10 (2.5)	14 (2.6)	34 (4.1)	19 (4.0)	8 (2.3)
<i>Austria</i>	s 5 (1.7)	3 (1.1)	4 (2.1)	5 (1.5)	17 (2.4)	23 (2.8)	9 (2.5)	1 (0.7)
Canada	7 (1.3)	8 (1.5)	7 (1.2)	11 (2.0)	16 (2.3)	39 (2.9)	14 (0.9)	6 (1.0)
Cyprus	7 (2.0)	6 (1.5)	5 (1.6)	5 (2.1)	21 (3.4)	30 (3.8)	20 (2.1)	18 (3.4)
Czech Republic	4 (0.9)	1 (0.6)	11 (1.9)	16 (1.8)	11 (1.9)	14 (1.6)	23 (2.2)	4 (1.0)
<i>Denmark</i>	r 11 (1.8)	9 (3.7)	5 (1.5)	5 (2.3)	8 (1.9)	25 (4.0)	14 (2.0)	4 (1.5)
France	10 (1.4)	9 (1.9)	16 (2.1)	21 (2.5)	11 (1.6)	31 (2.6)	22 (1.7)	11 (1.7)
Germany	8 (2.0)	7 (3.2)	4 (1.1)	4 (1.3)	5 (2.6)	10 (2.6)	18 (3.0)	4 (1.6)
Greece	11 (2.2)	16 (3.3)	2 (0.8)	3 (1.4)	0 (0.3)	1 (0.5)	36 (2.6)	37 (5.2)
Latvia (LSS)	3 (0.9)	2 (1.3)	4 (1.4)	6 (1.4)	5 (1.6)	11 (1.6)	18 (2.3)	7 (1.1)
Norway	13 (1.2)	9 (1.5)	4 (1.1)	4 (1.1)	12 (1.4)	41 (2.6)	14 (1.7)	7 (2.2)
Russian Federation	9 (1.8)	3 (1.3)	3 (1.3)	3 (1.0)	3 (0.8)	11 (2.5)	36 (2.8)	20 (2.8)
<i>Slovenia</i>	7 (1.5)	8 (5.0)	5 (1.2)	5 (2.3)	7 (2.3)	24 (5.3)	26 (4.4)	10 (2.6)
Sweden	6 (1.4)	11 (1.9)	5 (1.1)	13 (2.4)	4 (0.9)	25 (4.0)	17 (2.9)	3 (0.9)
Switzerland	7 (1.2)	2 (0.7)	7 (1.3)	7 (1.2)	10 (1.4)	25 (2.4)	5 (1.1)	2 (0.8)
<i>United States</i>	5 (0.8)	2 (0.5)	7 (0.9)	8 (0.9)	16 (2.4)	31 (2.5)	10 (1.1)	4 (0.6)

SOURCE: IEA Third International Mathematics and Science Study (TIMSS), 1995-96.

* See Appendix A for characteristics of the students sampled.

Countries shown in italics did not satisfy one or more guidelines for sample participation rates or student sampling (see Figure B.6).

Because population coverage falls below 65%, Latvia is annotated LSS for Latvian Speaking Schools only.

() Standard errors appear in parentheses. Because results are rounded to the nearest whole number, some totals may appear inconsistent.

An "r" indicates a 70-84% student response rate. An "s" indicates a 50-69% student response rate.

Table 10.12 (Continued)

**Physics Students' Reports on the Area They Intend to Study After Secondary School
by Gender – Physics
Final Year of Secondary School***

Country	Percent of Students					
	Engineering		Business		Other	
	Males	Females	Males	Females	Males	Females
<i>Australia</i>	37 (4.5)	10 (3.5)	6 (1.5)	13 (2.0)	10 (2.2)	16 (3.7)
<i>Austria</i>	13 (3.0)	3 (1.3)	20 (3.1)	11 (2.3)	30 (4.4)	53 (3.3)
Canada	33 (2.9)	9 (1.8)	10 (1.5)	10 (1.6)	13 (1.1)	17 (1.6)
Cyprus	26 (2.7)	16 (3.4)	4 (1.6)	3 (1.5)	18 (2.4)	22 (3.0)
Czech Republic	5 (1.2)	2 (0.5)	20 (2.6)	20 (2.0)	27 (2.6)	43 (3.9)
<i>Denmark</i>	34 (3.0)	11 (3.2)	12 (2.0)	6 (2.8)	16 (2.8)	41 (6.3)
France	22 (2.8)	5 (1.7)	5 (1.1)	9 (1.8)	14 (1.9)	14 (1.9)
Germany	23 (2.3)	7 (1.5)	24 (3.4)	29 (6.3)	17 (2.6)	39 (5.7)
Greece	29 (3.0)	25 (3.9)	2 (1.2)	2 (1.1)	18 (2.4)	18 (3.0)
Latvia (LSS)	11 (1.8)	1 (0.4)	35 (2.6)	34 (2.7)	25 (2.1)	39 (3.9)
Norway	33 (1.7)	21 (2.6)	8 (1.5)	2 (1.4)	15 (1.0)	16 (2.5)
Russian Federation	15 (1.7)	2 (0.6)	25 (2.8)	37 (2.4)	11 (1.5)	24 (2.8)
<i>Slovenia</i>	23 (4.4)	3 (1.4)	17 (2.3)	19 (3.5)	14 (2.7)	31 (5.7)
Sweden	51 (3.4)	22 (3.0)	4 (0.9)	4 (1.2)	14 (2.3)	23 (2.3)
Switzerland	12 (1.5)	4 (1.2)	24 (2.7)	4 (0.8)	36 (2.6)	56 (2.5)
<i>United States</i>	24 (1.9)	5 (0.7)	15 (1.8)	16 (1.3)	24 (1.9)	34 (2.4)

SOURCE: IEA Third International Mathematics and Science Study (TIMSS), 1995-96.

* See Appendix A for characteristics of the students sampled.

Countries shown in italics did not satisfy one or more guidelines for sample participation rates or student sampling (see Figure B.6).

Because population coverage falls below 65%, Latvia is annotated LSS for Latvian Speaking Schools only.

() Standard errors appear in parentheses. Because results are rounded to the nearest whole number, some totals may appear inconsistent.

An "r" indicates a 70-84% student response rate. An "s" indicates a 50-69% student response rate.