Chapter 8

International Student Achievement in Physics

Chapter 8 focuses on the TIMSS Advanced 2008 achievement results for students enrolled in physics courses in the final year of secondary school in each of the participating countries. The chapter also addresses trends in physics achievement over time for participants in the previous TIMSS assessment at this level in 1995. Achievement differences by gender are also discussed.

Distribution of Physics Achievement in the Participating Countries

Exhibit 8.1 shows the distribution of student achievement in physics for the participants in TIMSS Advanced 2008, including the average (mean) scale score with its 95 percent confidence interval and the ranges in performance for the middle half of the students (25th to 75th percentiles) as well as the extremes (5th and 95th percentiles). Countries are listed in decreasing order of average scale score.

TIMSS Advanced used item response theory (IRT) methods to summarize the physics achievement for each country on the TIMSS Advanced physics scale with a mean of 500 and a standard deviation of 100.[1] The TIMSS Advanced physics scale for reporting the TIMSS Advanced 2008 results was established by rescaling the

1 Given the matrix-sampling approach, the scaling process averages students' responses in a way that accounts for differences in the difficulty of different subsets of items. It allows students' performance to be summarized on a common metric even though individual students responded to different items in the physics test.

data from the 1995 TIMSS physics assessment of students in the final year of secondary school together with the physics data from the 2008 assessment using the scaling procedures currently used by TIMSS, and the methodology enables comparable trend measures from assessment to assessment.[2] That is, on the newly developed TIMSS Advanced scale for physics, a score of 500 in physics in 2008 is equivalent to a score of 500 in physics in 1995.[3] (Because the rescaled 1995 data together with the 2008 data have been used in the analyses conducted for TIMSS Advanced 2008 and procedures differed from those used in 1995, the achievement results for the 1995 data in this report cannot be directly compared with previously published 1995 achievement results.)

In Exhibit 8.1, there is a symbol by a participant's average scale score indicating whether the average achievement is significantly higher (up arrow) or significantly lower (down arrow) than the scale average of 500. Achievement on the TIMSS Advanced scale cannot be described in absolute terms (like all such scales developed using IRT technology), so these results cannot be directly compared to those for advanced mathematics found in Chapter 2. Comparisons between physics and advanced mathematics can only be made in terms of relative performance (higher or lower), for example, among countries as well as between assessments.

Exhibit 8.1 shows that the nine countries participating in the TIMSS Advanced 2008 physics assessment had considerable differences in their average achievement. The Netherlands was the top performing country with higher average achievement (nearly 50 scale-score points) than Slovenia and Norway, the next highest achieving countries. Slovenia and Norway had very similar average achievement in physics,[4] and together with the Netherlands had average scale scores significantly higher than the international scale average of 500.

2 Please see Appendix A for further information. A detailed description of the TIMSS Advanced 2008 scaling is provided in Foy, P., Galia, J., & Li, I. (2009). Scaling the data from the TIMSS Advanced 2008 mathematics and physics assessments. In A. Arora, P. Foy, M.O. Martin, & I.V.S. Mullis. (Eds.), *TIMSS Advanced 2008 technical report*. Chestnut Hill, MA: TIMSS & PIRLS International Study Center, Boston College.

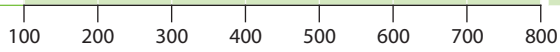
3 Because the rescaled 1995 data together with the 2008 data have been used in the analyses conducted for TIMSS Advanced 2008 and procedures differed from those used in 1995, the results from the 1995 data in this report cannot be compared directly with previous published 1995 achievement results.

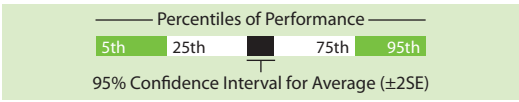
4 Taking into account the standard error provided in parentheses with each average scale score (mean achievement for the country), it can be said with 95 percent confidence that the corresponding value in the population falls between the sample estimate plus or minus two standard errors. Confidence intervals allow for an "eyeball" test of significance on whether the difference in the estimates (i.e., the means in this case) are statistically significant. If the confidence intervals of two estimates do not overlap, then differences in mean achievement are considered to be statistically significant. If the confidence intervals do overlap, then the estimates may or may not be statistically significantly different.

Exhibit 8.1 **TIMSS Advanced 2008 Distribution of Achievement in Physics**

TIMSSAdvanced 2008 Physics

Country	Physics Achievement: Physics Achievement Distribution	Physics Achievement: Average Scale Score	Country Context for Achievement: Physics Coverage Index	Years of Formal Schooling*	Average Age at Time of Testing	Human Development Index**
† Netherlands		▲ 582 (3.7)	3.4%	12	18.1	0.953
‡ Slovenia		▲ 535 (1.9)	7.5%	12	18.7	0.917
Norway		▲ 534 (4.2)	6.8%	12	18.8	0.968
Russian Federation		▲ 521 (10.2)	2.6%	10/11	17.1	0.813
TIMSS Adv. Scale Avg.		500				
Sweden		497 (5.6)	11.0%	12	18.8	0.956
Armenia		495 (5.3)	4.3%	10	17.7	0.775
Iran, Islamic Rep. of		▼ 460 (7.2)	6.6%	12	18.0	0.759
Lebanon		▼ 444 (3.0)	5.9%	12	17.9	0.772
Italy		▼ 422 (7.6)	3.8%	13	18.9	0.941





▲ Country average significantly higher than TIMSS Advanced scale average

▼ Country average significantly lower than TIMSS Advanced scale average

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

** Taken from United Nations Development Programme's *Human Development Report 2007/2008*, p.229-232.

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

‡ Did not satisfy guidelines for sample participation rates (see Appendix A).

