TRENDS IN INTERNATIONAL MATHEMATICS AND SCIENCE STUDY

TIMSS

TIMSS Advanced 2008 International Report

Findings from IEA's Trends in International Mathematics and Science Study at the Twelfth Grade

Ina V.S. Mullis
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Pierre Foy

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International Study Center
Lynch School of Education, Boston College

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Foreword

In addressing the challenges associated with developing a nation's educational policies, countries need to consider not only the broader societal demands for a system of education that meets the challenge of producing an educated citizenry but also the need to provide educational opportunities and experiences that adequately prepare students pursuing their education to the most advanced levels. Technologically advanced economies demand a workforce with advanced skills and knowledge, which requires an education system capable of preparing those students who will be the future technicians, scientists, engineers and doctors.

TIMSS Advanced 2008, which is a project of the International Association for the Evaluation of Educational Achievement (IEA), is part of the TIMSS (Trends in International Mathematics and Science Study) series of projects that examine student achievement in mathematics and science together with curricular and instructional practices in a number of countries. It represents the continued efforts of the IEA to work with countries in assisting them to improve educational policies and practices related to the teaching and learning of mathematics and science in elementary and secondary schools.

In 1995, the first cycle of TIMSS, which examined the teaching and learning of mathematics and science at five grade levels in 45 countries, included an assessment of students in their final year of schooling who were studying advanced mathematics and physics in preparation, usually, for further study in tertiary institutions. The advanced assessment in 1995 had 20 participating countries, 16 in advanced mathematics and 16 in physics. TIMSS Advanced 2008, like its predecessor in 1995, once again focuses on those students who were enrolled in their final year of schooling and were studying advanced mathematics or physics as part of their academic program. Conducted thirteen years later, TIMSS Advanced 2008 provides an opportunity for those countries that participated in 1995 to examine and reflect on changes in performance that may have occurred in the intervening period, and for countries that are participating for the first time to consider the performance of their elite mathematics and physics students in an international context.

Despite the fact that a relatively small and select group of countries participated in this project, studies such as TIMSS Advanced 2008 require considerable support. Funding for this project was provided through a generous grant from the Norwegian Ministry of Education, fees from participating countries and through IEA's own resources. IEA remains particularly grateful for the support it received from the Norwegian Ministry of Education

The work contained in this document represents the efforts of a considerable number of people. I would like to express my thanks to the Mathematics coordinator, Robert Garden, the Physics Coordinator, Svein Lie, the subject matter specialists, the staff of the TIMSS & PIRLS International Study Center at Boston College, especially Alka Arora, the TIMSS Advanced Coordinator; and to the staff involved from the IEA Data Processing Center and Secretariat, Statistics Canada, and

Educational Testing Service. I appreciate, in particular, the contribution of the National Research Coordinators, and of the TIMSS Advanced Executive Directors, Ina V.S. Mullis and Michael O. Martin.

Hans Wagemaker
Executive Director, IEA

Introduction

This report presents findings from the TIMSS Advanced 2008 assessments of advanced mathematics and physics at the senior secondary school level in 10 countries, and includes a discussion of changes in students' achievement over time in the 5 countries whose students participated in both cycles of the project in 1995 and 2008. (For a list of countries, please see Exhibit 1 in the following section headed, "Countries Participating in TIMSS Advanced 2008.") The report contains considerable information about the contexts for teaching and learning advanced material in mathematics and physics in the participating countries.

Two other volumes, the *TIMSS Advanced 2008 Assessment Frameworks* and the *TIMSS Advanced 2008 Technical Report*, are also available. The *TIMSS Advanced 2008 Assessment Frameworks* describes the advanced mathematics and physics frameworks, respectively, underlying the two assessments as well as the design of the assessments. The *TIMSS Advanced 2008 Technical Report* provides technical documentation about the development and implementation of the assessments. The *TIMSS Advanced 2008 International Database and User Guide* includes the entire international database for both assessments together with proprietary database management and analysis software. The TIMSS Advanced 2008 publications and the database can be found on the TIMSS website (timssandpirls.bc.edu).

Achievement results from a study such as this are influenced by many factors, and the international report is typically complemented by a national report prepared in each country. In their national reports, countries can explore their data in more detail, or examine aspects of particular policy relevant factors in more depth than is possible in the international report.

Background for IEA's TIMSS Advanced 2008 Assessment

TIMSS Advanced 2008 is one in a series of TIMSS assessments designed to provide comparative information about educational achievement across countries as part of a continuing effort to improve the teaching and learning of mathematics and science in elementary and secondary schools internationally. TIMSS (Trends in International Mathematics and Science Study) is a global enterprise, with countries working cooperatively together to examine students' achievement in mathematics and science as well as report on curricular innovations and instructional practices in the participating countries.

TIMSS is a major project of the International Association for the Evaluation of Educational Achievement (IEA), an independent cooperative of national research institutions and government agencies with the mission of providing high quality information on students' achievement outcomes and on the educational contexts in which students achieve. IEA has been conducting cross-national studies of student achievement in a wide range of school subjects since 1959.

The first cycle of TIMSS was conducted in 1995 and examined the teaching and learning of mathematics and science at several grade levels, including a senior secondary school population of students in their last year of secondary school who were studying advanced mathematics or physics to prepare them for further study of mathematics and science at the tertiary level. Twenty countries participated in that study altogether, with 16 countries participating in the advanced mathematics study and a slightly different set of 16 countries participating in the physics study. There was considerable interest in the 1995 TIMSS Advanced project, particularly among educational policy makers, mathematics educators, and science educators. Many viewed the study as an opportunity to "use the world as an educational laboratory," in Torsten Husén's memorable phrase, to learn more about what was educationally feasible with respect to the teaching and learning of mathematics and science in preparing students for their future careers.

In the almost 15 years that have elapsed since that first cycle of TIMSS, there have been regular 4-year iterations of the study at the fourth and eighth grades,[1] but not at the senior secondary level. Over that period, a number of countries and individuals have expressed interest in replicating the 1995 TIMSS assessment of students having taken advanced courses, and a decision was made to conduct TIMSS Advanced 2008, focusing once again on students who were enrolled in the last year of secondary school, and who were specializing in advanced mathematics or physics as part of an academic program.

Taking part in an international study comparing and contrasting the achievement of senior secondary students enrolled in the most advanced programs in mathematics and science that their countries have to offer is an attractive prospect for many educators, researchers, and policy makers. Many believe that the future security and well-being of their societies are strongly linked to the quality and quantity of well educated citizens graduating from their secondary schools,

1 TIMSS 1995, TIMSS 1999, TIMSS 2003, and TIMSS 2007 have been completed, and TIMSS 2011 currently is underway.

particularly those with strong backgrounds and career interests in fields related to mathematics, science, engineering, and technology.

In shaping education policy, every country confronts the challenge of providing a high level of education for all students. As part of this challenge, countries need to consider the issue of at what level and how many specialists they should be preparing in mathematics, science, and engineering. It is important globally for countries to educate students who can teach and pursue careers in a host of crucial medical, social, and industrial fields requiring specialized mathematics or physics knowledge and who are capable of making the kinds of technological discoveries that will improve the quality of life worldwide. To address this need, countries typically offer a variety of specialized programs for their senior secondary students, including programs designed to prepare students for admission to the study of mathematics, science, and related areas at the university or other tertiary levels. Decisions about what constitutes a high level of education or a specialized program, however, differ considerably across countries as do ideas about how many students should or can participate in advanced courses or receive specialist or even "super" specialist training. Across countries, programs in advanced mathematics and physics vary widely in terms of the proportion of the age cohort of students enrolled in them, in the depth and sophistication of the subject matter content included, and in their pedagogical and administrative contexts.

As attractive as the prospect of participating in an international comparative study at this level might be, there are significant obstacles to be overcome. At the elementary or lower secondary school levels, it is generally the case that virtually all of the children in the relevant age cohort in a given country are enrolled in school and studying more or less the same content. Also, at least as far as mathematics and science are concerned, there is a great deal of curricular commonality across countries. So reaching agreement on the content to be assessed is quite feasible, although still a challenging task.

The challenge is considerably more difficult at the senior secondary level. By that time, a significant proportion of the age cohort may no longer be in school, either because students who were registered in certain programs have completed their program at an earlier exit point in the system (e.g., after Grade 10 in some countries), or they have dropped out of school. Also, the number of program and curricular choices available to students varies significantly across countries at the senior secondary level. This means that the percentage of students who elect to specialize in advanced mathematics or physics varies greatly across countries, as does the content of the curriculum they are taught. In addition, there are complications inherent in the assessment of older students. In many countries, students in their final year of secondary school, and especially those in advanced programs, are facing the pressure associated with high-stakes, national, end-of-school-year examinations, particularly when the TIMSS Advanced 2008 data collection was scheduled in the last quarter of the school year, at about the same time as those examinations. Also, some countries have difficulty meeting the high standards that TIMSS has in place regarding student and school participation rates, and it is well known that as students get older and more independent, it is more difficult to get them to participate voluntarily in such a project.

In looking at the results for TIMSS Advanced 2008, the additional sources of variation across countries complicate the interpretation of the outcome data; however, considerable effort has been made to provide detailed descriptions about the educational programs for learning advanced mathematics and physics in each of the participating countries and to fully document educational and demographic information about the students assessed. Also, every effort was made to ensure that the assessments would provide fair comparisons of student achievement in advanced mathematics and physics. The frameworks for the content to be assessed and the assessment items were developed through a collaborative process involving representatives from the participating countries. The data provide a rich source of information for those interested in examining what higher learning is possible. If, for example, Country A offers a highly enriched program in advanced mathematics to a significant percentage of its age cohort, and those students achieve at comparatively high levels on an international assessment, what implications do such results have for educators, researchers, and policy makers in other countries?

The TIMSS Curriculum Model

The purpose of the TIMSS international endeavor as a whole is to help improve teaching and learning in mathematics and science, and to this end the project is designed specifically to provide important, policy-relevant information that can be used to evaluate the success of educational systems. In addition to providing information about trends in academic achievement, TIMSS collects a rich array of background information to provide comparative perspectives on the achievement trends in the context of different educational systems, school organizational approaches, and instructional practices.

Because every country has national or regional curriculum goals and expends significant resources on developing and implementing those goals, the information that TIMSS collects about the success of curriculum implementation is extremely valuable for participating countries. TIMSS uses the curriculum, broadly defined, as the major organizing concept in considering how educational opportunities are provided to students, and the factors that influence how students use these opportunities. The TIMSS curriculum model has three aspects:

the intended curriculum, the implemented curriculum, and the achieved curriculum. These represent, respectively, the mathematics and science curriculum that the country (or regional entity) intends for students to learn and policies that have been developed to facilitate this learning; what is actually taught in classrooms, who teaches it, and how it is taught; and, finally, what it is that students have learned, and what they think about these subjects.

While the results on the TIMSS Advanced 2008 achievement tests in advanced mathematics and physics describe students' learning in the participating countries, responses to a series of background questionnaires provide extensive information about the structure and content of the intended curriculum, the preparations and experience of teachers, the mathematics and physics actually taught, the instructional approaches used, the organization and resources of schools and classrooms, and the experiences and attitudes of students in the schools. An important characteristic of IEA studies, notably including TIMSS, is that they are designed on the basis of a representative sample of intact classrooms within schools in the participating countries. As a result, student outcomes can be examined in the light of curricular and pedagogical variables in ways that would not be possible in the case of studies based on random selections of students within schools.

Countries participating in TIMSS Advanced 2008 completed questionnaires about their national education systems and situations, providing descriptions of their official curricula and identifying the TIMSS Advanced topics that were specified in the intended curricula. Data about the instructional methods used to implement the curriculum were provided by teachers and principals of the assessed students and by the students themselves. Corresponding to the information about the intended curriculum, teachers provided information about each of the TIMSS topics taught to the students.

The students provided information about their home and classroom experiences, and their teachers and schools provided information about instructional practices, school resources, and the school climate for learning.

Conducting TIMSS Advanced 2008

IEA has delegated responsibility for the overall direction and management of TIMSS Advanced to the TIMSS & PIRLS International Study Center at Boston College, which also conducts IEA's TIMSS and PIRLS projects. Since first being conducted in 1995, TIMSS has reported every four years on the achievement of fourth and eighth grade students in countries all around the world. TIMSS 2011, the fifth in the series of TIMSS assessments, is currently underway and is expected to have more than 60 participating countries. TIMSS, together with PIRLS, comprises the core of IEA's regular cycle of studies. PIRLS (Progress in International Reading Literacy Study) has been assessing reading comprehension at the fourth grade since 2001 on a regular 5-year cycle. Forty countries participated in PIRLS 2006 and PIRLS 2011 is underway. In 2011, TIMSS and PIRLS are being conducted together, providing an unprecedented opportunity to assess mathematics, science, and reading at the fourth grade for the same students in an international context.

Headed by Ina V.S. Mullis and Michael O. Martin, the TIMSS & PIRLS International Study Center is located in the Lynch School of Education. In carrying out the projects, the study center works closely with the IEA Secretariat in Amsterdam, the IEA Data Processing and Research Center in Hamburg, Statistics Canada in Ottawa, and Educational Testing Service in Princeton, New Jersey. For TIMSS Advanced 2008, as in 1995, Bob Garden from New Zealand is the Advanced Mathematics Coordinator and Svein Lie from Norway is the Physics Coordinator. To work with the international team and coordinate within-country activities, each participating country designated one or two individuals to be the TIMSS National Research Coordinator or Coordinators, known as NRCs. TIMSS expends enormous energy to ensure the reliability, validity, and comparability of the data through careful planning and documentation, cooperation among participating countries, standardized procedures, and rigorous attention to quality control throughout. The data are collected according to rigorous scientific standards detailed in procedural manuals and implemented through software applications where appropriate, with countries receiving training every step of the way.

Countries Participating in TIMSS Advanced 2008

Ten countries, with widely divergent socioeconomic characteristics and from different cultural and geographic parts of the world, took part in TIMSS Advanced 2008. They were Armenia, the Islamic Republic of Iran, Italy, Lebanon, the Netherlands, Norway, the Philippines, the Russian Federation, Slovenia, and Sweden. All 10 countries participated in the advanced mathematics assessment and all except the Philippines participated in the physics assessment. In Exhibit 1 the participating countries are shown in two columns, with the five countries that participated in TIMSS Advanced in both 1995 and 2008 shown in green. Four of the five countries have trend data for the advanced mathematics assessment, including Italy, the Russian Federation, Slovenia, and Sweden. A slightly different set of four countries have trend data for the physics assessment, including Norway, the Russian Federation, Slovenia, and Sweden. The decision to participate in any IEA study is coordinated through the IEA Secretariat in Amsterdam and made by each member country according to its own data needs and resources.

Exhibit 1 **Countries Participating in TIMSS Advanced 1995 and 2008**

TIMSSAdvanced 2008

Armenia	Norway
Islamic Rep. of Iran	Philippines
Italy	Russian Federation
Lebanon	Slovenia
Netherlands	Sweden

■ Also participated in 1995

SOURCE: IEA TIMSS Advanced 2008 ©

Exhibit 2 presents selected information about the demographic and economic characteristics of the TIMSS Advanced 2008 countries, since such factors are known to influence education policies and decision making. The TIMSS Advanced 2008 countries vary widely in population size and geographic area, as well as in population density. The Russian Federation is by far the largest country in population size and geographic area (142 million people and over 16 million square kilometers) with Armenia, Lebanon, and Slovenia being the smallest (2–4 million people and 10–28 thousand square kilometers). The Netherlands has the highest population density and the Russian Federation the lowest (484 compared to 9 people per square kilometer). The countries also vary widely on indicators of health, such as life expectancy and infant mortality rate. Five countries (Italy, the Netherlands, Norway, Slovenia, and Sweden) had relatively longer life expectancies of 78 years or more and relatively low infant mortality rates (3 or 4 per 1000 live births). The remaining countries reported life expectancies of 68 to 72 years, and infant mortality rates between 13 and 29 out of every 1000 births.

The economic indicators in Exhibit 2, such as the data for gross national income per capita, reveal great disparities in the economic resources available, and also that different policies exist concerning the percent of the gross domestic product (GDP) devoted to education. Economically, the participants ranged from Italy, the Netherlands, Norway, and Sweden (all members of the OECD), with relatively high gross national incomes per capita (in US dollars adjusted for purchasing power parity), to Armenia, Iran, Lebanon, the Philippines, and the Russian Federation with relatively low gross national incomes per capita. In seven of the participating countries, over 90 percent of the relevant age cohort attended primary school. Armenia and Lebanon had somewhat lower rates, and these data were not available for the

Exhibit 2 **Selected Characteristics of the TIMSS Advanced 2008 Countries**

TIMSSAdvanced2008

Country	Population Size (Millions)[1]	Area of Country (1000s of km^2)[2]	Population Density (People/km^2)[3]	Urban Population (%)[4]	Life Expectancy at Birth (Years)[5]	Infant Mortality Rate (per 1,000 Live Births)[6]
Armenia	3	28.2	107	64	72	22
Iran, Islamic Rep. of	71	1628.6	44	68	71	29
Italy	59	294.1	202	68	81	3
Lebanon	4	10.2	400	87	72	26
Netherlands	16	33.9	484	81	80	4
Norway	5	304.3	15	77	80	3
Philippines	88	298.2	295	64	72	23
Russian Federation	142	16381.4	9	73	68	13
Slovenia	2	20.1	100	49	78	3
Sweden	9	410.3	22	84	81	3

SOURCE: IEA TIMSS Advanced 2008 ©

Country	Gross National Income per Capita (US $)[7]	GNI per Capita (Purchasing Power Parity)[8]	Public Expenditure on Education (% of GDP)[9]	Net Enrollment Ratio in Education (% of Relevant Group)[10]	
				Primary	Secondary
Armenia	2630	5870	2.7	85	86
Iran, Islamic Rep. of	3540	10840	5.5	94	77
Italy	33490	30190	4.4	99	94
Lebanon	5800	10040	2.7	83	73
Netherlands	45650	39470	5.2	98	88
Norway	77370	53650	7.0	98	96
Philippines	1620	3710	2.5	91	60
Russian Federation	7530	14330	3.1	–	–
Slovenia	21510	26230	5.8	95	90
Sweden	47870	37490	7.1	95	99

All data taken from the *2009 World Development Indicators* (World Bank, 2009) .