( ) Standard errors appear in parentheses.

SOURCE: IEA TIMSS Advanced 2008 ©

The Russian Federation had average achievement somewhat above the scale average (but the difference was not statistically significant). Sweden (497) and Armenia (495) had average achievement very close to the scale average. Iran, Lebanon, and Italy had average achievement below the scale average, with each country performing successively lower than the next, on average.

The outer ends of the bar graphs in Exhibit 8.1 show the range of scores for a given country from the 5th to the 95th percentile. The Netherlands had the narrowest range of scores between the 5th and 95th percentiles, from a low of about 500 to a high of 675, about 1.75 standard deviations. Next, Slovenia, Norway, and Lebanon had a somewhat wider range of about 250 points, or 2.5 standard deviations. The remaining four countries had ranges close to or exceeding 300 scale points, with the Russian Federation having the greatest range of about 400 scale points. That is, the range of scores within countries exceeded, typically by a considerable margin, the difference of 160 scale-score points across countries from the highest average achievement in the Netherlands to the lowest in Italy.

Because one of the factors complicating this kind of comparison is the variation in the proportion of students taking physics in the final year of secondary school, Chapter 7 presented and discusssed the TIMSS Advanced Physics Coverage Index (see Exhibit 7.2). For ease of reference, it also is provided in Exhibit 8.1. For example, looking at the highest achieving countries, the Netherlands included 3.4 percent of its students in the TIMSS Advanced 2008 population from the possible population of all 18-year olds in the country. Slovenia and Norway included a slightly higher percentage of their age cohorts of 19-year-old students in the assessed population (7.5 and 6.8%, respectively). Across countries, at 11 percent, Sweden covered the largest percentage of their

age cohort of 19-year olds, and the Russian Federation, with an age cohort of 17, had the lowest coverage at 2.6 percent.

Exhibit 8.1 also shows the number of years of schooling completed in each country by the students who participated in TIMSS Advanced 2008 and the average age at the time of testing (see Exhibit 7.2). At the time of the TIMSS Advanced 2008 assessment, the students enrolled in physics courses in their final year of secondary school were in the 12th year of formal schooling in six of the participating countries: the Netherlands, Lebanon, Iran, Slovenia, Norway, and Sweden. However, Italy reported 13 years, the Russian Federation reported 10 or 11 years, and Armenia reported 10 years. It should be noted that, as discussed in Chapter 7, a number of these countries have implemented reforms in the number of years of schooling since the TIMSS Advanced assessment or are in the process of doing so.

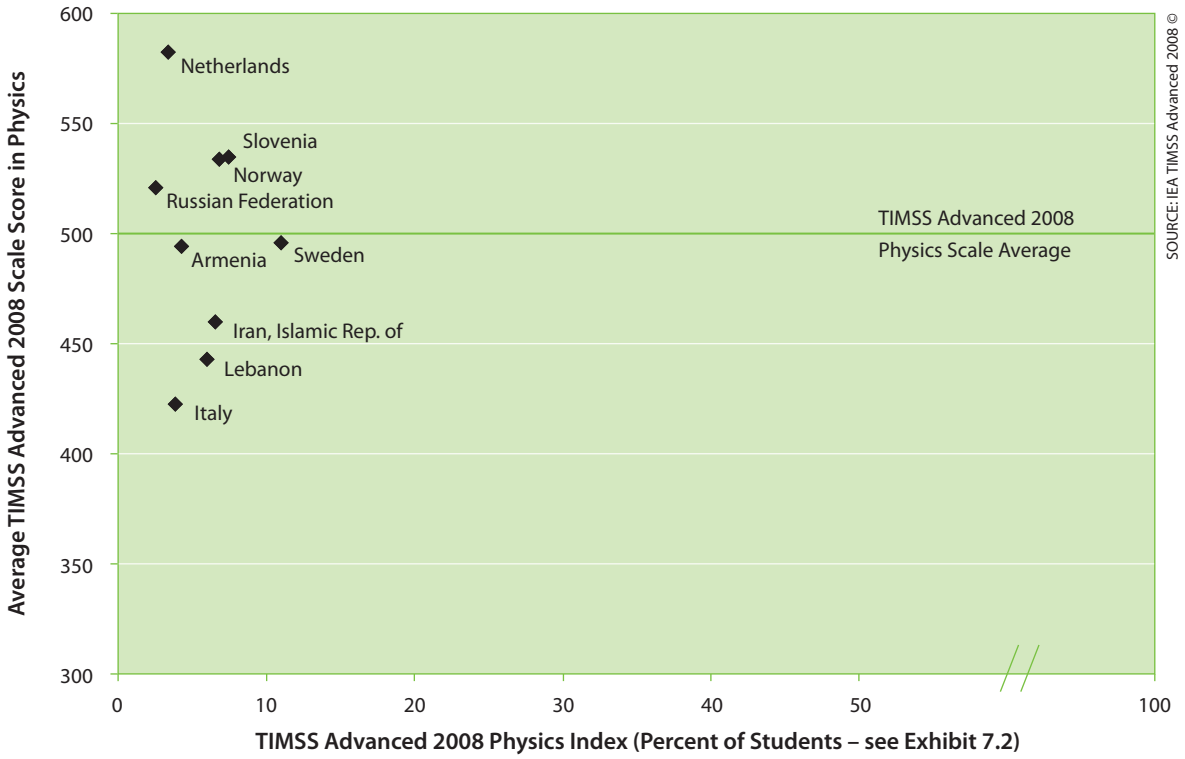
Because of differences among the years of schooling for these students in their final year as well as differences in age of entry to school and in promotion/retention policies, students' ages also varied across countries. The average age of the TIMSS Advanced 2008 students in Slovenia, Norway, Sweden, and Italy was about 19, whereas it was about 18 in the Netherlands, Armenia, Iran, and Lebanon. The physics students in the Russian Federation averaged about 17 years old.

The Human Development Index (HDI) was developed by the United Nations Development Programme, and is used in TIMSS to provide some context about the economic and educational development of the TIMSS participants. The index has a minimum value of 0.0 and a maximum of 1.0. Countries with high values on the index (over 0.8 as defined by the UNDP) have long life expectancies, high levels of school enrollment and adult literacy, and a good standard

of living, as measured by per capita Gross Domestic Product. Five of the TIMSS Advanced 2008 participants had index values over 0.9, including the Netherlands (0.953), Slovenia (0.917), Norway (0.968), Sweden (0.956), and Italy (0.941). With an index value of 0.813, the Russian Federation also falls into the UNDP's high category. However, three countries had index values in the 0.7 range and fall into the UNDP's medium category. Of the three countries, Armenia and Lebanon had nearly identical HDIs (0.772–0.775) with that of Iran being only slightly lower (0.759). Across the nine participating countries, there was some relationship between a country's HDI value and average achievement in physics for the specialized groups of students that participated in TIMSS Advanced 2008. With the exception of Italy, average achievement for the countries with HDIs over 0.9 ranged from a high of 582 in the Netherlands to a low of 497 in Sweden, with all performing average or above average on the TIMSS Advanced physics scale. Also, the Russian Federation with an HDI of 0.813 had about average achievement, and achievement for countries with HDIs in the 0.7 range was average or below the scale average ranging from a high of 495 in Armenia to a low of 444 in Lebanon.

Because of the importance of the proportion of the age cohort covered when considering how countries performed on the TIMSS Advanced 2008 physics assessment, Exhibit 8.2 presents average physics achievement in relation to the TIMSS Advanced 2008 Physics Coverage Index. In the graph, countries are arranged along the horizontal axis in ascending order of their TIMSS Advanced 2008 physics coverage index, from a low of 2.6 percent in the Russian Federation to a high of 11 percent in Sweden. Countries are arranged along the vertical axis in ascending order of their average TIMSS Advanced 2008 scale scores for physics, from a low of 422 in Italy to a high of 582 in the Netherlands. The *x*-coordinate for the point

Exhibit 8.2 **Average Achievement in Physics by TIMSS Advanced 2008 Coverage Index for Physics**



TIMSS Advanced 2008 Coverage Index for Physics

Country	Average Achievement	Coverage Index
Armenia	495	4.3%
Iran, Islamic Rep. of	460	6.6%
Italy	422	3.8%
Lebanon	444	5.9%
† Netherlands	582	3.4%
Norway	534	6.8%
Russian Federation	521	2.6%
‡ Slovenia	535	7.5%
Sweden	497	11.0%

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

‡ Did not satisfy guidelines for sample participation rates (see Appendix A).

corresponding to a given country, therefore, is the TIMSS coverage index for physics in that country, and the *y*-coordinate is the average scale score in physics. In general, the more to the right and the higher a country's point is on the graph, the better. And, correspondingly, the lower and the more to the left the point is, the more cause for concern there could be.

The results in Exhibit 8.2 reveal that none of the TIMSS Advanced participants were in the upper right hand corner, which would result from educating substantial proportions of students to high levels of achievement in physics. Sweden, with 11 percent of its population of final year students assessed in physics as part of TIMSS Advanced 2008, is the farthest right with average achievement about in the middle of the participating countries. The Netherlands, the Russian Federation, and Italy had the smallest coverage percentages (2.6–3.8%) but a substantial range in average achievement, with the Netherlands performing far above average, the Russian Federation about average, and Italy below average. Norway, Slovenia, Armenia, Iran, and Lebanon had slightly larger coverage percentages (5.9–7.5%), but these five countries also had differences in average achievement, with Norway and Slovenia performing similarly and above average, and each of the other three countries with somewhat successively lower achievement.