1 Includes all residents regardless of legal status or citizenship except refugees not permanently settled in the country of asylum as they are generally considered to be part of their country of origin (pp. 40–43).

2 Area is the total surface area in square kilometers, excluding the area under inland water bodies and national claims to the continental shelf and exclusive economic zones (pp. 134–137).

3 Mid-year population is divided by land area in square kilometers (pp. 14–17).

4 Urban population is the mid-year population of areas defined as urban in each country and reported to the United Nations. It is measured here as the percentage of the total population (pp. 174–177).

5 Number of years a newborn infant would live if prevailing patterns of mortality at its birth were to stay the same throughout its life (pp. 122–125).

6 Infant mortality rate is the number of deaths of infants under 1 year of age, per 1,000 live births in the same year (122–125).

7 GNI per capita in U.S. dollars is converted using the World Bank Atlas method (pp. 14–17).

8 An international dollar has the same purchasing power over GNI as a U.S. dollar in the United States (pp. 14–17).

9 Current and capital public expenditure on primary, secondary, and tertiary education expressed as a percentage of GDP (pp. 80–83)

10 Ratio of the children of official school age who are enrolled in school to the population of the corresponding official school age, based on the International Standard Classification of Education 1997 (pp. 84–87).

A dash (–) indicates comparable data are not available.

Russian Federation. School enrollment rates at the secondary school level were similar to those in primary school in Armenia, Norway, and Sweden. The levels of students enrolled in secondary school were lower in the other countries, with the Philippines having the lowest enrollment rate, 60 percent.

Description of the TIMSS Advanced 2008 Assessment

The publication entitled *TIMSS Advanced 2008 Assessment Frameworks*[2] contains frameworks for the advanced mathematics and physics assessments. Each assessment was organized around two dimensions, a content dimension specifying the subject matter domains to be assessed within advanced mathematics or physics, respectively, and a cognitive dimension specifying the thinking processes or domains to be assessed. The content domains for advanced mathematics are algebra, calculus, and geometry; and for physics they are mechanics, electricity and magnetism, heat and temperature, and atomic and nuclear physics. The cognitive domains are the same for both assessments: knowing, applying, and reasoning. Each cognitive domain is described according to the sets of processing behaviors expected of students as they engage with the mathematics or physics content. The emphasis across the cognitive domains is such that 65 to 70 percent of the assessments measure the applying or reasoning domains.

Developing the tests was a cooperative undertaking involving representatives from the participating countries throughout the process. Participating countries field-tested the items with representative samples of students. The Advanced Mathematics and Physics Coordinators provided guidance throughout the development process, and the National Research Coordinators had several opportunities to review the items and scoring criteria to ensure

2 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.

the items were measuring objectives in the frameworks, and were appropriate for students in their countries. The advanced mathematics test included 72 items and 82 score points and the physics test included 70 items and 82 score points.[3] Each of the tests was comprised of approximately one third multiple-choice items and two thirds constructed-response items. Chapters 3 and 9, respectively, contain more information about the advanced mathematics and physics tests, including example items. Appendix A contains further information about the numbers of items by type in each domain. Although the assessments were developed collaboratively to represent agreed-upon frameworks, Appendix B contains information about the degree to which the TIMSS Advanced 2008 assessments matched the curricula in the participating countries. In general, the assessment items covered material included in the countries' curricula, and any differences in coverage had little effect on relative performance.

TIMSS Advanced 2008 was conducted in the language of instruction in each country, involving a substantial effort by National Research Coordinators in translating all of the assessment instruments. The translations underwent a complex verification procedure coordinated by the IEA Secretariat, while the test booklet layouts were verified by the TIMSS & PIRLS International Study Center. All student sampling activities for TIMSS Advanced 2008 were monitored by Statistics Canada and conducted with careful attention to quality and comparability. The sampling was designed to ensure that the data provided accurate and economical estimates of the student populations. For the sake of comparability across countries and across assessments, testing for TIMSS Advanced 2008 was generally conducted at the end of the school year (during February through May of 2008 with most countries testing in April). Adherence to the test administration procedures was monitored through the use of international quality

3 One mathematics item and two physics items were deleted due to the analysis results.

control observers arranged by the IEA Secretariat, and also through within-country quality control procedures. The TIMSS & PIRLS International Study Center conducted several training sessions to ensure that the constructed-response scoring was done correctly, and scoring reliability data were collected from each country.

Subsequent to the data collection, the IEA Data Processing and Research Center checked each country's data files for internal consistency and accuracy, and interacted with countries to resolve data issues. The TIMSS & PIRLS International Study Center reviewed achievement item statistics for every country and consulted with Educational Testing Service on the methods and results of the scaling process. The primary approach to reporting the TIMSS Advanced 2008 achievement data was based on item response theory (IRT) scaling methods. More information about the TIMSS Advanced 2008 procedures for sampling, scaling, and data analysis can be found in Appendix A. Details are provided in the *TIMSS Advanced 2008 Technical Report*[4].

All of those involved in the complex task of implementing TIMSS Advanced 2008 met their responsibilities with great dedication, competence, and energy, and are to be commended for their commitment to the project and the high quality of their work. Appendix D lists the names of many of those responsible for the management, coordination, and conduct of TIMSS 2008, including the National Research Coordinators from each participating country.

4 Arora, A., Foy, P., Martin, M.O., & Mullis, I.V.S. (Eds.). (2009). *TIMSS Advanced 2008 technical report*. Chestnut Hill, MA: TIMSS & PIRLS International Study Center, Boston College.

Chapter 1

The Advanced Mathematics Curriculum in the Participating Countries

The mathematics assessment for TIMSS Advanced 2008 was developed according to a framework designed to reflect the mathematics studied around the world in advanced mathematics programs during the final year of schooling. More specifically, the TIMSS Advanced 2008 mathematics framework[1] was organized around content domains and cognitive domains. The content domains or subject matter to be assessed included algebra, calculus, and geometry, while the cognitive domains or thinking behaviors expected of students as they engaged with the mathematics content included knowing, applying, and reasoning. The TIMSS Advanced 2008 countries participated in the iterative review process used to develop the framework and worked collaboratively with the TIMSS & PIRLS International Study Center to develop the test questions (items) covering the framework. Although all countries agreed that the mathematics described in the framework and addressed by the items in the assessment represented a reasonable fit to their curricular goals, it must be emphasized that each of the 10 participating countries had its own approach to teaching and learning advanced mathematics. To better understand the results, therefore, it is important first to understand the differences in the education systems

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

in the participating countries and the characteristics of the students assessed for TIMSS Advanced.

Because the participating countries had substantive differences in their approaches to educating students in advanced mathematics, the first section of Chapter 1 contains information about the structure of the educational systems in the countries that participated in TIMSS Advanced 2008, with a particular focus on the number of years of schooling involved and the selectivity of the program or track assessed by TIMSS Advanced. Data are presented about the characteristics of the advanced mathematics curriculum in each country, and about the students who participated. Later sections deal with the amount of instructional time allocated to mathematics in these advanced programs or tracks, the degree to which certain topics from the TIMSS Advanced mathematics framework were taught, and the extent to which teachers indicated that they felt well-qualified to teach advanced mathematics.

In comparing achievement across countries, it is important to consider differences in students' curricular experiences, how these differences may affect the mathematics they have studied, and their subsequent achievement. Students' opportunities to learn the mathematics covered by the TIMSS Advanced 2008 content and cognitive domains depend initially to some degree on that mathematics being part of each country's guidelines and policies for mathematics education. Thus, participants provided information about various educational policies and the curriculum topics covered in their respective curriculum guidelines (intended curriculum). Inclusion in the country's curriculum, however, does not guarantee students' opportunity to learn. Just as important is what their teachers choose to teach them. The lessons provided by the teachers ultimately determine the mathematics students are taught (implemented curriculum).

The goal of Chapter 1 is to provide information about the teaching and learning of advanced mathematics in each of the 10 countries that participated in the TIMSS Advanced assessment in 2008. It is hoped that this information will enable readers to compare and contrast the different approaches taken by different countries in this area, in order to establish a basis for making cross-country comparisons of outcome data in subsequent chapters.

Among the topics to be covered in Chapter 1 are an overview of the educational systems in the participating countries, descriptions of the populations of students tested, the characteristics of the advanced mathematics curriculum, the amount of time devoted to mathematics in the curriculum at this level, and students' opportunity to learn the advanced mathematics topics covered in the TIMSS Advanced mathematics assessment, including teachers' reports about whether those topics were taught and their feelings about how well prepared they were to teach mathematics at this level.

Overview of the Educational Systems

Mathematics curricula internationally tend to be similar in the early years of schooling.[2] However, at the secondary school level, and especially in the final year or two of secondary school, significant differences can be found across countries in the topics that are included in countries' curricula, in the degree of mathematical rigor expected, in the rates of participation of students in the mathematics courses available at that level, and in the proportions of students still in school and studying advanced mathematics.

Such considerations add to the complexity of making achievement comparisons across countries at this level, but they also heighten the degree of interest in those comparisons. When all children are in school learning the basic concepts and skills of arithmetic, the

2 Mullis, I.V.S., Martin, M.O., & Foy, P. (2008). *TIMSS 2007 international mathematics 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.

basics of geometry, and elementary problem solving, cross-country comparisons, while complicated by socioeconomic and cultural factors among others, are somewhat less problematic. But when there are substantial variations among countries with respect to these kinds of factors, as there are at the senior secondary level, straightforward comparisons are more difficult to draw. Thus, readers of this report are cautioned to be judicious in drawing conclusions about the relative strengths of national systems of education on the basis of the results presented in this volume. The results can be used to examine the range of educational outcomes produced in different countries, and to illustrate the wide range of educational choices that are in effect in those countries.

Exhibit 1.1 presents information about how the overall curriculum for secondary school and the advanced mathematics program are structured in each of the 10 countries that participated in TIMSS Advanced 2008. In 8 of the 10 countries, the last year of secondary school is either the 11th or the 12th year of schooling. The exceptions are Italy where some programs include a 13th year, and the Philippines where the last year of secondary school is the 10th year of schooling. Normally, students in the Russian Federation would complete secondary school after 11 years of schooling; however, about half of the students in their final year at the time of the TIMSS Advanced data collection were in their 10th year, having skipped Year 4 as part of the implementation process for the current program.

In 5 of these 10 countries—Armenia, Iran, Lebanon, the Netherlands, and Sweden—upper secondary schooling consists of a 3-year program. However, in Norway and the Russian Federation it is 2 years, in the Philippines and Slovenia it is 4 years, and in Italy it can be 5 years (the Netherlands may also be considered a 5-year program since it begins with 2 years of basic education where students follow the same curriculum).

The number of hours of advanced mathematics studied was in the range of 100 to 200 hours per year for most countries. It seems clear that students who studied 200 hours or more of mathematics per year (i.e., Iran, Lebanon, and the Russian Federation) would have studied considerably more mathematics in their programs than students in other countries.

In some of the countries, including Armenia, Iran, Italy, the Philippines, and the Russian Federation, students had to meet special entrance requirements (e.g., previous grades, exams, recommendations) to be permitted to enroll in the advanced mathematics program. In the rest of the countries, secondary school students appeared to have considerable latitude in making decisions about which program to follow after completing basic education or general courses required of all students.

In several countries, the students who were identified for participation in TIMSS Advanced 2008 were enrolled in rather highly specialized programs, notably Armenia where the TIMSS advanced mathematics students were enrolled in the "physmat" program and, similarly in Iran, where the track assessed was specifically for university-bound students studying both mathematics and physics. In the Netherlands, most of the TIMSS advanced mathematics students were taking a specialized mathematics program as part of the science and technology program. Those in the Philippines were enrolled in special science and technology schools, and in the Russian Federation they were concentrating on mathematics for 6 hours or more per week in several types of schools. In other countries, a broader cross-section of the final year population was represented.

Exhibit 1.1 **Structural Characteristics of the Advanced Mathematics Programs (Tracks) Assessed by TIMSS Advanced 2008**

TIMSSAdvanced2008 Advanced Mathematics

Country	Description of How the Programs (Tracks) Fit into Overall Curriculum	Number of Years Students Spent in These Programs (Tracks)	Number of Hours of Mathematics Instruction per Year	Criteria for Admission to These Programs (Tracks)
Armenia	Secondary schooling is a 3-year program up to the 11th grade. All students follow the same curriculum through the 3-year program, although students in a small number of special "physmat" schools cover additional topics in mathematics and science. Students at the 11th grade in these "physmat" schools constitute the target population for TIMSS Advanced 2008. As a result of recent reforms to increase the number of years of school, Armenian students were assessed in what is now called the 11th grade. However, since the assessed students skipped a grade as part of implementing the reform, they have had 10 years of formal schooling.	Three years	132	Completion of elementary school and success on the centralized state examination after the 9th grade.
Iran, Islamic Rep. of	After lower secondary schooling (grade 9), students can choose the track they wish to attend in upper secondary school. Students who complete the 11th grade in the mathematics track are allowed to participate in the advanced mathematics and physics track in the pre-university stage. This advanced mathematics and physics track is the target population assessed by TIMSS Advanced 2008.	Three years	220	For enrollment in the advanced mathematics and physics track, students' cumulative grade point average at the 9th grade, their grades in mathematics and science, and the opinion of the school counselor are taken into consideration.
Italy	Secondary education can last 3, 4, or 5 years and is given in four types of schools: lyceums, art schools, technical schools, and vocational schools. The students assessed by TIMSS Advanced 2008 are in grade 13 and have taken an advanced mathematics course or an advanced mathematics and physics course. Most of these students are found in the Liceo Scientifico (general schools with scientific focus), Liceo Scientifico Tecnologico (general school with focus on technology), or Instituti Technici (vocational full time training).	Five years	100	Completion of lower secondary education and success on the national examination after the 8th grade.
Lebanon	Secondary schooling is a 3-year program up to the 12th grade. All students follow the same curriculum in their first year (grade 10). In the second year (grade 11), students can choose between humanities and sciences and in the third year (grade 12), students from the sciences can choose from one of three programs: sociology and economics, life science, or general science. Students from the general science program at the 12th grade constitute the TIMSS Advanced 2008 target population.	Three years	250	Diploma from basic education (brevet).
Netherlands	Secondary education begins with 2 years (grades 7 and 8) of basic education where all students follow the same curriculum. Students can then choose one of three tracks. In the pre-university track (VWO) which is a 4-year program, in the first year (grade 9) all students follow the same curriculum. The next year (grade 10) they can choose one of four programs. Students who select the advanced mathematics course Math B2—most of whom come from the science and technology program—constitute the target population for TIMSS Advanced 2008.	Three years	152*	Students are free to enroll in the different tracks and programs based on their ability and interest.
Norway	The Norwegian students assessed for TIMSS Advanced 2008 had 9 years of compulsory education followed by 3 years of secondary education. The first year of secondary education consists of general courses for all students in the academic track. In the last 2 years, students choose which subjects they want to take. Advanced mathematics courses in the last 2 years consists of 2MX and 3MX. The students assessed by TIMSS Advanced 2008 were in the final year of secondary education and had taken the 3MX mathematics course. After implementing a curriculum reform, the Norwegian school system consists of 13 years of schooling.	Two years	140	Completion of all general courses in the first year of upper secondary schooling.

SOURCE: IEA TIMSS Advanced 2008 ©

Data provided by National Research Coordinators.

* Instructional time is not prescribed for advanced mathematics. According to the curriculum, a total of 760 hours over three years should be spent by the students on advanced mathematics (including homework and instruction). About 60% on average should be spent as class time.