Achievement on TIMSS Advanced 2008 Physics Compared with Relative Achievement on TIMSS 2007

When the IEA began studying education internationally in the 1950s and 1960s, the populations compared often were to some degree comprised of elite students, especially at the secondary school level. That is, substantial proportions of students had dropped out of school and only the better students were continuing their schooling. Beyond that, most systems employed some type of tracking or streaming

so that the better students received the more advanced education. However, as the years have gone by, more and more students in more and more countries are enrolled in basic education and also completing secondary education. Thus, recent international assessments conducted by TIMSS at the fourth and eighth grades[5] provide results that pertain to the success countries are having in educating their entire school-aged populations. In contrast, TIMSS Advanced assesses the success countries have in educating a smaller proportion of select students to high levels of achievement on complicated content. Because all the TIMSS Advanced 2008 countries also participated in TIMSS 2007[6], it is interesting to make some comparisons about their relative standings in physics achievement internationally at the fourth and eighth grades compared to that for the advanced students in the final year of schooling (also keeping in mind the differences among the educational systems).

Exhibit 8.3 presents the average achievement in TIMSS 2007 in physical science (chemistry and physics) at the fourth grade and in physics at the eighth grade as well as in physics for TIMSS Advanced 2008. For each assessment, countries are shown from highest to lowest average achievement, with symbols indicating statistically significant differences above or below the scale average.

Interestingly, although several of the countries have consistent relative standing across the three assessments—fourth grade, eighth grade, and the final year of schooling—several also have very different patterns from assessment to assessment. The Russian Federation, Slovenia, and Armenia had consistent relative standings across the physics assessments, including on the physical science scale at the fourth grade, the physics scale at the eighth grade, and the TIMSS Advanced scale for their final year students enrolled in physics courses. The Russian Federation, with either 10 or 11 years of

5 Martin, M.O., Mullis, I.V.S. & Foy, P. (2008). *TIMSS 2007 international science report: Findings from IEA's Trends in International Mathematics and Science Study at the fourth and eighth grades*. Chestnut Hill, MA: TIMSS & PIRLS International Study Center, Boston College.

6 All participated at the fourth grade except Lebanon and all at the eighth grade except the Netherlands. However, the Netherlands did participate in TIMSS 2003 at the eighth grade.

Exhibit 8.3 **Average Physics Achievement at Fourth and Eighth Grades* and in the Final Year of Secondary School for the TIMSS Advanced 2008 Countries**

TIMSSAdvanced2008 Physics

TIMSS 2007 Physical Science - Fourth Grade			TIMSS 2007 Physics - Eighth Grade			TIMSS Advanced 2008 - Physics		
Country			Country			Country		
Russian Federation	547 (4.6)	▲	** Netherlands	536 (3.8)	▲	Netherlands	582 (3.7)	▲
Slovenia	530 (1.6)	▲	Slovenia	524 (2.0)	▲	Slovenia	535 (1.9)	▲
Italy	521 (3.1)	▲	Russian Federation	519 (4.0)	▲	Norway	534 (4.2)	▲
Sweden	508 (2.7)	▲	Sweden	506 (2.7)	▲	Russian Federation	521 (10.2)	▲
** Netherlands	503 (2.3)		Armenia	503 (5.6)		TIMSS Scale Avg.	500	
TIMSS Scale Avg.	500		TIMSS Scale Avg.	500		Sweden	497 (5.6)	
Armenia	492 (5.1)		Italy	489 (3.1)	▼	Armenia	495 (5.3)	
Norway	469 (2.7)	▼	Norway	475 (3.0)	▼	Iran, Islamic Rep. of	460 (7.2)	▼
Iran, Islamic Rep. of	454 (4.2)	▼	Iran, Islamic Rep. of	470 (3.6)	▼	Lebanon	444 (3.0)	▼
Lebanon	◊ ◊		Lebanon	431 (5.1)	▼	Italy	422 (7.6)	▼

SOURCE: IEA TIMSS Advanced 2008 ©

▲ Country average significantly higher than TIMSS scale average
▼ Country average significantly lower than TIMSS scale average

* TIMSS 2007 data taken from Martin, M.O., Mullis, I.V.S., & Foy, P. (2008). *TIMSS 2007 international science report: Findings from IEA's Trends in International Mathematics and Science Study at the fourth and eighth grades.* Chestnut Hill, MA: TIMSS & PIRLS International Study Center, Boston College.

** TIMSS 2003 data for the Netherlands at eighth grade taken from Martin, M.O., Mullis, I.V.S., Gonzalez, E.J., & Chrostowski, S.J. (2004). *TIMSS 2003 international science report: Findings from IEA's Trends in International Mathematics and Science Study at the fourth and eighth grades*. Chestnut Hill, MA: TIMSS & PIRLS International Study Center, Boston College.

( ) Standard errors appear in parentheses.

A diamond (◊) indicates the corresponding data are not available.

school and a medium HDI, performed above the scale average in all three assessments, as did Slovenia, with 12 years of school and a high HDI. Armenia, with 10 years of school and a medium HDI, performed approximately at the scale average in all three assessments. Lebanon, with 12 years of school and a medium HDI, performed below the physics scale average at the eighth grade in TIMSS and for their final year students in TIMSS Advanced.

Sweden performed relatively better in TIMSS 2007 physics than in TIMSS Advanced 2008. Sweden, with 12 years of schooling and a high HDI, also performed above average at the fourth and eighth grades, but only average for students taking physics during their last year of secondary school. Similarly, Italy, with 13 years of schooling and a high HDI, did relatively best at the fourth grade, performing above average, but then had below average achievement in physics at the eighth grade and in TIMSS Advanced 2008.