Exhibit 1.1 **Structural Characteristics of the Advanced Mathematics Programs (Tracks) Assessed by TIMSS Advanced 2008 (Continued)**

TIMSSAdvanced2008 Advanced Mathematics

Country	Description of How the Programs (Tracks) Fit into Overall Curriculum	Number of Years Students Spent in These Programs (Tracks)	Number of Hours of Mathematics Instruction per Year	Criteria for Admission to These Programs (Tracks)
Philippines	Secondary education is a 4-year program (grades 7–10). Graduates from elementary education may choose to enroll in a general high school or in special schools such as science and technology oriented high schools or in regional science high schools, which prepare students for science-oriented courses in the university. These special schools offer advanced mathematics subjects. Students can also enroll in private and university laboratory high schools, which offer advanced mathematics subjects. Students from these science-oriented schools as well as private and university laboratory high schools offering advanced mathematics subjects are the target population assessed by TIMSS Advanced 2008.	Four years	100-200	Admission to these science high schools may involve a written test, an oral test, and also the grades obtained in elementary school.
Russian Federation	All students study mathematics and physics every year in basic and upper secondary education. In basic education, all students follow the same curriculum, but in upper secondary (grades 10 and 11), the programs differ. The students assessed by TIMSS Advanced 2008 are the 11th grade students who had 6 hours or more per week of instruction in mathematics. These students can be found in lyceums, gymnasiums, special schools for mathematics and physics, and general secondary schools with different profiles in the upper secondary level. As the result of an ongoing reform to increase the number of years of school, Russian students were assessed in what is now called the 11th grade and about half the students have had 11 years of formal schooling. However, the other half skipped grade 4 as part of implementing the reform and only have had 10 years of formal schooling.	Two years	204-306	Admission to the advanced mathematics course involves an interview, students' performance in mathematics for the previous years of schooling, and a written test if necessary.
Slovenia	The Slovenian students assessed for TIMSS Advanced 2008 had 8 years of elementary education and 4 years of secondary education. Secondary education in Slovenia consists of two types of programs: general gymnasia and vocational or technically oriented programs. Only the general gymnasia program offers students the possibility of admission to university studies. All general gymnasia students study the same mathematics courses during their 4-year program. Students in the fourth year of general gymnasia programs were the target population assessed in mathematics by TIMSS Advanced 2008. Currently, Slovenia is in the process of increasing elementary school to 9 years, so that students will have 13 years of schooling.	Four years	105	Completion of elementary schooling. There are no other special admission criteria for the general gymnasia program.
Sweden	Upper secondary education starts from grade 10 and is divided into 17 national 3-year programs. Of these programs, the natural science program has four mandatory mathematics courses (Mathematics A, B, C, and D) and an optional fifth course called Mathematics E. The technology program has three mandatory mathematics courses (Mathematics A, B, and C) and two optional courses (Mathematics D and E). The students assessed by TIMSS Advanced 2008 were the 12th grade students who had taken the Mathematics D course and may have taken the Mathematics E course (58% of students in the sample have taken the Mathematics E course).	Three years	100-150	Completion of compulsory education. Students are then free to choose any upper secondary program.

Data provided by National Research Coordinators.

SOURCE: IEA TIMSS Advanced 2008 ©

Description of the Students Assessed for TIMSS Advanced 2008

More information about the makeup of the TIMSS Advanced 2008 target populations in the participating countries can be found in Exhibit 1.2. As noted in the first data column, the number of students in the program or track assessed for TIMSS Advanced 2008 varied from fewer than 3,000 students in Armenia to nearly 120,000 in Italy, primarily because (as described in the introduction) some countries had much larger populations than others. Also, as would be expected based on the variation in the number of years of schooling (shown in the fifth data column), students in their final year of schooling were older in some countries than they were in others, ranging from the relatively young 16-year-old students in the Philippines (with only 10 years of schooling) to those approximately 19 years old in Italy, Norway, Slovenia, and Sweden (with 12 or 13 years of schooling).

Because the number of students taking advanced mathematics in a country is affected not only by the size of the country, but also by the selectivity of the program or track, Exhibit 1.2 provides information about the relative situation in each of the 10 countries. In particular, the TIMSS Advanced Mathematics Coverage Index shown in the fourth data column of Exhibit 1.2 provides a means of comparing the relative sizes of the populations included in the study in these countries. The coverage index for a given country is an estimate of the percentage of the entire national age cohort covered by the TIMSS Advanced target population. It may be helpful to consider the TIMSS Advanced coverage index as a fraction, expressed as a percentage. For most countries, the denominator of the fraction (found in the third data column) is the estimate of the size of the entire national population for the same age cohort as the students tested for TIMSS Advanced. For example, the students assessed in Iran for TIMSS Advanced were,

Exhibit 1.2 **Size of the TIMSS Advanced 2008 Target Population for Advanced Mathematics, the Age Cohort, and the TIMSS Advanced Mathematics Coverage Index**

TIMSSAdvanced2008 Advanced Mathematics

Country	Estimated Size of the Population of Students in the Final Year of Secondary School Taking the Advanced Mathematics Track or Program Targeted by TIMSS Advanced (Derived from TIMSS Advanced Student Sample)	Age Cohort Corresponding to the Final Year of Secondary School	Size of the Age Cohort Corresponding to the TIMSS Advanced Population Based on National Census Figures[a]	TIMSS Advanced Mathematics Coverage Index – the Percentage of the Entire Corresponding Age Cohort Covered by the TIMSS Advanced Target Population	Years of Formal Schooling*
Armenia	2,684	18	62,758	4.3%	10
Iran, Islamic Rep. of	111,298	18	1,705,000	6.5%	12
Italy	119,162	19	605,507	19.7%	13
Lebanon	4,702	18	79,784	5.9%	12
Netherlands	7,091	18	205,200	3.5%	12
Norway	6,668	19	61,093	10.9%	12
Philippines	14,007	16	1,900,656	0.7%	10
Russian Federation	29,672	17	2,073,041	1.4%	10/11
Slovenia	8,836	19	21,815	40.5%	12
Sweden	16,116	19	125,923	12.8%	12

SOURCE: IEA TIMSS Advanced 2008 ©

a Armenia: Estimate derived by dividing the population of 15–19-year olds by 5 for the single year estimate for the year 2008. Data taken from the U.S. Census Bureau's International Database (www.census.gov/). Islamic Rep. of Iran: Total population of 18-year olds in Iran in 2008. Data taken from the Statistical Center of Iran (SCI) (http://www.sci.org.ir/portal/faces/public/sci_en). Italy: Total population of 19-year olds in Italy for the year 2008. Data taken from the Italian Bureau of Statistics (ISTAT) (http://demo.istat.it/pop2008/index.html). Lebanon: Estimate derived by dividing the population of 18–20-year olds by 3 for the single year estimate. Data taken from the Central Bureau for Statistics in the Ministry of Interior. Netherlands: Estimate based on data taken from the Central Bureau of Statistics in the Netherlands (www.cbs.nl). Norway: Total population of 19-year olds in Norway on 1 January 2008. Data taken from the Norwegian National Bureau of Statistics (SSB) (http://www.ssb.no/english/). Philippines: Population of 16-year olds for 2008 projected from the 2000 census. Data taken from the National Statistics Office, Philippines (NSO) (http://www.census.gov.ph/). Russian Federation: Total population of 17-year olds in 2008. Data taken from the Federal State Statistics Service (http://www.gks.ru/wps/portal/english). Slovenia: Estimate was derived by dividing the population of 15–19-year olds by 5 for the single year estimate for the year 2008. Data taken from the Statistical Office of the Republic of Slovenia (www.stat.si). Sweden: Total population of 19-year olds in Sweden for the year 2008. Data taken from Statistics Sweden (SCB) (http://www.scb.se/default____2154.aspx). Data provided by National Research Coordinators.

* Represents years of formal schooling counting from the first year of primary or basic education (first year of ISCED Level1). Because of ongoing reforms in some countries to increase the number of years of schooling, the number of years of formal schooling is not always the same as the grade assessed (see Exhibit 1.1).

on average, 18 years of age (the second data column), so the population estimate for Iran in the third data column is for all 18-year olds in Iran. For Armenia, Lebanon, and Slovenia, data for the age cohorts were not available year-by-year but only for the group of students aged 15 to 19 (18 to 20 for Lebanon), so the population estimates for those countries are averages. The numerator of the fraction is the estimated size of the target population assessed by TIMSS Advanced derived from the TIMSS Advanced student sample (first data column).

The TIMSS Advanced Mathematics Coverage Index expresses the number of students enrolled in the advanced mathematics program or track assessed by TIMSS Advanced as a percentage of all of the students of the same age that could potentially have been in the advanced program or track (if they had all continued their schooling to the final year, wanted to be in the program, and had been accepted). That is, this is the percentage of students in the age cohort in each country receiving the most elite mathematics education. The exhibit shows that the coverage extends from lows of 0.7 and 1.4 percent in the Philippines and the Russian Federation, respectively, to 3.5 and 4.3 percent in the Netherlands and Armenia, to 5.9 and 6.5 percent in Lebanon and Iran, to 10.9 and 12.8 percent in Norway and Sweden, to highs of nearly 20 percent in Italy and 40.5 percent in Slovenia.

The 10 countries that participated in TIMSS Advanced 2008 were very different both in terms of the overall size of their age cohorts (which depend on the size of their national populations), and the numbers of students enrolled in their advanced mathematics programs (which depend both on the size of the population and the degree of selectivity and availability of the program or track assessed). In Iran, the Philippines, and the Russian Federation, the estimated size of the age group from which the TIMSS Advanced 2008 population was selected was greater than 1.5 million. At the opposite extreme, the size of the comparable age cohort in Slovenia was less than 25,000. Armenia, Lebanon, and Norway also had rather small age cohorts, ranging from 60 to 80 thousand.

As has already been indicated, there were large differences across countries in the situations and proportions of the students that were included in the TIMSS Advanced 2008 mathematics study. At one extreme, the three most populous countries—Iran, the Philippines, and the Russian Federation—assessed elite populations of students, as did several countries with much smaller populations, including Armenia, Lebanon, and the Netherlands. In the Philippines, students had fewer years of schooling and were younger than those in the other countries. However, the population assessed for TIMSS Advanced was an elite one for that country, because only a small percentage of students complete secondary schools and those assessed for TIMSS Advanced 2008 were attending the small set of special secondary schools that prepare students for science programs in university, giving them a coverage index of 0.7 percent.

The Russian Federation also assessed an elite population of students. All students in Russia study mathematics and physics every year in lower and upper secondary school. The Russian students assessed for TIMSS Advanced 2008 were from the relatively small percentage who were taking a mathematics course for at least 6 hours a week during the final year of secondary school. This resulted in a coverage index of 1.4 percent. In cases such as these, the rather narrow definition used to define the sample resulted in the selection of a highly specialized group of students compared to other students in the country. And, of course, this fact needs to be borne in mind when making cross-national comparisons.

Some countries elected to assess a much broader cross-section of their students in mathematics. In Slovenia, the smallest participating country in terms of population, there are two types of programs, vocational and general gymnasia, with only the latter offering the possibility of university admission. All students following the general gymnasia program study advanced mathematics and comprised the target population for TIMSS Advanced. This gave Slovenia a coverage index of 41 percent. Italy, with a coverage index of 20 percent, also included a sizeable proportion of their students in their population definition. In Italy, all students who were in Grade 13 and who had taken an advanced mathematics or an advanced mathematics and physics course were included.

Characteristics of the Advanced Mathematics Curriculum

Exhibit 1.3 summarizes how recently the advanced mathematics curriculum has been updated in each of the participating countries. It shows that, in almost all cases, the advanced mathematics curriculum had been revised within the 10 years preceding the TIMSS Advanced 2008 assessment. Several of the participating countries indicated that their advanced mathematics curriculum was in the process of being revised while the data for this study were being collected.

Exhibit 1.4 contains summary information for each country about whether the TIMSS Advanced 2008 mathematics topics were covered in their national curriculum guidelines. The information about topics included in the participants' curricula is discussed in greater depth in Exhibits 1.12 through 1.15, which also include information about the implemented curriculum and provide the results topic-by-topic within each content domain. In general, the countries reported a high degree of correspondence between the topics covered by the TIMSS Advanced 2008 assessment and the topics included in their national curricula for the programs, tracks, or courses identified to be assessed in TIMSS Advanced. As previously described, the framework

Exhibit 1.3 **Structural Characteristics of the Advanced Mathematics Curriculum in Participating Countries**

TIMSSAdvanced2008 Advanced Mathematics

Country	Year Curriculum Taken by Students Assessed in TIMSS Advanced Was Introduced	Curriculum Changes
Armenia	2001	
Iran, Islamic Rep. of	1998	At present there is no national curriculum, instead there are syllabus guides provided by the Mathematics Council of the Organization for Educational Research and Planning, Ministry of Education. Currently, the council is developing the mathematics national curriculum for K–12. In this process the aims, content, teaching, and assessment methods are being revised.
Italy	1923; last revised: Technical Schools 1994, Lyceum 2000	The curriculum is being revised to increase the number of hours of teaching the English language, mathematics and science. The new curriculum will be introduced in 2010.
Lebanon	2001	
Netherlands	1998	The various mathematics subjects have been reorganized and the number of instructional hours reduced from 760 to 600. One new mathematics subject has been added that students can choose; however it is not compulsory. The new curriculum started in August 2007 in grade 10 and therefore has not affected the students participating in TIMSS Advanced 2008.
Norway	2000	A new curriculum was implemented in 2006 with more emphasis on competencies and basic skills and less on instructional methods. The TIMSS Advanced population belonged to the last cohort not affected by this curriculum reform.
Philippines	2004	
Russian Federation	1994 & 2004*	
Slovenia	1998	In 1998, the curriculum for the general gymnasia program was changed to align with the compulsory Matura examination in terms of content, standards, number of hours per subject, and content of compulsory parts of optional courses. The previous curriculum for all 4 years of secondary schools was divided into one curriculum for the general gymnasia program and another curriculum for vocational or technically oriented programs, with the former being more advanced in all subjects.
Sweden	2000	The curriculum is under revision and is intended to be implemented in 2011.

SOURCE: IEA TIMSS Advanced 2008 ©

Data provided by National Research Coordinators.

* The Advanced Mathematics classes use as a rule two documents: 1) the syllabus for Advanced Mathematics, introduced in 1994 (not revised since that time); 2) the Educational Standards in Mathematics, introduced in 2004.

Exhibit 1.4 **Number of TIMSS Advanced Mathematics Topics in the Intended Curriculum**

TIMSSAdvanced 2008 Advanced Mathematics

Country	Overall (27 topics)	Algebra (10 Topics)	Calculus (9 topics)	Geometry (8 Topics)
Armenia	22	9	5	8
Iran, Islamic Rep. of	26	9	9	8
Italy	26	9	9	8
Lebanon	27	10	9	8
Netherlands	20	9	7	4
Norway	25	9	9	7
Philippines	25	9	9	7
Russian Federation	25	8	9	8
Slovenia	25	10	8	7
Sweden	19	8	7	4

SOURCE: IEA TIMSS Advanced 2008 ©

Data provided by National Research Coordinators.

and the test items for the TIMSS Advanced 2008 mathematics assessment covered three mathematics content domains: algebra, calculus, and geometry. As is shown in Exhibit 1.4, the test items dealt with 27 mathematical topics chosen from the three content domains: 10 in algebra, 9 in calculus, and 8 in geometry.

The vast majority of topics included in the TIMSS Advanced 2008 mathematics framework were included in the advanced mathematics curricula of all the participating countries. In 7 of the 10 countries, almost all (25 or more out of 27) of the topics from the TIMSS Advanced 2008 mathematics framework were included in their intended curriculum. Sweden, the Netherlands, and Armenia had the lowest inclusion rates, the lowest of which was 19 out of 27 in Sweden; that is, an inclusion rate of 70 percent or more across the board. All three content domains had very high inclusion rates, with the rate for geometry being slightly lower than the rate for algebra or calculus. All countries included 8 or more of the 10 algebra topics, and most covered 7 or more of the 9 calculus topics except Armenia (only 5). Most countries also covered either 7 or all 8 of the geometry topics, but the lower rate in this area resulted from the fact that the Netherlands and Sweden had relatively low coverage (half the topics).

Because the TIMSS Advanced assessment attempted to align with instructional practices as much as possible, the assessment was designed so that students could use calculators in ways that mirrored their classroom experiences without unduly advantaging or disadvantaging students either way. Exhibit 1.5 summarizes information concerning the policies in effect in the countries with respect to the use of calculators and computers in mathematics classrooms and during examinations. A majority of participating countries, 8 out of 10, reported permitting students to use calculators of various kinds on national examinations. Two countries, Iran and the Russian Federation, indicated that there

Exhibit 1.5 **Curriculum Studied by TIMSS Advanced Students Includes Policies Regarding Use of Computers and Calculators**

TIMSSAdvanced 2008 Advanced Mathematics

Country	Computers	Calculators	Types of Calculators	Calculators in National Examinations	Description of Policies
Armenia	○	○	○	●	Simple calculators with arithmetic operations are allowed in national examinations.
Iran, Islamic Rep. of	○	○	○	●	Since calculators and computers are not accessible for all students, use of them is not discussed in the national curriculum. Simple calculators only for calculation are permitted in national examination.
Italy	●	○	○	●	There are no policies about the use of calculators, but they are not provided. Students use their own calculator during the examinations. Students use computers while studying some subjects in the lyceum or in specific subjects of technical schools.
Lebanon	○	●	●	●	Non-programmable calculators are permitted. There are no curricular policies about the use of computers. Computer use is optional.
Netherlands	●	●	○	●	Only graphing calculators are allowed in national examinations. The examination board yearly prescribes which brands are allowed.
Norway	●	●	●	●	Graphing calculators are allowed during examinations and frequently used in class. The curriculum, however, only has a vague and general statement about using technological tools in investigations, modeling, and problem solving.
Philippines	●	●	○	○	Information Technology materials/equipment may be used in the teaching/learning process and calculators and computers are considered as IT material/equipment.
Russian Federation	○	○	○	○	There is a general recommendation for middle school that calculators and computers may be used for routine calculations.
Slovenia	●	●	●	●	The national curriculum requires that calculators used in the national examination should be scientific calculators without the capability of symbolic or graphic calculations. During lessons students are allowed to use their own calculators. The use of computers is recommended.
Sweden	○	○	○	●	The students are expected to learn to use graphical, numerical, and symbolic software to find integrals and solve equations; but for the advanced courses it is not stated that this means calculators. National tests in Sweden (which are not formal examinations, but rather tests that are intended to support teachers in their grading of students) are divided into two parts, one where calculators are not allowed, and one where students are expected to have a calculator at hand. The calculators allowed for advanced mathematics students are expected to have a graphing or symbolic capability. There are statements in the curriculum about the use of "Information and Communication Technology", but there are no specific references to computers.