In contrast, the Netherlands and Norway (both with high HDIs and 12 years of schooling) performed relatively better in TIMSS Advanced than in TIMSS. The top-performing Netherlands in TIMSS Advanced 2008, also with a very high physics average in TIMSS 2003 at the eighth grade, only performed just about at the scale average for physical science at the fourth grade. The Norwegian physics specialists had above average achievement in TIMSS Advanced 2008, but the fourth and eighth grade students had below average achievement in the TIMSS 2007 domains of physical science and physics, respectively.

Gender Differences in Physics Achievement in the Participating Countries

Exhibit 8.4 shows the percentages of girls and boys enrolled in physics in each of the participating countries and their differences in average physics achievement on TIMSS Advanced 2008. It presents average achievement separately for females and males for the TIMSS Advanced 2008 countries, as well as the absolute difference between the two averages. The difference between the average achievement of females and males is shown in the graph by a bar indicating the amount of the difference, whether the direction of the difference was positive for females or males, and whether the difference is statistically significant (indicated by a darkened bar). Countries are shown in increasing order of the absolute difference in average achievement between females and males.

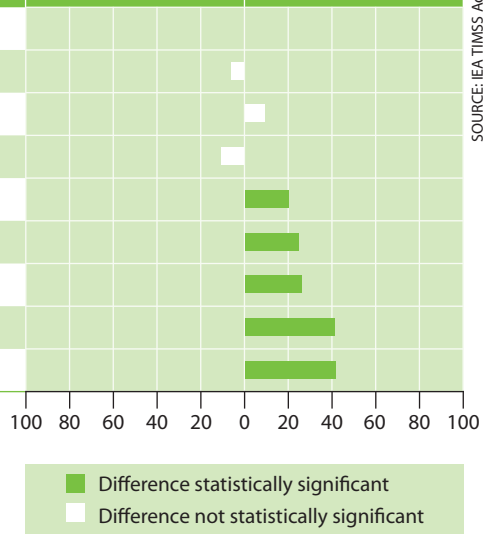
Enrollment in physics courses was predominately male in the TIMSS Advanced countries. In almost all of the countries, higher percentages of males than females were studying physics, and in some cases the physics courses were comprised primarily of male students; for example, 81 percent male students in the Netherlands and 71 to 73 percent male students in Slovenia, Lebanon, and Norway, as well as two thirds male students in Sweden and 60 percent in Italy. Although the Russian Federation and Iran had nearly similar percentages (about 55% male and 45% female), Armenia was the only country with somewhat more female students (53%) than male students (47%) taking physics.

In four countries, there was no or little difference in average achievement in physics between female students and male students. The four countries with equity in performance included Slovenia, Armenia, Sweden, and Lebanon. Males had higher average achievement in physics than females in the other five countries—the Netherlands, Norway, Italy, the Islamic Republic of Iran, and the Russian Federation.

Exhibit 8.4 **TIMSS Advanced 2008 Average Achievement in Physics by Gender**

TIMSSAdvanced2008 Physics

Country	Percent of Students		Average Achievement			
	Females	Males	Females	Males	Absolute Difference	Females Scored Higher / Males Scored Higher
‡ Slovenia	27 (1.2)	73 (1.2)	535 (5.2)	535 (2.7)	0 (6.8)	
Armenia	53 (1.5)	47 (1.5)	498 (5.9)	492 (6.6)	6 (6.6)	
Sweden	35 (2.4)	65 (2.4)	491 (6.8)	500 (6.3)	9 (6.3)	
Lebanon	29 (1.3)	71 (1.3)	451 (4.5)	440 (3.7)	11 (5.7)	
† Netherlands	19 (1.1)	81 (1.1)	566 (5.1)	586 (3.6)	20 (3.9)	
Norway	29 (1.7)	71 (1.7)	517 (6.2)	541 (4.3)	25 (5.9)	
Italy	40 (2.4)	60 (2.4)	407 (10.5)	432 (7.5)	26 (9.0)	
Iran, Islamic Rep. of	44 (1.6)	56 (1.6)	437 (7.3)	478 (11.4)	41 (13.6)	
Russian Federation	45 (1.3)	55 (1.3)	498 (10.5)	540 (10.4)	42 (6.8)	



SOURCE: IEA TIMSS Advanced 2008 ©

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

‡ Did not satisfy guidelines for sample participation rates (see Appendix A).

( ) Standard errors appear in parentheses.

In particular, the advantage for male students was substantial in the Islamic Republic of Iran and the Russian Federation—41 to 42 scale score points.

Changes in Advanced Physics Achievement Between 1995 and 2008

Exhibit 8.5 displays changes in average physics achievement for the four countries that participated in both the 1995 and 2008 cycles of this study, and these data are shown together with changes in the TIMSS Advanced Coverage Index. Coverage was comparable for the Russian Federation in both assessments as it was in Norway, although the coverage in the Russian Federation was slightly increased in 2008 and the coverage in Norway was slightly decreased. However, coverage was considerably less in 2008 for Slovenia than it was in 1995, decreasing from about 39 to 8 percent. Coverage for Sweden also was reduced to some extent from approximately 16 to 11 percent.