● Yes
○ No

Data provided by National Research Coordinators.

SOURCE: IEA TIMSS Advanced 2008 ©

was little, if any, mention of calculator and computer use by students in official documents related to the curriculum. In some countries, curriculum documents encourage teachers to explore applications of technology with their students, but do not provide a lot of specific suggestions or recommendations. Some countries allow students to use graphing calculators during examinations; others forbid their use. In the Netherlands, the examination board each year produces a list of the specific brands of calculators that may be used by students during examinations. On the whole, it seems that mathematics and science educators in many countries are still unsure about how best to incorporate technology into mathematics and science teaching, given the constraints they face in terms of the content of the curriculum and the availability of software of sufficiently high quality and low enough cost to make its adoption possible.

Because public examinations are used in some countries to make decisions about the students enrolled in advanced mathematics programs, tracks, or courses, participating countries were asked to provide information about their examination systems. Exhibit 1.6 indicates that some type of "high-stakes" examinations (i.e., an examination or system of examinations with academic consequences) were a feature of all 10 educational systems except Sweden. In the other participating countries, students write national examinations in mathematics and other subjects during their final year of secondary school and, in some cases, at other grade levels as well. In most cases the important examinations at the end of secondary school are administered by the Ministry of Education or a national examination board. In Sweden, on the other hand, evaluation is the responsibility of the teacher. There are national examinations, but they are intended to supplement the evaluation information that teachers develop on their own.

Exhibit 1.6 **Examination System in Participating Countries**

TIMSSAdvanced 2008
Advanced Mathematics

Country	Examinations with Consequences for Individuals	Grades at Which Examinations Are Given	Nature and Format of Examination	Purpose of Examination and Consequences	Comments
Armenia	●	Compulsory examinations at grades 9 and 11.		The 9th grade examination is used to determine which students can continue their secondary schooling. The 11th grade examination is necessary for graduation and entry to university.	Both of these are centralized state examinations.
Iran, Islamic Rep. of	●	Examination given at the pre-university year.	Assessment at pre-university includes mid-semester and final examinations.	Passing all subjects in both semesters is a requirement for entering university.	National examinations for grade promotion are given each semester, in two subjects chosen randomly. Examinations in the rest of the subjects are given by the schools. Another national examination is given for entry to the university.
Italy	●	Compulsory examinations at the end of grade 8 and at the end of grade 13.	The assessment includes written tests developed by the teacher and Ministry of Education.	The national examination at grade 8 determines entry to secondary school. The national examination at grade 13 determines entry to university.	Final examinations for technical and professional schools also give students an opportunity to find a job.
Lebanon	●	Examination at the end of the 12th grade.	Written examination.	The examination is used to determine which students have completed secondary schooling and is also used for university admission.	Some university faculties, especially science, engineering and medicine, administer entrance examinations in subjects such as mathematics and physics.
Netherlands	●	There is a national examination at the end of lower-secondary (grade 8) and at the end of upper-secondary education. Depending on the track in upper-secondary the examinations are in grade 10 (pre-vocational), grade 11 (senior general), and grade 12 (pre-university).	Diploma for the upper secondary level is given based on three school-based examinations, number of practical assignments, and final national examinations in different subjects.	The pre-university diploma is needed in order to enter into university.	The national examinations are conducted by the National Examination Board.
Norway	●	Students may be selected for examination in the last 2 years of upper secondary school.	Written national examination or oral local examination.	The examination results influence entrance to tertiary education.	National examinations are administered by the Ministry of Education.
Philippines	●	Schools give achievement tests at the end of every school year for each grade level.	The examinations can be in oral or paper-and-pencil format.	The purpose of the examination is formative. It is used to measure how much a student has learned over a given period of time.	

● Yes
○ No

Data provided by National Research Coordinators.

SOURCE: IEA TIMSS Advanced 2008 ©

Exhibit 1.6 **Examination System in Participating Countries (Continued)**

TIMSSAdvanced 2008 Advanced Mathematics

Country	Examinations with Consequences for Individuals	Grades at Which Examinations Are Given	Nature and Format of Examination	Purpose of Examination and Consequences	Comments
Russian Federation	●	There is an examination at the end of basic school (grade 9) and at the end of upper secondary school (grade 11).	Examinations in Russian and mathematics are compulsory and conducted in written form.	The purpose of the examination is to certify that students have completed basic education and can enter the next level. The grade 11 examination is necessary for university entrance.	The Federal Service of Supervision in Education and Science administers the examination in mathematics.
Slovenia	●	There is a national examination at the end of elementary school (grade 8) and at the end of secondary school (grade 12). The national examination at the end of secondary school is called the Matura (General Matura for gymnasia program and Vocational Matura for vocational/technical programs).	The Matura consists of written and oral examinations from the compulsory subjects of mathematics, mother tongue, and foreign language as well as two subjects of the student's choice.	The Matura is a school-leaving examination required for the completion of secondary education and for university entrance.	A pass in the Matura is a general admission requirement for any academic university study program and a minimal admission requirement for those academic courses having no limit on the number of students. Achievement on the Matura and achievement in the last 2 years of schooling are used to select students where there is a limit to the number of candidates for a university program. The Matura is prepared and administered by the National Examination Center.
Sweden	○				Sweden does not have an examination system with direct consequences for individual students. However, national tests are used as an important tool to support teachers in grading their students.

● Yes
○ No

Data provided by National Research Coordinators.

SOURCE: IEA TIMSS Advanced 2008 ©

The National Research Coordinators responsible for implementing TIMSS Advanced in each of the participating countries were asked to indicate which of six possible methods for evaluating the degree of implementation of the advanced mathematics curriculum were used in their countries, and their responses are summarized in Exhibit 1.7. The results show that countries tend to use several sources to collect data about curriculum implementation, including results from international comparative studies such as TIMSS Advanced 2008. The most commonly used sources were national examinations, assessments, or tests while the category used least frequently was research and evaluation programs.

All of the participating countries publish either an official curriculum document or a set of notes and directives detailing the advanced mathematics curriculum for teachers, as shown in Exhibit 1.8. Most of them also reported either recommending or mandating particular textbooks to be used by teachers and students for the advanced course. Other kinds of support materials were made available for teachers in some, but not all, countries. These materials included some form of a teacher's guide with suggestions for teaching various topics, suggested instructional activities, and a description of the structure and content of the formal examination to be administered at the end of the year. In some countries, copies of examinations from previous years are made available to teachers and students to familiarize them with the kind of examination they should expect. Armenia, Lebanon, and the Russian Federation indicated that they provide all of these kinds of curriculum support, while Sweden provides only an official curriculum guide for its teachers.

Exhibit 1.9 describes how teachers are kept abreast of changes to the official curriculum in advanced mathematics in their school system. All of the TIMSS Advanced 2008 countries reported documenting such

Exhibit 1.7 **Methods Used to Evaluate the Implementation of the Curriculum for Advanced Mathematics**

TIMSSAdvanced 2008 Advanced Mathematics

Country	Visits by Inspectors	Evaluation or Research Programs	School Self-Evaluation	National Examinations, Assessments, or Tests	TIMSS Advanced	Others
Armenia	●	●	●	●	●	● Subject monitored by National Institute of Education
Iran, Islamic Rep. of	●	○	○	●	●	○
Italy	●	○	●	●	●	○
Lebanon	●	●	○	●	●	○
Netherlands	●	○	○	●	○	● Subject monitored and textbooks reviewed by the Netherlands Institute for Curriculum Development (SLO)
Norway	○	●	○	●	●	○
Philippines	●	○	●	●	○	○
Russian Federation	●	●	●	●	●	● Regional monitoring of students' achievement
Slovenia	○	○	●	●	●	○
Sweden	●	○	●	●	●	○

● Yes
○ No

Data provided by National Research Coordinators.

SOURCE: IEA TIMSS Advanced 2008 ©

Exhibit 1.8 **Formats in Which the Curriculum for Advanced Mathematics Is Made Available**

TIMSSAdvanced 2008 Advanced Mathematics

Country	Official Publication Containing the Curriculum	Ministry Notes and Directives	Mandated or Recommended Textbooks	Instructional or Pedagogical Guide	Specifically Developed or Recommended Instructional Activities	Description of Content of Public Examination	Other
Armenia	●	●	●	●	●	●	○
Iran, Islamic Rep. of	○	●	●	●	○	●	○
Italy	●	●	○	○	●	○	● Professional development for teachers
Lebanon	●	●	●	●	●	●	○
Netherlands	●	●	○	●	●	●	○
Norway	●	●	○	○	○	●	○
Philippines	●	●	○	●	●	○	○
Russian Federation	●	●	●	●	●	●	● Professional development for teachers
Slovenia	●	●	●	○	○	●	● Regular workshops for teachers organized by mathematics department of the National Board for Education
Sweden	●	○	○	○	○	○	○

● Yes
○ No

Data provided by National Research Coordinators.

SOURCE: IEA TIMSS Advanced 2008 ©

Exhibit 1.9 **Ways in Which Changes in the Curriculum Are Communicated to Teachers**

TIMSSAdvanced 2008
Advanced Mathematics

Country	Special Conferences/ Seminars	Ministry Website	Printed Copies of the Curriculum Distributed to Schools	Teachers Receive Own Printed Copy	Professional Development/ Inservice Education	Ministry Notes	Professional Association Newsletter	Education Journals	Other*
Armenia	●	●	●	○	●	●	○	●	○
Iran, Islamic Rep. of	●	●	○	○	●	●	●	○	○
Italy	●	●	●	○	●	●	●	●	○
Lebanon	●	●	●	○	●	●	○	○	○
Netherlands	○	●	●	○	●	●	●	●	○
Norway	●	●	●	●	●	●	●	○	○
Philippines	●	●	●	○	●	○	○	○	●
Russian Federation	●	●	○	○	●	●	○	●	○
Slovenia	●	●	○	○	●	○	○	○	●
Sweden	●	●	●	○	●	○	●	●	○

● Yes
○ No

Data provided by National Research Coordinators.

* Phillipines: Information is disseminated through a Department of Education order.
Slovenia: Schools help each other in getting information.

SOURCE: IEA TIMSS Advanced 2008 ©

changes on the Ministry of Education's website, conducting special conferences or seminars for teachers (except in the Netherlands), and making various forms of in-service education and professional development opportunities available to teachers. Other activities carried out in five or more countries included distributing copies of revised curricula to schools, issuing notices to schools about recent changes to the curriculum, and publishing announcements of changes in professional association newsletters and in journals for teachers.

Exhibit 1.8 shows that, in Sweden, copies of the official curriculum were made available in printed form to teachers and others, but that none of the other alternatives listed were supported. Exhibit 1.9, on the other hand, shows that Sweden makes use of six of the eight listed alternatives for helping teachers to stay up-to-date with curricular changes. Most countries indicated that they used five or more of the ways listed. The Philippines supported four, and Slovenia, three.

Implementation of the TIMSS Advanced Mathematics Curriculum

Exhibit 1.10 presents information about how many hours of classroom time are devoted each week to advanced mathematics in the participating countries. The National Research Coordinators provided the estimates for the amount of time prescribed in the official curriculum, and the teachers of the students being assessed provided the information about the number of hours devoted to advanced mathematics each week in their own classrooms. While the two estimates were equal only in Norway, there was a fairly high degree of agreement in all countries. That is, the estimate of class time in the intended curriculum is more or less the same as that in the implemented curriculum.

Teachers also were asked to report the percent of instructional time they devoted to the three TIMSS Advanced 2008 content domains—

Exhibit 1.10 **Weekly Hours of Intended and Implemented Instructional Time for Advanced Mathematics in the Final Year**

TIMSSAdvanced 2008
Advanced Mathematics

Country	Intended Instructional Time as Prescribed in the Curriculum (in Hours per Week)	Number of Weeks Schools Are Open in a Year*		Weekly Hours of Implemented Instructional Time for Advanced Mathematics
Armenia	3.9	34	r	4.6 (0.07)
Iran, Islamic Rep. of	6.0	36		4.9 (0.23)
Italy	3.0–5.0	42		3.6 (0.10)
Lebanon	9.6	26		8.6 (0.10)
Netherlands	4.0**	40		3.8 (0.08)
Norway	3.7	38		3.7 (0.07)
Philippines	2.5–5.0	36		5.2 (0.24)
Russian Federation	6.0–9.0	34		5.8 (0.15)
Slovenia	3.7	35		3.8 (0.04)
Sweden	2.7–3.1***	38		3.9 (0.13)

SOURCE: IEA TIMSS Advanced 2008 ©

Intended instructional time provided by National Research Coordinators. Implemented instructional time provided by teachers.

* Number of weeks are estimated by dividing total number of school days in a year by five.

** Instructional time is not prescribed for advanced mathematics. According to the curriculum, a total of 760 hours over three years should be spent by the students on advanced mathematics (including homework and instruction). About 60% on average should be spent as class time.

*** Instructional time is not prescribed in the current curriculum. The range above is an estimate based on prescriptions of instructional time from the previous curriculum averaged over three years.

( ) Standard errors appear in parentheses.

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

algebra, calculus, and geometry—as well as to other topics. As shown in Exhibit 1.11, the three TIMSS Advanced content domains together accounted for at least 80 percent of the instructional time available for advanced mathematics in every country as reported by the final year teachers.

The largest proportion of class time in advanced mathematics in eight of the participating countries was devoted to calculus, but there was considerable variation across countries in this regard. In Italy, 62 percent of class time was taken up by calculus, the largest proportion by far for this group of countries. In Armenia, on the other hand, calculus accounted for only 20 percent of instructional time (presumably because fewer calculus topics are covered as reported in Exhibit 1.4), and the largest segment of the advanced mathematics program there was algebra. Algebra had the highest share of instructional time in the Russian Federation also, although the same percent of time was devoted to geometry as to algebra. Geometry had less time than either of the other two content domains in Italy, the Netherlands, the Philippines, and Slovenia.

TIMSS Advanced asked teachers about the topics actually taught in the mathematics classroom. Teachers of the assessed students were asked to indicate whether each of the TIMSS Advanced topics was *mostly taught before this year*, *mostly taught this year*, or *not yet taught or just introduced.* Exhibit 1.12 presents teachers' reports on the percentages of students who were taught the TIMSS Advanced mathematics topics prior to or during the year of the assessment. The exhibit shows, for each country, averaged across the content domains, the percentage of students whose teachers reported that the students had been taught each topic. Teachers in Lebanon and Slovenia reported an extremely high degree of correspondence, with 95 to 96 percent of the students having been taught the topics. In the remaining countries,

Exhibit 1.11 **Percent of Time in Advanced Mathematics Class Devoted to TIMSS Content During the Final Year**

TIMSSAdvanced2008 Advanced Mathematics

Country	Algebra	Calculus	Geometry	Other
Armenia	r 37 (0.5)	r 20 (0.8)	r 33 (0.6)	r 10 (0.3)
Iran, Islamic Rep. of	20 (0.9)	41 (1.5)	24 (1.2)	14 (1.0)
Italy	17 (1.1)	62 (1.9)	13 (1.0)	8 (1.4)
Lebanon	r 21 (0.6)	r 35 (0.6)	r 28 (0.5)	r 15 (0.9)
Netherlands	31 (1.2)	34 (1.6)	28 (1.1)	7 (1.2)
Norway	23 (0.9)	31 (1.0)	28 (0.8)	17 (1.0)
Philippines	30 (1.7)	37 (2.1)	27 (1.7)	6 (1.3)
Russian Federation	32 (1.2)	27 (0.8)	32 (0.9)	9 (0.9)
Slovenia	36 (1.1)	43 (1.1)	9 (0.9)	12 (1.2)
Sweden	24 (0.9)	42 (0.8)	32 (1.1)	2 (0.4)

SOURCE: IEA TIMSS Advanced 2008 ©

Data provided by teachers.

( ) Standard errors appear in parentheses.

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

Exhibit 1.12 **Average Percent of Students Taught the TIMSS Advanced 2008 Mathematics Topics Prior to or During the Final Year***

TIMSSAdvanced2008 Advanced Mathematics

Country	Overall (16 topics)	Algebra (6 Topics)	Calculus (5 topics)	Geometry (5 Topics)
Armenia	r 80 (0.4)	r 80 (0.2)	r 66 (1.4)	r 94 (0.2)
Iran, Islamic Rep. of	89 (1.1)	80 (1.2)	95 (1.3)	93 (1.6)
Italy	86 (1.4)	70 (2.0)	94 (1.6)	93 (1.8)
Lebanon	96 (0.4)	95 (0.7)	95 (0.5)	99 (0.2)
Netherlands	86 (0.8)	84 (0.7)	93 (0.9)	81 (1.7)
Norway	89 (0.8)	81 (0.9)	96 (0.9)	91 (1.3)
Philippines	79 (1.6)	85 (1.7)	64 (2.9)	87 (1.5)
Russian Federation	– –	– –	– –	– –
Slovenia	95 (0.6)	97 (0.6)	88 (1.5)	99 (0.4)
Sweden	79 (1.1)	69 (1.5)	95 (1.0)	72 (1.9)

SOURCE: IEA TIMSS Advanced 2008 ©

Data provided by teachers.