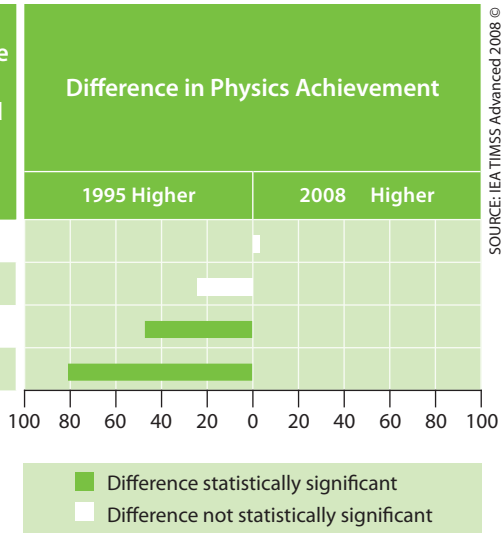
The participants are shown in the exhibit according to the difference between their 1995 and 2008 scores. In two of the four countries—Norway and Sweden—average achievement in physics declined between the two assessments. Sweden showed the greatest average decline—81 points, although the decrease in Norway of 47 points also was substantial. In the Russian Federation, average achievement in 2008 showed some signs of decline but was not statistically different from that in 1995. Slovenia, with the largest decrease in the TIMSS Advanced Coverage Index, had essentially no change in average achievement in physics between the 1995 and 2008 assessments.

Exhibit 8.6 shows changes in average achievement separately for females and males. In general, the trend results were more negative for males than for females. Reflecting the overall declines in Norway

Exhibit 8.5 Trends in Average Achievement in Physics

TIMSSAdvanced 2008 Physics

Countries	TIMSS Physics Coverage Index		TIMSS Advanced 2008 Physics Average Scale Score	TIMSS Advanced 1995 Physics Average Scale Score*	Difference Between 1995 and 2008 Scores
	2008	1995			
‡ Slovenia	7.5%	38.6%	535 (1.9)	532 (13.3)	3 (13.4)
Russian Federation	2.6%	1.5%	521 (10.2)	546 (10.5)	–24 (14.6)
Norway	6.8%	8.4%	534 (4.2)	581 (5.4)	–47 (6.8)
Sweden	11.0%	16.3%	497 (5.6)	578 (3.6)	–81 (6.7)



SOURCE: IEA TIMSS Advanced 2008 ©

* To measure trends, the 1995 data were rescaled together with the 2008 data. Because procedures differed from those used in 1995, the achievement results for the 1995 assessment in this report cannot be compared directly with previously published 1995 achievement results.

‡ In 2008 and 1995, did not satisfy guidelines for sample participation rates (see Appendix A).

( ) Standard errors appear in parentheses.

Exhibit 8.6 Trends in Average Achievement in Physics by Gender

TIMSSAdvanced 2008 Physics

Country	Females		Males	
	2008 Average Scale Score	1995 to 2008 Difference	2008 Average Scale Score	1995 to 2008 Difference
Norway	517 (6.2)	-36 (10.6) ▼	541 (4.3)	-50 (6.8) ▼
Russian Federation	498 (10.5)	-9 (17.8)	540 (10.4)	-37 (13.3) ▼
‡ Slovenia	535 (5.2)	57 (18.7) ▲	535 (2.7)	-15 (12.9)
Sweden	491 (6.8)	-60 (8.9) ▼	500 (6.3)	-90 (7.2) ▼

SOURCE: IEA TIMSS Advanced 2008 ©

▲ 2008 average significantly higher than 1995
▼ 2008 average significantly lower than 1995

‡ In 2008 and 1995, did not satisfy guidelines for sample participation rates (see Appendix A).

( ) Standard errors appear in parentheses.

and Sweden, decreases in achievement for both males and females were found in these two countries. However, in both cases, the overall declines may be more related to declines by male students (50 points in Slovenia and 90 points in Sweden) than by female students (36 points in Slovenia and 60 points in Sweden). In the Russian Federation, the males had lower average physics achievement in 2008 than in 1995, and females' average achievement remained relatively stable. In Slovenia, females had higher achievement in 2008 than 1995 by 57 points, whereas males had no change (or perhaps even a slight decrease). The positive gains by Slovenian female students resulted in equivalent average achievement between the genders in 2008.

Achievement Differences Across the TIMSS Advanced 2008 Physics Content and Cognitive Domains

As described in the *TIMSS Advanced 2008 Assessment Frameworks*,[7] the physics assessment was organized around two dimensions, a content dimension specifying the subject matter or content domains to be assessed in physics and a cognitive dimension specifying the thinking processes that students were deemed likely to use as they engaged with the content. Each item in the physics assessment was associated with one content domain and one cognitive domain, providing for both content-based and cognitive-oriented perspectives on student achievement in physics.

This section presents average student performance in the four content domains of the physics framework: mechanics, electricity and magnetism, heat and temperature, and atomic and nuclear physics. Average performance also is presented for each of three cognitive domains: knowing, applying, and reasoning. Knowing refers to the student's knowledge base of physics facts, concepts, tools, and procedures. Applying focuses on the student's ability to apply

7 Garden, R.A., Lie, S., Robitaille, D.F., Angell, C., Martin, M.O., Mullis, I.V.S., Foy, P., & Arora, A. (2006). *TIMSS Advanced 2008 Assessment Frameworks*. Chestnut Hill, MA: TIMSS & PIRLS International Study Center, Boston College.

knowledge and conceptual understanding in a problem situation. Reasoning goes beyond the solution of routine problems to encompass unfamiliar situations, complex contexts, and multi-step problems.