* The 27 topics on the intended curriculum in the TIMSS Advanced Curriculum Questionnaire were combined into 16 topics for the Teacher Questionnaire about the implemented curriculum.

A dash (–) indicates comparable data are not available. The Russian Federation did not collect this information.

( ) Standard errors appear in parentheses.

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

most students (79 to 89 percent) had been taught the topics. Looking at the particular domains, fewer Italian and Swedish students (69–70%) had been taught the algebra topics, fewer Armenian and Philippine students (64–66%) had been taught topics in calculus—Armenia being the country with the least curricular emphasis on this area—and fewer Swedish students (72%) had been taught the geometry topics, consistent with reports about less emphasis on this area in the Swedish curriculum.

As previewed in the discussion of Exhibit 1.4, the participating countries were asked to indicate whether each of the TIMSS Advanced 2008 mathematics topics was included in their intended curriculum; and, as summarized in Exhibit 1.12, the teachers of the TIMSS Advanced 2008 mathematics classes in every country (except the Russian Federation) were asked to indicate whether the advanced mathematics students had been taught that topic. There were 27 topics in all: 10 in algebra, 9 in calculus, and 8 in geometry. The topic-by-topic responses are summarized in Exhibits 1.13 through 1.15.

Exhibit 1.13 shows that 9 of the 10 topics in the algebra domain were reported by the National Research Coordinators to be included in the intended curriculum of their country. The only exception was complex numbers which was included in the intended curriculum of only five countries. As would be anticipated, if the topic of complex numbers was not in the intended curriculum for the country, it was taught to only a few students in those countries. Generally speaking, the remaining TIMSS Advanced topics in algebra corresponded to those topics in the intended curriculum and were taught to a large proportion of the TIMSS Advanced 2008 students.

Exhibit 1.14 shows that all eight of the topics in the TIMSS Advanced 2008 calculus domain were included in the intended curriculum of almost all these countries except Armenia. In particular,

Exhibit 1.13 **Intended and Taught TIMSS Advanced 2008 Algebra Topics**

TIMSSAdvanced2008 Advanced Mathematics

Algebra (10 topics)	Complex Numbers		Numeric and Algebraic Series		Permutations, Combinations, and Probability		
Country	Topic Is in the Intended Curriculum	Percent of Students Taught This Topic	Topic Is in the Intended Curriculum	Percent of Students Taught This Topic	Topic Is in the Intended Curriculum: Permutations and Combinations	Topic Is in the Intended Curriculum: Probability	Average Percent of Students Taught These Topics
Armenia	○	r 12 (0.4)	●	r 95 (0.3)	●	●	r 89 (0.4)
Iran, Islamic Rep. of	○	7 (1.8)	●	93 (2.4)	●	●	93 (2.0)
Italy	●	54 (4.8)	○	34 (4.9)	●	●	46 (5.3)
Lebanon	●	99 (0.3)	●	92 (1.2)	●	●	93 (1.7)
Netherlands	○	14 (3.6)	●	96 (2.3)	●	●	100 (0.0)
Norway	○	3 (1.8)	●	97 (2.0)	●	●	93 (2.4)
Philippines	●	62 (4.9)	●	81 (4.1)	●	●	73 (3.8)
Russian Federation	●	– –	●	– –	●	●	– –
Slovenia	●	100 (0.0)	●	100 (0.0)	●	●	89 (2.7)
Sweden	○	59 (2.4)	●	82 (3.5)	○	●	37 (4.2)

SOURCE: IEA TIMSS Advanced 2008 ©

Algebra (10 topics)	Polynomial Equations and Inequalities, Radical Equations, and Logarithmic and Exponential Equations				Equivalent Representation of a Function		Values of a Function and Function of a Function		
Country	Topic Is in the Intended Curriculum: Polynomial Equations and Inequalities	Topic Is in the Intended Curriculum: Radical Equations	Topic Is in the Intended Curriculum: Logarithmic and Exponential Equations	Average Percent of Students Taught These Topics	Topic Is in the Intended Curriculum	Percent of Students Taught This Topic	Topic Is in the Intended Curriculum: Values of a Function	Topic Is in the Intended Curriculum: Function of a Function	Average Percent of Students Taught These Topics
Armenia	●	●	●	r 96 (0.2)	●	r 94 (0.4)	●	●	r 91 (0.3)
Iran, Islamic Rep. of	●	●	●	96 (1.5)	●	95 (1.6)	●	●	96 (1.4)
Italy	●	●	●	97 (1.9)	●	92 (2.7)	●	●	99 (1.3)
Lebanon	●	●	●	97 (1.2)	●	92 (1.4)	●	●	96 (1.4)
Netherlands	●	●	●	100 (0.0)	●	94 (2.0)	●	●	99 (0.8)
Norway	●	●	●	99 (0.6)	●	94 (2.0)	●	●	100 (0.0)
Philippines	●	●	●	97 (1.4)	●	98 (1.2)	●	○	98 (1.3)
Russian Federation	●	●	●	– –	●	– –	●	●	– –
Slovenia	●	●	●	100 (0.0)	●	96 (2.5)	●	●	100 (0.0)
Sweden	●	●	●	98 (1.3)	●	91 (2.7)	●	●	94 (2.3)

● Yes ○ No

Data on intended curriculum provided by National Research Coordinators, and on implemented curriculum by teachers at the time of testing.

A dash (–) indicates comparable data are not available. The Russian Federation did not collect this information.

( ) Standard errors appear in parentheses.

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

Exhibit 1.14 **Intended and Taught TIMSS Advanced 2008 Calculus Topics**

TIMSSAdvanced2008 Advanced Mathematics

Calculus (9 topics)	Limits and Continuity			Differentiation of a Function			Using Derivatives to Solve Problems	
	Topic Is in the Intended Curriculum			Topic Is in the Intended Curriculum				
Country	Limits of Functions	Conditions for Continuity and Differentiability	Average Percent of Students Taught These Topics	Differentiation of a Function (Polynomial, Logarithmic, Exponential and Trigonometric)	Differentiation of Composite and Parametric Functions	Average Percent of Students Taught These Topics	Topic Is in the Intended Curriculum	Percent of Students Taught This Topic
Armenia	●	○	r 91 (0.3)	●	●	r 87 (0.4)	●	r 65 (2.3)
Iran, Islamic Rep. of	●	●	97 (1.3)	●	●	97 (1.3)	●	96 (1.3)
Italy	●	●	98 (1.5)	●	●	97 (1.7)	●	94 (2.4)
Lebanon	●	●	99 (0.1)	●	●	97 (1.0)	●	81 (2.0)
Netherlands	○	○	69 (4.6)	●	●	100 (0.0)	●	100 (0.0)
Norway	●	●	84 (4.2)	●	●	98 (1.7)	●	99 (0.7)
Philippines	●	●	88 (2.9)	●	●	81 (3.4)	●	54 (4.8)
Russian Federation	●	●	– –	●	●	– –	●	– –
Slovenia	●	●	100 (0.0)	●	●	100 (0.3)	●	65 (5.7)
Sweden	○	○	77 (4.1)	●	●	100 (0.0)	●	100 (0.5)

Calculus (9 topics)	Gradient, Turning Points, and Points of Inflection of Functions			Integration		
	Topic Is in the Intended Curriculum			Topic Is in the Intended Curriculum		
Country	Using First Derivative to Determine Gradients and Turning Points	Using Second Derivative to Determine Maxima, Minima, and Points of Inflection	Average Percent of Students Taught These Topics	Integrating Functions	Evaluating Definite Integrals	Average Percent of Students Taught These Topics
Armenia	●	○	r 66 (4.3)	○	○	r 20 (4.9)
Iran, Islamic Rep. of	●	●	97 (1.3)	●	●	89 (2.5)
Italy	●	●	96 (2.1)	●	●	85 (3.9)
Lebanon	●	●	100 (0.3)	●	●	98 (0.0)
Netherlands	●	●	100 (0.0)	●	●	98 (1.3)
Norway	●	●	99 (0.6)	●	●	100 (0.0)
Philippines	●	●	57 (4.6)	●	●	41 (5.3)
Russian Federation	●	●	– –	●	●	– –
Slovenia	●	○	93 (1.6)	●	●	81 (3.9)
Sweden	●	●	100 (0.0)	●	●	97 (1.3)

● Yes ○ No

Data on intended curriculum provided by National Research Coordinators, and on implemented curriculum by teachers at the time of testing.

A dash (–) indicates comparable data are not available. The Russian Federation did not collect this information.

( ) Standard errors appear in parentheses.

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

SOURCE: IEA TIMSS Advanced 2008 ©

the Armenian curriculum does not include integration, and few students had been taught these topics. Other than that, four of the topics—differentiation of a function; differentiation of composite and parametric functions; using derivatives to solve problems; and using second derivatives to determine maxima, minima, and points of inflection—were part of the curriculum in every participating country. The others were included in the curricula of at least eight countries. There was a high degree of agreement between the fact that a topic was deemed to be part of the official curriculum for a country and that relatively high percentages of students were taught that topic according to their teachers, but less than in algebra. For example, the Netherlands and Sweden reported that topics related to limits and continuity were not covered in their curricula, yet according to teachers, on average 69 and 77 percent of the students, respectively, had been taught the two topics asked about—limits of functions and conditions for continuity and differentiability. In contrast, the Philippines reported that topics related to derivatives, points of inflection, and integration were included in the curriculum; but according to their teachers only about half of the students or fewer had been taught any of these topics.

Exhibit 1.15 focuses on the geometry content domain where, for many years, there has likely been more variability across countries with respect to which topics should be part of the curriculum and what pedagogical approach should be taken than in any other area of the mathematics curriculum. The topics included in TIMSS Advanced 2008 geometry domain are indicative of that variability, covering quite a wide variety of areas including traditional Euclidean geometry, analytic geometry, transformation geometry approached through vectors, and trigonometry.

Three of the TIMSS Advanced geometry topics—proving geometric propositions in two dimensions, trigonometric properties

Exhibit 1.15 **Intended and Taught TIMSS Advanced 2008 Geometry Topics**

TIMSSAdvanced2008 Advanced Mathematics

Geometry (8 topics)	Properties of Geometric Figures (2- and 3-D)			Gradients, Y–axis Intercepts, and Point of Intersection of Straight Lines in Cartesian Coordinates		Circles		
	Topic Is in the Intended Curriculum					Topic Is in the Intended Curriculum		
Country	Proving Geometric Propositions in 2-D	Proving Geometric Propositions in 3-D	Average Percent of Students Taught These Topics	Topic Is in the Intended Curriculum	Percent of Students Taught This Topic	Equations and Properties of Circles in the Cartesian Plane	Tangents and Normals to Circles	Average Percent of Students Taught These Topics
Armenia	●	●	r 97 (0.1)	●	r 92 (0.3)	●	●	r 95 (0.2)
Iran, Islamic Rep. of	●	●	92 (2.2)	●	95 (1.8)	●	●	93 (2.0)
Italy	●	●	92 (2.9)	●	93 (2.6)	●	●	97 (1.7)
Lebanon	●	●	97 (0.6)	●	99 (0.4)	●	●	100 (0.2)
Netherlands	●	○	100 (0.0)	○	79 (4.9)	○	○	69 (4.7)
Norway	●	●	63 (4.9)	●	99 (0.6)	●	○	92 (3.1)
Philippines	●	●	88 (2.8)	●	96 (1.8)	●	●	98 (1.0)
Russian Federation	●	●	– –	●	– –	●	●	– –
Slovenia	●	○	100 (0.0)	●	100 (0.0)	●	●	96 (2.1)
Sweden	●	○	88 (3.5)	●	97 (1.4)	○	○	55 (5.7)

Geometry (8 topics)	Trigonometry			Properties of Vectors and Their Sums and Differences	
	Topic Is in the Intended Curriculum				
Country	Trigonometric Properties of Triangles	Solving Equations Involving Trigonometric Functions	Average Percent of Students Taught These Topics	Topic Is in the Intended Curriculum	Percent of Students Taught This Topic
Armenia	●	●	r 96 (0.2)	●	r 92 (0.4)
Iran, Islamic Rep. of	●	●	94 (1.8)	●	92 (2.0)
Italy	●	●	98 (1.5)	●	85 (2.7)
Lebanon	●	●	99 (0.3)	●	100 (0.0)
Netherlands	●	●	100 (0.0)	●	55 (4.4)
Norway	●	●	99 (0.6)	●	99 (0.6)
Philippines	●	●	100 (0.2)	○	57 (5.1)
Russian Federation	●	●	– –	●	– –
Slovenia	●	●	100 (0.0)	●	100 (0.0)
Sweden	●	●	100 (0.0)	○	19 (4.5)

● Yes ○ No

Data on intended curriculum provided by National Research Coordinators, and on implemented curriculum by teachers at the time of testing.

A dash (–) indicates comparable data are not available. The Russian Federation did not collect this information.

( ) Standard errors appear in parentheses.

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

SOURCE: IEA TIMSS Advanced 2008 ©

of triangles, and solving equations involving trigonometric functions—were included in the curriculum of all countries and taught to nearly all students. However, in Sweden several geometry topics were not included in the curriculum and only about half the Swedish students were taught geometric topics related to circles and only 19 percent about vectors. Similarly, vectors were not included in the curriculum or taught very much in the Philippines. In a few cases, topics were not considered to be in the curriculum but teachers reported that substantial percentages of the students were taught the topics in any case. For example, in the Netherlands, teachers reported that three geometry topics not specified in the curriculum were taught to large percentages of students: gradients, y-axis intercepts, and intersections in the Cartesian plane (79%); and two circle topics: equations and properties of circles in the Cartesian plane, and tangents and normals to circles (69% on average for the two circle topics).

How Well Prepared Do Teachers Feel They Are to Teach Mathematics?

TIMSS Advanced 2008 asked the students' teachers of mathematics how well prepared they felt they were to teach some of the mathematics topics included in the advanced mathematics framework. For each topic, teachers were asked to indicate whether they felt *very well prepared*, *somewhat prepared*, or *not well prepared*. Teachers were asked about 16 topics in total, including 6 topics in algebra, 5 topics in calculus, and 5 topics in geometry. The percentages of students whose teachers reported feeling very well prepared to teach the various topics are presented in Exhibits 1.16 and 1.17. In Exhibit 1.16, the results are summarized by averaging the percentages of students whose teachers reported feeling very well prepared to teach each topic: first across all of the 16 mathematics topics, and next across the topics in each of

Exhibit 1.16 Percent of Students Whose Teachers Feel "Very Well" Prepared to Teach the TIMSS Advanced 2008 Mathematics Topics

TIMSSAdvanced2008 Advanced Mathematics

Country	Percent of Students			
	Overall (16 topics)	Algebra (6 topics)	Calculus (5 topics)	Geometry (5 topics)
Armenia	76 (1.1)	76 (1.7)	66 (2.0)	89 (0.9)
Iran, Islamic Rep. of	87 (1.2)	83 (1.5)	95 (0.9)	84 (2.1)
Italy	69 (2.9)	58 (3.0)	77 (3.6)	71 (3.1)
Lebanon	95 (0.5)	95 (0.6)	92 (0.6)	97 (0.6)
Netherlands	86 (1.8)	84 (2.2)	92 (1.6)	83 (2.6)
Norway	93 (0.9)	87 (1.3)	99 (0.6)	94 (1.2)
Philippines	65 (2.1)	76 (2.3)	51 (3.7)	67 (2.5)
Russian Federation	– –	– –	– –	– –
Slovenia	84 (2.1)	86 (2.5)	79 (3.0)	86 (2.1)
Sweden	81 (1.9)	77 (2.6)	90 (1.7)	77 (2.5)

SOURCE: IEA TIMSS Advanced 2008 ©

Data provided by teachers.

A dash (–) indicates comparable data are not available. The Russian Federation did not collect this information.

( ) Standard errors appear in parentheses.

the 3 content domains. Exhibit 1.17 presents the results for each topic. Teachers in the Russian Federation were not asked for this information so the cells in the table for them are blank.

Exhibit 1.16 makes it clear that, in most of the participating countries, the vast majority of students were taught by teachers who considered themselves to be very well prepared to teach these advanced mathematics topics at this level. This result is not particularly surprising, but there may be some cause for concern in those countries where 20 percent or more of the students were taught by teachers who considered themselves either somewhat prepared or not well prepared to teach these 16 topics. Over 90 percent of the advanced mathematics students in Lebanon and Norway as well as more than 80 percent of those in 4 more countries (Iran, the Netherlands, Slovenia, and Sweden) were taught by teachers who considered themselves well prepared, on average, to teach the TIMSS Advanced topics. On the other hand, more than 20 percent of students in Armenia, Italy, and the Philippines were taught by teachers who were not as confident about their degree of preparedness.

Examining these results on a country-by-country and topic-by-topic basis answers some questions about the variability across topics in countries such as Armenia and the Philippines. Exhibit 1.17 shows the percent of students whose teachers considered themselves to be very well prepared to teach the topics in the three TIMSS Advanced 2008 content domains on a topic-by-topic basis, again excluding the Russian Federation. One might expect that almost all mathematics teachers at this level would be well qualified insofar as the subject matter of the course is concerned, and that such teachers would feel themselves to be very well prepared to teach the course. This turns out, surprisingly enough, not to be the case for every topic in every country, and this is reflected in the content of the three tables that make up the exhibit: one table for each of the three content domains.

Exhibit 1.17 **Percent of Students Whose Teachers Feel "Very Well" Prepared to Teach the TIMSS Advanced 2008 Mathematics Topics in Algebra, Calculus, and Geometry**

TIMSSAdvanced 2008 Advanced Mathematics

Country	Percent of Students Whose Teachers Report Feeling Very Well Prepared to Teach the Topics in Algebra (6 topics)					
	Complex Numbers	Numeric and Algebraic Series	Permutations, Combinations, and Probability	Polynomial Equations and Inequalities, Radical Equations, and Logarithmic and Exponential Equations	Equivalent Representation of a Function	Values of a Function and Function of a Function
Armenia	40 (4.8)	94 (1.4)	62 (3.7)	94 (1.6)	78 (2.3)	83 (2.1)
Iran, Islamic Rep. of	47 (4.3)	81 (2.9)	80 (3.0)	96 (1.5)	97 (1.2)	96 (1.4)
Italy	54 (4.6)	39 (5.8)	25 (4.3)	87 (3.4)	63 (4.5)	79 (4.3)
Lebanon	98 (0.6)	92 (1.2)	95 (0.9)	96 (1.2)	94 (1.0)	97 (0.8)
Netherlands	61 (5.1)	82 (3.9)	74 (4.5)	98 (1.1)	89 (3.6)	97 (1.4)
Norway	56 (4.7)	99 (0.6)	76 (4.2)	100 (0.0)	94 (2.4)	100 (0.0)
Philippines	82 (3.8)	57 (4.9)	47 (5.1)	91 (3.0)	94 (2.7)	87 (3.3)
Russian Federation	– –	– –	– –	– –	– –	– –
Slovenia	94 (3.5)	89 (4.1)	52 (6.0)	96 (2.1)	89 (3.4)	96 (2.0)
Sweden	80 (3.9)	65 (5.3)	44 (5.5)	96 (1.6)	85 (3.6)	92 (2.9)

Country	Percent of Students Whose Teachers Report Feeling Very Well Prepared to Teach the Topics in Calculus (5 topics)				
	Limits and Continuity	Differentiation of a Function	Using Derivatives to Solve Problems	Gradient, Turning Points, and Points of Inflection of Functions	Integration
Armenia	91 (1.3)	96 (0.2)	52 (4.4)	51 (4.4)	36 (5.5)
Iran, Islamic Rep. of	97 (1.4)	99 (0.6)	88 (2.9)	100 (0.4)	93 (1.7)
Italy	86 (3.7)	84 (3.9)	57 (5.9)	78 (4.7)	79 (4.4)
Lebanon	97 (0.7)	98 (0.7)	70 (2.1)	97 (0.7)	98 (0.6)
Netherlands	82 (3.6)	98 (1.1)	89 (3.4)	98 (1.1)	92 (2.7)
Norway	95 (2.4)	100 (0.0)	97 (1.2)	100 (0.0)	100 (0.2)
Philippines	66 (4.5)	57 (5.4)	34 (5.1)	52 (4.4)	47 (4.7)
Russian Federation	– –	– –	– –	– –	– –
Slovenia	73 (5.1)	95 (2.6)	43 (5.7)	95 (2.7)	89 (4.1)
Sweden	69 (5.3)	97 (1.6)	93 (2.7)	98 (1.3)	95 (2.2)

Data provided by teachers.

A dash (–) indicates comparable data are not available. The Russian Federation did not collect this information.

( ) Standard errors appear in parentheses.

SOURCE: IEA TIMSS Advanced 2008 ©

Exhibit 1.17 **Percent of Students Whose Teachers Feel "Very Well" Prepared to Teach the TIMSS Advanced 2008 Mathematics Topics in Algebra, Calculus, and Geometry (Continued)**

TIMSSAdvanced 2008 Advanced Mathematics

Country	Percent of Students Whose Teachers Report Feeling Very Well Prepared to Teach the Topics in Geometry (5 topics)				
	Properties of Geometric Figures (2- and 3-D)	Gradients, Y-axis Intercepts, and Point of Intersection of Straight Lines in Cartesian Coordinates	Circles	Trigonometry	Properties of Vectors and Their Sums and Differences
Armenia	91 (1.7)	85 (1.6)	85 (1.3)	96 (0.2)	87 (3.3)
Iran, Islamic Rep. of	62 (4.2)	91 (2.2)	92 (2.3)	88 (2.2)	86 (2.8)
Italy	49 (5.5)	70 (4.6)	82 (3.9)	87 (3.5)	68 (4.3)
Lebanon	98 (0.6)	98 (0.7)	98 (0.7)	95 (1.0)	98 (0.6)
Netherlands	71 (5.1)	80 (3.3)	79 (4.2)	97 (1.3)	86 (3.8)
Norway	71 (5.2)	100 (0.0)	99 (0.9)	100 (0.4)	99 (1.2)
Philippines	42 (5.3)	87 (3.6)	82 (4.1)	87 (3.8)	39 (5.1)
Russian Federation	– –	– –	– –	– –	– –
Slovenia	59 (5.7)	99 (0.8)	82 (3.7)	94 (2.5)	95 (3.1)
Sweden	63 (5.9)	95 (2.1)	61 (4.8)	97 (1.5)	67 (4.7)

SOURCE: IEA TIMSS Advanced 2008 ©

Data provided by teachers.

A dash (–) indicates comparable data are not available. The Russian Federation did not collect this information.

( ) Standard errors appear in parentheses.

If 80 percent or more is used as a criterion for countries where a large majority of students were taught by teachers who consider themselves to be very well prepared to teach a topic, three algebra topics—equations and inequalities, equivalent representations of functions, and functional values and function of a function—are areas that most of these advanced mathematics teachers felt very comfortable teaching. That was not the case for the other three algebra topics: complex numbers, series, and permutations and combinations. In the case of complex numbers, the results are understandable for Armenia, Iran, the Netherlands, Norway, and Sweden, since this topic is not included in their curricula (see Exhibit 1.13) and teachers, therefore, mostly likely do not feel the need to be prepared and may not even be especially trained in this area. On the other hand, for permutations and combinations, the 80 percent or more criterion was reached in fewer than half the countries even though the topic typically was in their curricula. Taking into account that the series topic was not included in the curriculum, the proportion of Italian students who were taught by teachers who considered themselves to be very well prepared to teach these algebra topics was generally lower than in the other countries. Also, as shown in Exhibit 1.13, fewer Swedish students had been taught topics related to probability than might be expected.

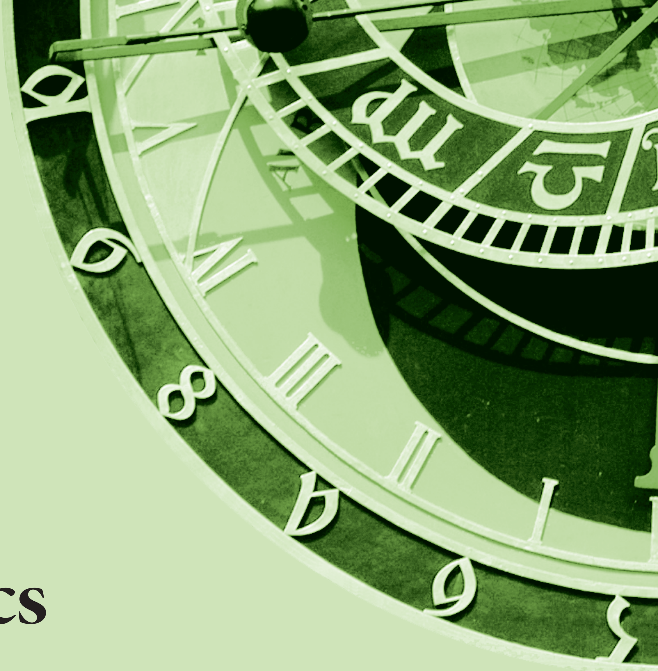
The second table in Exhibit 1.17 concerns the five calculus topics, and it raises similar issues. Three topics—differentiation; using derivatives to determine slopes, turning points, and points of inflection of functions; and integrating functions and evaluating definite integrals—are areas in which a large majority of students of advanced mathematics in most countries were being taught by teachers who felt they were well prepared to do so. This, however, was not true for some topics included in the curriculum for some countries (see Exhibit 1.14); for example, limits and continuity in the Netherlands

(69%) and Sweden (77%), and using derivatives to solve problems for several countries. In the latter case, the 80 percent or better criterion was not met in Armenia (65%), the Philippines (54%), and Slovenia (65%), and this should be a particular concern for such an essential part of any introductory calculus course. In particular, the proportions of students who were taught by teachers who considered themselves to be very well prepared to teach the calculus topics were generally lower in the Philippines than in the other countries, and this may help explain why substantial percentages of students were not being taught these topics even though the topics are in the curriculum (see Exhibit 1.14). The percentages also were lower in Armenia, but primarily because a number of the calculus topics (most notably integration) are not in the Armenian curriculum.

The third table in the exhibit deals with the five topics grouped under geometry. The first topic, properties of geometric figures, drew the least support; that is, the percent of students who were taught it by teachers who felt themselves to be well prepared to teach this topic was lower in most countries than for any other topic. The percentages were high (over 90%) only in Armenia and Lebanon, and ranged from 42 to 71 percent for the other countries. It is not clear what one might infer from such a result without knowing more about how teachers interpreted the question they were asked. One possibility is that the inclusion of 3-dimensional figures in the question might have affected the results, but this explanation works best for Sweden where the 3-dimensional topic is not in the curriculum and not covered in all classrooms. For the other countries, this topic was in the curriculum and even when it was not, such as in the Netherlands and Slovenia, teachers unanimously reported teaching it (Exhibit 1.15).

The other four geometry topics had much stronger support. Across the nine countries that provided data, over 80 percent of students in seven or more countries were taught these topics by teachers who considered themselves to be very well prepared to teach these topics. Country-by-country comparisons indicate that the proportions of students who were taught these geometry topics by teachers who felt very well prepared to do so were generally lower in Italy, the Philippines, and Sweden than in the other countries. As observed previously (see Exhibit 1.15), the Swedish curriculum does not include some of the TIMSS Advanced geometry topics. However, all the geometry topics are included in the Italian curriculum and taught to more than 90 percent of the students (except vectors, taught to 80%). Similarly, with the exception of vectors, all of the geometry topics are in the Philippine curriculum and taught to almost all students (88 to 100%). Interestingly, 86 percent of the students in the Netherlands have teachers who feel confident to teach vectors and the topic of vectors is in the Dutch curriculum, but just over half the students (55%) are taught vectors according to their teachers.

In summary, Chapter 1 presents a considerable amount of important information that should be taken into account when considering the achievement results presented in Chapter 2 for each country. Many country characteristics, such as socioeconomic factors and country population size can affect the challenges associated with educating students in advanced mathematics. Beyond that, in some countries, students have had more years of schooling or the advanced mathematics program entails as much as twice the hours of study across the years of the program. In some cases, countries were more selective than others in identifying the students to be assessed in TIMSS Advanced. Also, the curriculum differed somewhat across the advanced mathematics programs assessed in TIMSS Advanced as did teachers' confidence in their preparation to teach the topics assessed. The considerable variation across the 10 participating countries in these system-wide contexts for educating students in advanced mathematics provides a complicated and multifaceted backdrop for considering variation in mathematics achievement.



Chapter 2

International Student Achievement in Advanced Mathematics

Chapter 2 focuses on the TIMSS Advanced 2008 achievement results for students enrolled in advanced mathematics courses in the final year of secondary school in each of the participating countries. The chapter also addresses trends in mathematics achievement over time for participants in the previous TIMSS assessment at this level in 1995. Achievement differences by gender are also discussed.

Distribution of Advanced Mathematics Achievement in the Participating Countries

Exhibit 2.1 shows the distribution of student achievement in mathematics 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 2008 used item response theory (IRT) methods to summarize the advanced mathematics achievement for each country on the TIMSS Advanced mathematics scale with a mean of 500 and a standard deviation of 100.[1] The TIMSS Advanced mathematics scale for reporting the TIMSS Advanced 2008 results was established by rescaling the data from the 1995 TIMSS mathematics assessment of students in the final year of secondary school together with the mathematics 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 mathematics scale, a score of 500 in advanced mathematics in 2008 is equivalent to a score of 500 in advanced mathematics in 1995.[3] It should be noted, however, that achievement on the TIMSS Advanced mathematics scale cannot be described in absolute terms (as would be the case with all such scales developed using IRT technology), so these results cannot be directly compared to those for TIMSS Advanced physics found in Chapter 8. Comparisons between achievement in advanced mathematics and achievement in physics can only be made in terms of relative performance (higher or lower) among countries as well as between assessments.

Exhibit 2.1 shows that the 10 countries participating in the TIMSS Advanced 2008 mathematics assessment had considerable differences in their average achievement. At the top is a group of three countries—the Russian Federation, the Netherlands, and Lebanon. As shown by the symbol next to 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, each of the three top-performing countries had average achievement higher than the international scale average of 500. The average scale scores for these three countries are relatively close to one another compared to the rest of the participating countries (ranging from 561 to 545), with each of the countries having average achievement

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 advanced mathematics test.

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, and I.V.S. Mullis (Eds.), *TIMSS Advanced 2008 technical report*. Chestnut Hill, MA: TIMSS & PIRLS International Study Center, Boston College.

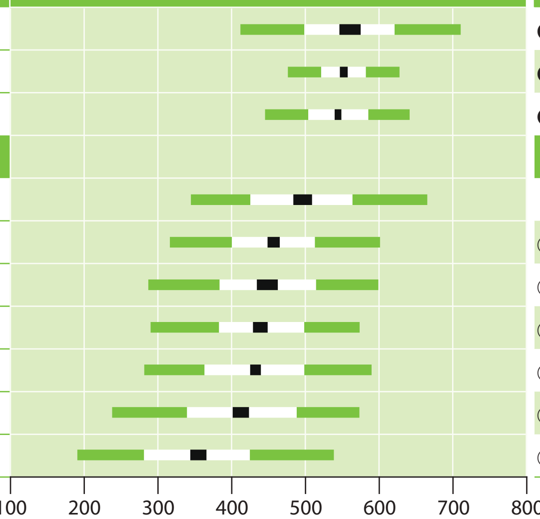
3 Because the rescaled 1995 data together with the 2008 data have been used in the analyses conducted for TIMSS Advanced 2008 and procedures differed from those used in 1995, the results from the 1995 data in this report cannot be compared directly with previous published 1995 achievement results.

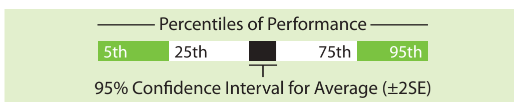
Exhibit 2.1 **TIMSS Advanced 2008 Distribution of Achievement in Advanced Mathematics**

TIMSSAdvanced2008 Advanced Mathematics

Country	Advanced Mathematics Achievement: Average Scale Score	Country Context for Achievement: Advanced Mathematics Coverage Index	Years of Formal Schooling*	Average Age at Time of Testing	Human Development Index**
Russian Federation	▲ 561 (7.2)	1.4%	10/11	17.0	0.813
† Netherlands	▲ 552 (2.6)	3.5%	12	18.0	0.953
Lebanon	▲ 545 (2.3)	5.9%	12	17.9	0.772
TIMSS Adv. Scale Avg.	500				
Iran, Islamic Rep. of	497 (6.4)	6.5%	12	18.1	0.759
Slovenia	▼ 457 (4.2)	40.5%	12	18.8	0.917
Italy	▼ 449 (7.2)	19.7%	13	19.0	0.941
Norway	▼ 439 (4.9)	10.9%	12	18.8	0.968
Armenia	▼ 433 (3.6)	4.3%	10	17.7	0.775
Sweden	▼ 412 (5.5)	12.8%	12	18.8	0.956
Philippines	▼ 355 (5.5)	0.7%	10	16.4	0.771

Advanced Mathematics Achievement Distribution





▲ Country average significantly higher than TIMSS Advanced scale average

▼ Country average significantly lower than TIMSS Advanced scale average

SOURCE: IEA TIMSS Advanced 2008 ©

* 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).

( ) Standard errors appear in parentheses.

similar to next.[4] However, there was a noticeable difference in average achievement between the Russian Federation with the highest average achievement and Lebanon (16 scale points), with the Netherlands in between the two. The Islamic Republic of Iran had average achievement below the top three countries and very close to the scale average (497).

The rest of the participating countries all had average achievement significantly below the scale average. The next cluster of countries in descending order by average achievement included Slovenia, Italy, Norway, and Armenia (457 to 433). These countries had average achievement that was similar from one country to the next adjacent country, although there was a significant difference between average achievement in Slovenia compared to Armenia (24 scale points). Next, Sweden's average achievement (412) was lower than that in Armenia (21 scale points). The Philippines, with an average scale score of 355, had the lowest average achievement.

The outer ends of the bar graphs in Exhibit 2.1 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 475 to a high of 625: about 1.5 standard deviations. Next was Lebanon with a somewhat wider range of about 200 points, or 2 standard deviations. The remaining 7 countries, including the highest scoring Russian Federation, had ranges close to or exceeding 300 scale points. That is, the range of scores within most countries exceeded the difference of 206 scale-score points across countries from the highest average achievement in the Russian Federation to the lowest in the Philippines.