Students' performance across the four content domains and the three cognitive domains is summarized in Exhibit 8.7. The table shows the average percent correct for all of the physics items for each country as well as the average percent correct with each of the four content domains and three cognitive domains. Standard errors are shown in parentheses. The analysis by content and cognitive domains uses average percent correct rather than average scale scores because there were insufficient items in each of the separate domains to develop reliable scales. The countries are listed in alphabetical order.

In the content domains, although the differences were not large, Armenia and Iran did relatively better on the atomic and nuclear physics items than they did overall. Armenia performed relatively less well on heat and temperature items and Iran on items in mechanics. Italian students did relatively better in electricity and magnetism than they did overall and less well in heat and temperature. The Lebanese students had much higher achievement in the atomic and nuclear physics content domain and much lower achievement in heat and temperature than they had overall. In the Netherlands, students had higher average achievement in the atomic and nuclear physics content domain and relatively lower achievement in electricity and magnetism. The Norwegian students performed relatively better in the mechanics content domain than they did overall and relatively worse in heat and temperature. In the Russian Federation, students performed about as well in mechanics, electricity and magnetism, and atomic and nuclear physics as they did overall. The Slovenian students had relatively higher achievement in mechanics than they did overall and lower achievement in heat and temperature. In Sweden, the students had relatively higher

Exhibit 8.7 **Average Percent Correct in the Physics Content and Cognitive Domains**

TIMSSAdvanced2008 Physics

Country	Physics (68 Items)	Physics Content Domains				Physics Cognitive Domains		
		Mechanics (18 Items)	Electricity and Magnetism (21 Items)	Heat and Temperature (15 Items)	Atomic and Nuclear Physics (14 Items)	Knowing (20 Items)	Applying (31 Items)	Reasoning (17 Items)
Armenia	42 (0.7)	40 (0.9)	44 (0.9)	39 (1.0) ▼	45 (0.9) ▲	56 (0.9) ▲	43 (0.7)	26 (0.9) ▼
Iran, Islamic Rep. of	37 (1.1)	34 (1.0) ▼	40 (1.2)	35 (1.2)	42 (1.2) ▲	53 (1.2) ▲	38 (1.2)	23 (1.0) ▼
Italy	32 (0.9)	31 (1.2)	36 (1.0) ▲	29 (1.0) ▼	33 (1.2)	45 (1.3) ▲	34 (1.0)	17 (0.8) ▼
Lebanon	33 (0.4)	32 (0.6)	33 (0.4)	21 (0.6) ▼	48 (0.8) ▲	44 (0.6) ▲	35 (0.5) ▲	18 (0.5) ▼
† Netherlands	57 (0.7)	55 (0.9)	50 (0.7) ▼	59 (1.1)	64 (0.9) ▲	68 (0.6) ▲	59 (0.8) ▲	41 (1.0) ▼
Norway	47 (0.7)	50 (0.9) ▲	47 (0.7)	42 (1.0) ▼	49 (0.9)	65 (0.9) ▲	46 (0.8)	33 (0.7) ▼
Russian Federation	46 (1.6)	48 (1.8)	47 (1.7)	39 (1.6) ▼	50 (1.8)	58 (1.6) ▲	49 (1.8)	29 (1.7) ▼
‡ Slovenia	47 (0.5)	50 (0.7) ▲	46 (0.6)	43 (0.8) ▼	47 (0.8)	57 (0.6) ▲	50 (0.5) ▲	32 (0.9) ▼
Sweden	41 (0.8)	41 (0.8)	41 (0.9)	36 (0.8) ▼	50 (1.1) ▲	58 (1.1) ▲	42 (0.8)	25 (0.7) ▼

▲ Significantly higher than overall Physics percent correct
▼ Significantly lower than overall Physics percent correct

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

‡ Did not satisfy guidelines for sample participation rates (see Appendix A).

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

performance in the atomic and nuclear physics content domain and lower achievement in heat and temperature. With the exception of Iran and the Netherlands, the TIMSS Advanced countries seemed to find the items in the heat and temperature domain to be more difficult than the items overall.

In the cognitive domains, the pattern was similar in all of the participating countries. The students found the physics items in the knowing domain to be considerably easier than the overall pool of items, and the reasoning items to be considerably more difficult. In several cases, the students also found the applying items to be slightly easier than the items overall (Lebanon, the Netherlands, and Slovenia).

Exhibit 8.8 presents the content and cognitive domain results by gender. The upper portion of the exhibit summarizes the results in the four content domains by gender, and the lower portion does the same for the three cognitive domains. Results for Armenia show no significant differences in average percent correct between females and males in any of the seven content and cognitive domains. Also, Slovenia had almost no difference in achievement by gender, except females had higher achievement than males in the atomic and nuclear physics content domain. In Sweden, there were few differences in achievement by gender, except males had higher achievement than females in the content domain of mechanics and in the cognitive domain of reasoning.