As described in some detail in Chapter 1, there are many differences among the education systems of the countries that participated in TIMSS Advanced 2008. Because of these differences, there are a number of factors that need to be kept in mind in making

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 differences between 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.

a comparison of the TIMSS Advanced achievement results. Exhibit 2.1 includes some of the basic information that needs to be taken into consideration. One essential factor to consider is that the number of years of schooling varied across countries (as described in more detail in Exhibit 1.1, and replicated here for ease of reference). Exhibit 2.1 shows the number of years of schooling completed in each country by the students who participated in TIMSS Advanced 2008 and their average age at the time of testing.

At the time of the TIMSS Advanced 2008 assessment, the students enrolled in advanced mathematics courses in their final year of secondary school were in their 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, in the middle of implementing a reform to increase the number of years of schooling, reported some students with 10 years of schooling and some with 11 years; and Armenia and the Philippines reported 10 years. It should be noted that, as discusssed in Chapter 1, 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 oldest students were in Slovenia, Italy, Norway, and Sweden, averaging from 18.8 to 19 years old. Students in the Netherlands, Lebanon, Iran, and Armenia were about a year younger, averaging from 17.7 to 18.1 years old. The students in the Russian Federation were even younger with an average age of 17, and, the students in the Philippines were the youngest, averaging 16.4 years of age. The three top-performing countries—the Russian Federation, the Netherlands, and Lebanon—are not among those with the most years of schooling or the oldest students. However, the Philippines did have the youngest students and was one of the two countries with the fewest years of schooling.

Another important consideration in making comparisons in achievement is the variation in the proportion of students taking advanced mathematics in the final year of secondary school and included in the TIMSS Advanced 2008 mathematics population for the different countries. To quantify this difference among countries, TIMSS created the TIMSS Advanced 2008 coverage index presented in Exhibit 1.2. For ease of reference, the coverage index also is provided in Exhibit 2.1. For example, looking at the highest achieving countries, the Russian Federation included only 1.5 percent of its students in the TIMSS Advanced 2008 population from the possible population of all 17-year olds in the country. It seems rather surprising that such a highly selective population would produce such a wide range of scores. The Netherlands, on the other hand, included a slightly higher percentage of its age cohort of 18-year-old students in the assessed population (3.5%), and had a considerably narrower range of scale scores.

Exhibit 2.1 also contains each country's Human Development Index (HDI) value. The HDI was developed by the United Nations Development Programme, and is used in TIMSS and TIMSS Advanced 2008 to provide some context about the economic and educational development of the 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), Italy (0.941), Norway

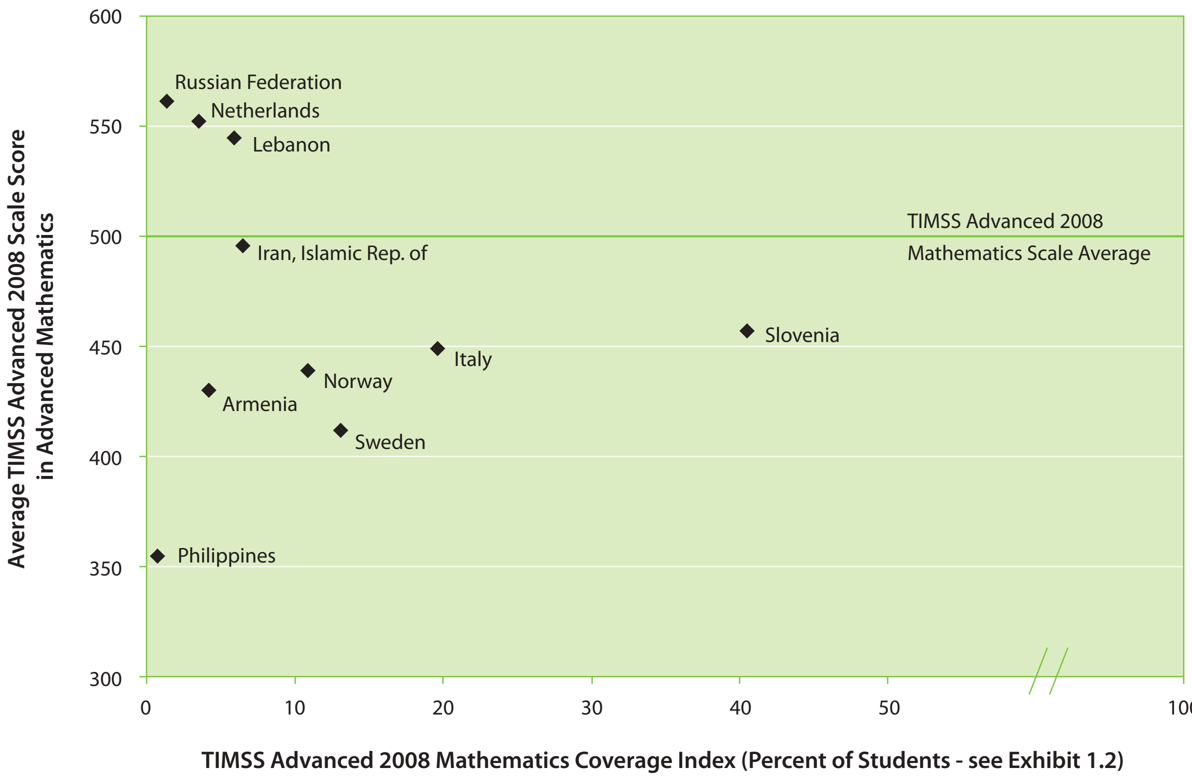
(0.968), and Sweden (0.956). With an index value of 0.813, just over the 0.8 borderline for the UNDP's high category, the Russian Federation also falls into the high category. However, four countries had index values in the 0.7 range and fall into the UNDP's medium category. Of the four countries, Armenia, Lebanon, and the Philippines had nearly identical HDIs (0.771–0.775), with that of Iran being only slightly lower (0.759). TIMSS results at the fourth and eighth grades have shown that while there is a positive relationship between having more country-wide resources and having higher average achievement in mathematics, the pattern is not always consistent[5] and this appears to be the case for TIMSS Advanced 2008 mathematics. There is little consistency across the 10 countries in the relationship between a country's HDI value and average achievement in advanced mathematics for the specialized groups of students that participated in TIMSS Advanced 2008. For example, average achievement for the countries with HDIs over 0.9 ranged from a high of 552 in the Netherlands to a low of 412 in Sweden, the Russian Federation with a 0.813 HDI was the top-performing country, and achievement for the countries with HDIs in the 0.7 range spanned nearly 200 scale-score points from a high of 545 in Lebanon to a low of 355 in the Philippines.

Because of the importance of the proportion of the age cohort covered when considering how countries performed on the TIMSS Advanced 2008 mathematics assessment, Exhibit 2.2 presents average mathematics achievement in relation to the TIMSS Advanced 2008 coverage index for mathematics. In the graph, countries are arranged along the horizontal axis in ascending order of their TIMSS Advanced 2008 mathematics coverage index, from a low of 0.7 percent in the Philippines to a high of 41 percent in Slovenia. Countries are arranged along the vertical axis in ascending order of their average TIMSS Advanced 2008 scale scores for mathematics,

5 Mullis, I.V.S. & Martin, M.O. (2007). Lessons learned from TIMSS. In T. Loveless (Ed.), *Lessons learned from international assessments*. Washington, DC: Brooking Institution.

Exhibit 2.2 **Average Achievement in Advanced Mathematics by TIMSS Advanced 2008 Coverage Index for Advanced Mathematics**

TIMSSAdvanced2008 Advanced Mathematics



SOURCE: IEA TIMSS Advanced 2008 ©

TIMSS Advanced 2008 Coverage Index for Advanced Mathematics

Country	Average Achievement	Coverage Index
Armenia	433	4.3%
Iran, Islamic Rep. of	497	6.5%
Italy	449	19.7%
Lebanon	545	5.9%
† Netherlands	552	3.5%
Norway	439	10.9%
Philippines	355	0.7%
Russian Federation	561	1.4%
Slovenia	457	40.5%
Sweden	412	12.8%

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

from a low of 355 in the Philippines to a high of 561 in the Russian Federation. The *x*-coordinate for the point corresponding to a given country, therefore, is the TIMSS Advanced coverage index for mathematics in that country, and the *y*-coordinate is the average scale score in mathematics. 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 2.2 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 advanced mathematics. Slovenia, with 41 percent of its population of final-year students assessed for TIMSS Advanced mathematics, is by far the farthest right followed by Italy with 20 percent. However, both had average mathematics achievement somewhat below the TIMSS scale average and in the middle of the participating countries. The three top performing countries—the Russian Federation, the Netherlands, and Lebanon—all included far smaller percentages of students than did Slovenia and Italy. However, looking at the three top-performing countries, each with somewhat successively lower achievement, it also can be seen that each also included a somewhat larger percentage of students in its TIMSS Advanced 2008 mathematics target population. Thus, taking the TIMSS Advanced 2008 Coverage Index into account, the results for the three countries could be considered even more similar than they appear to be looking only at average achievement.

Achievement on TIMSS Advanced 2008 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[6] 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 except the Philippines also participated in TIMSS 2007[7] and the Philippine data are available from TIMSS 2003, it is interesting to make some comparisons among countries' relative standings in mathematics 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 2.3 presents the average mathematics achievement in TIMSS 2007 and TIMSS Advanced for the TIMSS Advanced 2008 countries that participated in the mathematics assessment. For each assessment, countries are shown from highest to lowest average achievement, with symbols indicating statistically significant differences above or below the scale average.

6 Mullis, I.V.S., Martin, M.O., & Foy, P. (2008). *TIMSS 2007 international mathematics 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.

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

Exhibit 2.3 **Average Mathematics Achievement at Fourth and Eighth Grades* and in the Final Year of Secondary School for the TIMSS Advanced 2008 Countries**

TIMSSAdvanced 2008 Advanced Mathematics

TIMSS 2007 Mathematics – Fourth Grade			TIMSS 2007 Mathematics – Eighth Grade			TIMSS Advanced 2008 – Mathematics		
Country			Country			Country		
Russian Federation	544 (4.9)	▲	** Netherlands	536 (3.8)	▲	Russian Federation	561 (7.2)	▲
Netherlands	535 (2.1)	▲	Russian Federation	512 (4.1)	▲	Netherlands	552 (2.6)	▲
Italy	507 (3.1)	▲	Slovenia	501 (2.1)		Lebanon	545 (2.3)	▲
Sweden	503 (2.5)		TIMSS Scale Avg.	500		TIMSS Scale Avg.	500	
Slovenia	502 (1.8)		Armenia	499 (3.5)		Iran, Islamic Rep. of	497 (6.4)	
TIMSS Scale Avg.	500		Sweden	491 (2.3)	▼	Slovenia	457 (4.2)	▼
Armenia	500 (4.3)		Italy	480 (3.0)	▼	Italy	449 (7.2)	▼
Norway	473 (2.5)	▼	Norway	469 (2.0)	▼	Norway	439 (4.9)	▼
Iran, Islamic Rep. of	402 (4.1)	▼	Lebanon	449 (4.0)	▼	Armenia	433 (3.6)	▼
** Philippines	358 (7.9)	▼	Iran, Islamic Rep. of	403 (4.1)	▼	Sweden	412 (5.5)	▼
Lebanon	◊ ◊		** Philippines	378 (5.2)	▼	Philippines	355 (5.5)	▼

▲ Country average significantly higher than TIMSS scale average

▼ Country average significantly lower than TIMSS scale average

* TIMSS 2007 data taken from Mullis, I.V.S., Martin, M.O., & Foy, P. (2008). *TIMSS 2007 international mathematics 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 and the Philippines at fourth and eighth grade taken from Mullis, I.V.S., Martin, M.O., Gonzalez, E.J., & Chrostowski, S.J. (2004). *TIMSS 2003 international mathematics 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.

SOURCE: IEA TIMSS Advanced 2008 ©

The Russian Federation performed above the scale average in all three assessments—fourth grade, eighth grade, and the final year of secondary school. It appears to be doing a good job of educating all of its students through lower secondary school as well as making it possible for a small percentage of elite students (1.4%) to reach a high level of excellence in mathematics by their final year of secondary school. Although the Russian Federation had the smallest coverage index, its students had 10 or 11 years of school (compared to 12 or 13) and were among the youngest (17 years old). It is especially noteworthy that all Russian students study mathematics and physics every year in lower secondary and upper secondary education, and the students assessed by TIMSS Advanced 2008 were having 6 hours or more of mathematics instruction per week. Similarly, the Netherlands demonstrated high achievement in TIMSS 2007 at the fourth grade, in TIMSS 2003 at the eighth grade, and for their mathematics specialists (3.5% of the age cohort) in TIMSS Advanced 2008. Its mathematics specialists were in a pre-university track and had studied 6 years of mathematics, the last three of which were part of an advanced program.

Norway also had a consistent relative standing across the three assessments, although performance was below the scale average in all three, including for their advanced students (10.9% of the age cohort). Since Norway has the highest HDI, these relatively low results cannot be explained by lack of resources. At the fourth and eighth grades, the TIMSS 2007 Norwegian results may partially be explained by the fact that those students started school at a younger age than in some countries and had a correspondingly less demanding curriculum in their early years of schooling. However, the Norwegian students in TIMSS Advanced are among the oldest in the assessment and according to their teachers have covered the TIMSS Advanced assessment topics to a large extent. The Philippines also had below average results for the three populations of students, but its HDI value is among the lowest. Also, the Philippine students participating in TIMSS Advanced 2008 were among those with the fewest years of schooling, were the youngest, and according to their teachers had not been taught a considerable amount of the curriculum assessed.

Several countries had relatively lower achievement on TIMSS Advanced 2008 than on TIMSS 2007. Slovenia and Armenia performed at about the TIMSS scale average at the fourth and eighth grades, but below the scale average for TIMSS Advanced. Slovenia is a high HDI country and its students were in the 12th grade, averaging nearly 19 years old. However, it should be kept in mind that more than two fifths (41%) of the final-year students in Slovenia are being educated in advanced mathematics. Armenia's relative achievement for the students attending the special "physmat" schools (4.3%) in the final year of secondary school was relatively low, but Armenia is a middle HDI country and its TIMSS Advanced students were among those with the fewest years of schooling and less curriculum coverage, especially in calculus. Italy and Sweden performed close to the TIMSS scale average at the fourth grade, but below the TIMSS scale average at the eighth grade and also below the scale average on TIMSS Advanced 2008. Both of these countries have high HDI values and among the oldest students, but also relatively higher coverage indices with Sweden's advanced mathematics students comprising 13 percent of the age cohort and, in particular, Italy's advanced mathematics students comprising 20 percent of the age cohort.

Two countries, Lebanon and Iran, had relatively higher achievement on TIMSS Advanced 2008 than on TIMSS 2007. For both countries, the TIMSS Advanced 2008 students were in the 12th grade and just about 18 years old on average. Lebanon was one of the top-performing countries on TIMSS Advanced 2008, but this is in contrast to its TIMSS 2007 performance, which was below the TIMSS scale average at the eighth grade. Similarly, Iran performed at about the TIMSS Advanced 2008 scale average, in contrast to its performance in TIMSS 2007 of approximately 100 scale points below the TIMSS scale average at both the fourth and eighth grades. These two countries are facing a number of challenges that have likely impacted their TIMSS results, including socioeconomic difficulties (medium category HDIs). Nevertheless, as evidenced by their TIMSS Advanced 2008 results, these countries have educated select groups of students (about 6%) to relatively high levels of achievement in mathematics internationally.

Gender Differences in Advanced Mathematics Achievement in the Participating Countries

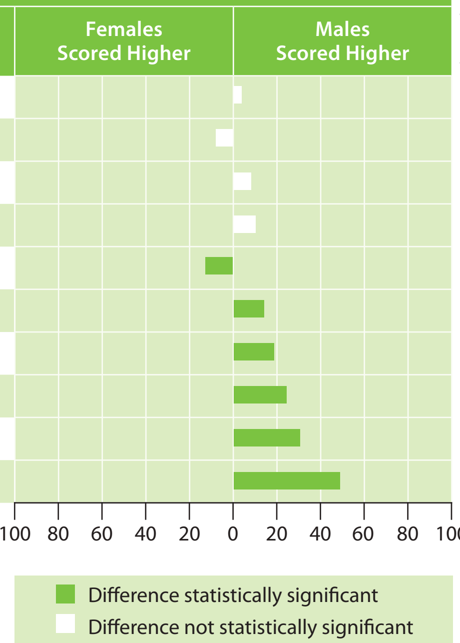
Exhibit 2.4 shows the percentages of girls and boys enrolled in advanced mathematics in each of the participating countries and their differences in mathematics achievement on TIMSS Advanced 2008. It presents average achievement separately for females and males for the TIMSS Advanced 2008 countries, 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.