In comparison, in the Russian Federation, males had higher average achievement than females across all seven of the content and cognitive domains. Iranian male students had higher average achievement in all four content domains, and in the applying and reasoning cognitive domains. Norwegian male students had higher average achievement than females in all content domains except atomic and nuclear physics and in all three cognitive domains. In Italy, males

Exhibit 8.8 **Average Percent Correct in the Physics Content and Cognitive Domains by Gender**

TIMSSAdvanced 2008 Physics

Country	Average Percent Correct for Physics Content Domains							
	Mechanics		Electricity and Magnetism		Heat and Temperature		Atomic and Nuclear Physics	
	Females	Males	Females	Males	Females	Males	Females	Males
Armenia	41 (1.2)	39 (1.3)	43 (1.2)	44 (1.2)	40 (1.2)	38 (1.3)	45 (0.9)	45 (1.3)
Iran, Islamic Rep. of	29 (1.0)	38 (1.6) ▲	36 (1.2)	44 (1.8) ▲	31 (1.2)	38 (2.0) ▲	39 (1.5)	44 (1.9) ▲
Italy	29 (1.4)	32 (1.4)	33 (1.3)	37 (1.2) ▲	25 (1.4)	31 (1.1) ▲	30 (1.6)	34 (1.3)
Lebanon	32 (1.1)	32 (0.7)	36 (0.7) ▲	33 (0.5)	21 (0.9)	21 (0.6)	51 (0.9) ▲	47 (1.0)
† Netherlands	52 (1.3)	56 (0.9) ▲	47 (1.0)	51 (0.7) ▲	56 (2.1)	60 (1.1)	63 (1.7)	65 (0.8)
Norway	46 (1.2)	52 (1.0) ▲	45 (1.2)	48 (0.8) ▲	38 (1.3)	44 (1.0) ▲	48 (1.6)	49 (1.0)
Russian Federation	43 (1.8)	51 (2.0) ▲	44 (1.8)	50 (1.7) ▲	35 (1.7)	42 (1.8) ▲	47 (1.9)	53 (1.8) ▲
‡ Slovenia	49 (1.7)	51 (0.7)	48 (1.5)	46 (0.7)	42 (1.6)	44 (0.9)	50 (1.6) ▲	46 (0.8)
Sweden	38 (0.9)	42 (1.0) ▲	39 (1.1)	41 (1.0)	35 (0.9)	37 (1.1)	51 (1.4)	49 (1.3)

Country	Average Percent Correct for Physics Cognitive Domains					
	Knowing		Applying		Reasoning	
	Females	Males	Females	Males	Females	Males
Armenia	57 (1.0)	55 (1.2)	44 (0.8)	43 (1.0)	27 (1.3)	26 (1.3)
Iran, Islamic Rep. of	51 (1.4)	55 (1.7)	33 (1.1)	42 (1.9) ▲	18 (1.0)	26 (1.6) ▲
Italy	43 (1.6)	47 (1.4)	31 (1.2)	36 (1.1) ▲	14 (1.0)	18 (0.9) ▲
Lebanon	46 (0.9) ▲	43 (0.7)	35 (0.7)	35 (0.6)	20 (0.8) ▲	18 (0.6)
† Netherlands	66 (1.4)	69 (0.7)	57 (1.2)	60 (0.8) ▲	37 (1.8)	42 (1.0) ▲
Norway	62 (1.4)	66 (0.9) ▲	44 (1.1)	48 (0.8) ▲	27 (1.1)	35 (0.9) ▲
Russian Federation	55 (1.7)	61 (1.7) ▲	45 (1.8)	52 (1.8) ▲	24 (1.6)	32 (1.8) ▲
‡ Slovenia	56 (1.4)	58 (0.8)	50 (1.1)	49 (0.6)	32 (2.1)	32 (0.9)
Sweden	56 (1.3)	59 (1.3)	41 (0.9)	43 (1.0)	24 (0.9)	26 (0.8) ▲

▲ Significantly higher than other gender

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

‡ Did not satisfy guidelines for sample participation rates (see Appendix A).

( ) Standard errors appear in parentheses.

SOURCE: IEA TIMSS Advanced 2008 ©

had higher average achievement than females in two content domains (electricity and magnetism as well as heat and temperature) and in the Netherlands males also had higher average achievement than females in two content domains (electricity and magnetism as well as mechanics). In both Italy and the Netherlands, males had higher average achievement than females in the applying and reasoning cognitive domains.

In Lebanon, female students had higher achievement than male students in two content domains—atomic and nuclear physics as well as electricity and magnetism; and in two cognitive domains—knowing and reasoning.

Looking across countries, males had higher average achievement than females in five countries in the content domains of mechanics and electricity and magnetism, and higher average achievement in four countries in the heat and temperature domain. Among these three content domains, females had higher average achievement than males in only one country (Lebanon) in only one domain—electricity and magnetism. Interestingly, in atomic and nuclear physics, females had higher achievement in two countries (Lebanon and Slovenia) and males had higher achievement in two countries (Iran and the Russian Federation).

In the cognitive domains, females had higher achievement than males in the knowing domain in one country (Lebanon) and males had higher achievement than females in two countries (Norway and the Russian Federation). In the applying domain, males had higher average achievement than females in five countries and females did not have higher average achievement than males in any of the countries. Male students had higher average achievement than female students in the reasoning domain in six countries compared to females having higher average achievement in only one country—again, Lebanon.