Armenia was the only country with equivalent percentages of female students (52%) and male students (48%) taking advanced courses in mathematics, although the Russian Federation and Iran had nearly equivalent percentages (about 45% female and 55% male). The greatest imbalance was in the Netherlands, where 77% of the students

Exhibit 2.4 TIMSS Advanced 2008 Average Achievement in Advanced Mathematics by Gender

TIMSSAdvanced2008 Advanced Mathematics

Country	Percent of Students		Average Achievement		
	Females	Males	Females	Males	Absolute Difference
† Netherlands	23 (1.2)	77 (1.2)	549 (4.2)	553 (3.0)	4 (4.8)
Italy	34 (2.5)	66 (2.5)	454 (9.3)	446 (8.3)	8 (10.4)
Norway	38 (1.7)	62 (1.7)	434 (5.4)	442 (5.6)	8 (5.2)
Armenia	52 (2.0)	48 (2.0)	428 (4.8)	438 (6.1)	10 (8.2)
Lebanon	29 (1.6)	71 (1.6)	554 (3.2)	541 (2.7)	13 (3.7)
Sweden	40 (2.1)	60 (2.1)	404 (6.9)	418 (6.1)	14 (6.4)
Russian Federation	45 (1.8)	55 (1.8)	551 (7.7)	569 (7.4)	19 (5.1)
Slovenia	60 (1.8)	40 (1.8)	448 (5.3)	472 (4.3)	24 (5.2)
Iran, Islamic Rep. of	44 (1.6)	56 (1.6)	480 (6.7)	510 (10.1)	31 (12.1)
Philippines	63 (1.2)	37 (1.2)	337 (5.7)	386 (7.6)	49 (7.5)



SOURCE: IEA TIMSS Advanced 2008 ©

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

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

were male. Also, in Italy, Norway, Lebanon, and Sweden, from 60 to 66 percent of the students were male. In Slovenia and the Philippines, there was approximately a 60/40 split with the larger percentage of students being female.

In four countries, there was essentially no difference in average achievement in advanced mathematics between female students and male students. The four countries with equity in performance include the Netherlands, Italy, Norway, and Armenia. It can be noted that the Netherlands, the country with greatest imbalance in enrollment by gender, and Armenia, the country with least imbalance, are both included among the countries with no differences in average achievement by gender.

There were significant differences in achievement by gender in six of the participating countries, with the difference favoring males in five of them. Although females in Lebanon had significantly higher average scale scores than their male counterparts, male students had significantly higher average achievement in advanced mathematics in 5 of the 10 participating countries. In particular, the advantage for male students was rather large in the Philippines and Iran—almost 50 scale score points in the former, and about 30 in the latter.

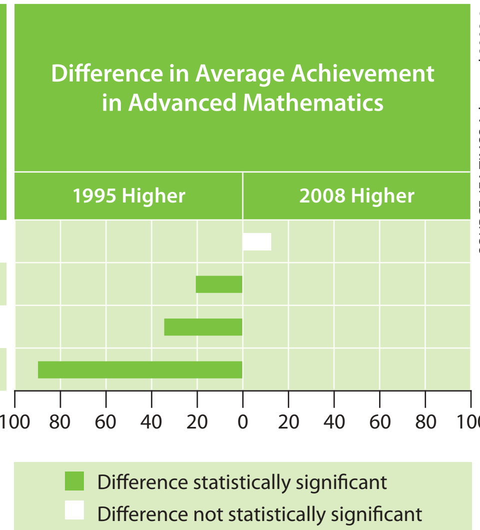
Changes in Advanced Mathematics Achievement Between 1995 and 2008

Exhibit 2.5 displays changes in average advanced mathematics 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 Italy and the Russian Federation in both assessments, but there were changes for the other two trend countries. Coverage was considerably less in 2008 for Slovenia than it was in 1995, decreasing

Exhibit 2.5 Trends in Average Achievement in Advanced Mathematics

TIMSSAdvanced2008 Advanced Mathematics

Countries	TIMSS Advanced Mathematics Coverage Index 2008	TIMSS Advanced Mathematics Coverage Index 1995	TIMSS Advanced 2008 Mathematics Average Scale Score	TIMSS Advanced 1995 Mathematics Average Scale Score*	Difference Between 1995 and 2008 Scores
Russian Federation	1.4%	2.0%	561 (7.2)	549 (7.7)	12 (10.6)
‡ Slovenia	40.5%	75.4%	457 (4.2)	478 (9.3)	–20 (10.2)
Italy	19.7%	20.2%	449 (7.2)	483 (10.8)	–34 (12.9)
Sweden	12.8%	16.2%	412 (5.5)	502 (5.6)	–89 (7.9)



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

( ) Standard errors appear in parentheses.

Exhibit 2.6 Trends in Average Achievement in Advanced Mathematics by Gender

TIMSSAdvanced2008 Advanced Mathematics

Country	Females: 2008 Average Scale Score	Females: 1995 to 2008 Difference	Males: 2008 Average Scale Score	Males: 1995 to 2008 Difference
Italy	454 (9.3)	–23 (15.7)	446 (8.3)	–41 (15.2) ▼
Russian Federation	551 (7.7)	25 (11.4) ▲	569 (7.4)	0 (11.3)
‡ Slovenia	448 (5.3)	–21 (12.5)	472 (4.3)	–14 (11.9)
Sweden	404 (6.9)	–88 (8.5) ▼	418 (6.1)	–88 (9.6) ▼

SOURCE: IEA TIMSS Advanced 2008 ©

▲ 2008 average significantly higher than 1995

▼ 2008 average significantly lower than 1995

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

( ) Standard errors appear in parentheses.

from about 75 to 41 percent, and coverage for Sweden also was reduced to some extent, from approximately 16 to 13 percent.

The participants are shown in the exhibit according to the difference between their average achievement in 1995 and 2008. In three of the four countries—Slovenia, Italy, and Sweden—average achievement in advanced mathematics declined significantly between the two assessments. Sweden showed the greatest average decline—almost 90 points. In the Russian Federation, average achievement in 2008 showed some signs of improvement but was not statistically different from that in 1995. The reasons underlying changes such as these in achievement over a substantial amount of time are difficult to pinpoint. For example, many cultural and educational factors could be involved, including changes in how the country organizes schooling, modifications in the advanced mathematics curriculum, and possibly changes in the characteristics and attitudes of the student population deciding to study advanced mathematics. Examining various hypotheses for the changes will take careful investigation and study.

Exhibit 2.6 shows changes in average achievement separately for females and males. Statistically significant decreases in achievement were found for male students in Italy and both groups in Sweden. It appears that the overall declines in achievement in advanced mathematics in Italy may be more related to greater declines by male students (41 points), on average, than by female students (23 points). In Sweden, both genders had equivalent decreases in average achievement (88 scale points). In Slovenia, the decrease in overall average achievement in 2008 compared to 1995 was related to non-statistically significant changes in a negative direction for both males and females.

Females in the Russian Federation had the only significant increase in average achievement between 1995 and 2008 (25 scale points). The improvement by female students in the Russian Federation appears to underlie the indication of improvement overall, since males showed absolutely no difference in achievement between assessments.

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

As described in the *TIMSS Advanced 2008 Assessment Frameworks*,[8] the advanced mathematics assessment was organized around two dimensions, a content dimension specifying the subject matter or content domains to be assessed in mathematics 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 mathematics assessment was associated with one content domain and one cognitive domain, providing for both content-based and cognitive-oriented perspectives on student achievement in mathematics.

This section presents average student performance in the three content domains of the advanced mathematics framework: algebra, calculus, and geometry. Average performance also is presented for each of three cognitive domains: knowing, applying, and reasoning. Knowing refers to the student's knowledge base of mathematical facts, concepts, tools, and procedures. Applying focuses on the student's ability to apply 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 three content domains and the three cognitive domains is summarized in Exhibit 2.7. The table shows the average percent correct for all of the advanced mathematics items for each country as well as within the six domains. Standard errors are shown in parentheses. This analysis by content and cognitive domains

8 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.

uses average percent correct rather than average scale scores because there were insufficient items in all of the different domains to develop reliable scales. The countries are listed in alphabetical order.

In Armenia, students did relatively better in the algebra content domain than they did overall and relatively less well in calculus. The result in calculus is consistent with the reports that Armenia covered fewer of the TIMSS Advanced calculus topics than the other participating countries. In the cognitive domains, Armenian students did relatively better in the knowing domain than they did overall and less well in the applying domain. Iranian students and Italian students had similar achievement patterns across domains, demonstrating consistency with their overall average achievement in the content domains, but relatively higher average achievement on the knowing items and lower average achievement on the applying items. Dutch students also had consistent performance across the content domains, but had relatively higher average achievement in the reasoning domains and relatively lower average achievement in knowing and applying. Students in Lebanon performed relatively better in geometry and less well in algebra, and better in knowing and less well in applying and reasoning. Compared to their overall average achievement, students in Norway, the Philippines, and Slovenia demonstrated relative weakness in the calculus domain and relative strength in the geometry domain. For the Philippines and to a lesser extent Slovenia, this is consistent with teacher reports that they did not feel well prepared to teach some calculus topics and some calculus topics were not taught to sizeable percentages of students. Norway had consistent performance across the cognitive domains, whereas the Philippines had relative strength in knowing and relative weakness in applying. Slovenia's relative strength was in knowing and relative weakness in applying. Students in the Russian Federation did comparatively better in the content domain

Exhibit 2.7 **Average Percent Correct in the Advanced Mathematics Content and Cognitive Domains**

TIMSSAdvanced 2008 Advanced Mathematics

Country	Advanced Mathematics (71 Items)	Advanced Mathematics Content Domains			Advanced Mathematics Cognitive Domains		
		Algebra (25 Items)	Calculus (25 Items)	Geometry (21 Items)	Knowing (27 Items)	Applying (27 Items)	Reasoning (17 Items)
Armenia	32 (0.7)	37 (0.8) ▲	27 (0.6) ▼	33 (0.8)	39 (0.7) ▲	27 (0.8) ▼	31 (0.8)
Iran, Islamic Rep. of	43 (1.4)	45 (1.5)	41 (1.4)	44 (1.4)	52 (1.3) ▲	36 (1.4) ▼	42 (1.7)
Italy	35 (1.1)	33 (1.2)	36 (1.3)	36 (1.1)	40 (1.1) ▲	31 (1.2) ▼	33 (1.3)
Lebanon	53 (0.5)	51 (0.6) ▼	53 (0.6)	55 (0.5) ▲	65 (0.5) ▲	43 (0.6) ▼	51 (0.6) ▼
† Netherlands	54 (0.5)	55 (0.5)	53 (0.6)	53 (0.6)	51 (0.5) ▼	51 (0.6) ▼	63 (0.6) ▲
Norway	33 (0.7)	33 (0.8)	30 (0.7) ▼	37 (0.7) ▲	34 (0.7)	33 (0.7)	32 (0.8)
Philippines	24 (0.6)	24 (0.9)	19 (0.5) ▼	31 (0.6) ▲	28 (0.7) ▲	21 (0.7) ▼	24 (0.6)
Russian Federation	57 (1.6)	62 (1.6) ▲	53 (1.6)	56 (1.6)	59 (1.4)	56 (1.7)	56 (1.7)
Slovenia	36 (0.7)	38 (0.7)	32 (0.8) ▼	38 (0.9) ▲	41 (0.8) ▲	34 (0.8)	33 (0.7) ▼
Sweden	31 (0.7)	32 (0.9)	28 (0.8) ▼	32 (0.6)	32 (0.8)	28 (0.7) ▼	34 (0.8) ▲

▲ Significantly higher than overall Advanced Mathematics percent correct
▼ Significantly lower than overall Advanced Mathematics percent correct

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

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

SOURCE: IEA TIMSS Advanced 2008 ©

of algebra than they did overall and otherwise their performance was consistent across both content and cognitive domains. Swedish students performed relatively less well in calculus but showed achievement in the other content domains consistent with their overall performance, which might be surprising considering that some of the geometry topics were not included in the curriculum. Across the cognitive domains, they showed relative weakness in applying and strength in reasoning.

Exhibit 2.8 presents the content and cognitive domain results by gender. The upper portion of the exhibit summarizes the results in the three content domains by gender; and the lower portion does the same for the three cognitive domains. Results for Italy show no significant differences in average achievement between females and males in any of the six content and cognitive domains. Also, Armenia, the Netherlands, and Norway had almost no differences in average achievement by gender; except males had higher average achievement than females in calculus and in applying in Armenia, higher average achievement in knowing in the Netherlands, and in reasoning in Norway.

As would be expected given the general advantage for males across the TIMSS Advanced assessment (see Exhibit 2.4), when there was a difference in achievement between genders, the male students typically had higher average achievement. In the Russian Federation, males had higher average achievement than females in geometry and in reasoning. In Sweden, males had higher average achievement than females in algebra and in reasoning.

Several countries had gender differences in most of the content areas. In the Philippines and in Slovenia, males had significantly higher average scores than females in all six areas—the three content domains and the three cognitive domains. In Iran, males had significantly higher average achievement than females in all except the knowing

Exhibit 2.8 **Average Percent Correct in the Advanced Mathematics Content and Cognitive Domains by Gender**

TIMSSAdvanced2008 Advanced Mathematics

Country	Average Percent Correct for Advanced Mathematics Content Domains					
	Algebra		Calculus		Geometry	
	Females	Males	Females	Males	Females	Males
Armenia	36 (0.9)	39 (1.4)	25 (0.8)	31 (0.9) ▲	33 (1.0)	34 (1.5)
Iran, Islamic Rep. of	40 (1.7)	49 (2.3) ▲	37 (1.6)	44 (2.1) ▲	39 (1.6)	47 (2.2) ▲
Italy	32 (1.6)	34 (1.4)	37 (1.9)	35 (1.4)	35 (1.8)	36 (1.2)
Lebanon	53 (1.1) ▲	50 (0.7)	56 (1.0) ▲	53 (0.6)	56 (0.8) ▲	54 (0.7)
Netherlands	54 (1.0)	55 (0.6)	52 (1.2)	53 (0.7)	52 (1.3)	54 (0.6)
Norway	32 (0.9)	34 (0.9)	29 (0.7)	30 (0.9)	37 (0.8)	37 (0.8)
Philippines	22 (0.7)	29 (1.5) ▲	17 (0.5)	22 (0.9) ▲	29 (0.6)	34 (0.9) ▲
Russian Federation	60 (1.7)	64 (1.6)	51 (2.0)	54 (1.5)	54 (1.7)	59 (1.6) ▲
Slovenia	36 (0.8)	41 (1.1) ▲	31 (0.9)	34 (1.0) ▲	36 (1.0)	42 (1.1) ▲
Sweden	30 (0.9)	34 (1.2) ▲	27 (1.2)	28 (0.9)	31 (0.8)	33 (0.8)

Country	Average Percent Correct for Advanced Mathematics Cognitive Domains					
	Knowing		Applying		Reasoning	
	Females	Males	Females	Males	Females	Males
Armenia	38 (0.9)	40 (1.4)	26 (0.9)	32 (1.5) ▲	31 (1.1)	32 (1.1)
Iran, Islamic Rep. of	50 (1.6)	53 (2.0)	31 (1.5)	40 (2.2) ▲	35 (1.8)	47 (2.6) ▲
Italy	40 (1.7)	40 (1.3)	31 (1.7)	31 (1.3)	32 (2.2)	34 (1.4)
Lebanon	68 (0.8) ▲	64 (0.5)	46 (1.0) ▲	42 (0.8)	50 (1.2)	51 (0.7)
† Netherlands	49 (1.0)	51 (0.6) ▲	50 (1.2)	51 (0.6)	62 (1.1)	63 (0.6)
Norway	35 (0.8)	34 (0.8)	33 (0.7)	33 (0.9)	29 (1.0)	34 (0.9) ▲
Philippines	26 (0.6)	31 (1.0) ▲	19 (0.5)	24 (1.1) ▲	22 (0.5)	28 (1.4) ▲
Russian Federation	58 (1.7)	60 (1.4)	54 (1.8)	57 (1.8)	52 (1.8)	60 (1.6) ▲
Slovenia	39 (0.9)	42 (1.0) ▲	32 (1.0)	36 (1.0) ▲	29 (0.8)	38 (1.1) ▲
Sweden	30 (1.0)	33 (0.9)	27 (0.8)	28 (0.9)	31 (1.1)	36 (1.1) ▲

▲ Significantly higher than other gender

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

( ) Standard errors appear in parentheses.

SOURCE: IEA TIMSS Advanced 2008 ©

cognitive domain. In contrast, in Lebanon, females had higher average achievement than males in all except the reasoning domain.

Looking across countries, males had higher average achievement in each of the content domains in four countries compared to one country for females—Lebanon in each case. However, the countries where males had higher average achievement than females varied from content domain to content domain. Similarly, males had higher achievement than females in the knowing domain in three countries and in the applying domain in four countries compared to females having higher achievement in only one country—again, Lebanon in both cases. From the perspective of achieving gender equity in advanced mathematics achievement, perhaps of greatest concern is the finding that male students had higher average achievement than female students in the reasoning domain in 6 out of the 10 countries and females did not have higher average achievement than males in reasoning in any of the countries.

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Chapter 3

Mathematics Performance at the TIMSS Advanced 2008 International Benchmarks

As was described more fully in the Introduction, the TIMSS advanced mathematics achievement scale summarizes students' performance on test items designed to measure breadth of content in algebra, geometry, and calculus, as well as a range of cognitive processes within the knowing, applying, and reasoning domains. To interpret the achievement results in meaningful ways, it is important to understand the relationship between scores on the scale and students' success on the content of the assessment. As a way of interpreting the scaled results, three points on the scale were identified as international benchmarks and descriptions of student achievement at those benchmarks in relation to students' performance on the test items were developed. The TIMSS Advanced benchmarks represent the range of performance shown by students internationally. The Advanced International Benchmark is 625, the High International Benchmark is 550, and the Intermediate International Benchmark is 475. In TIMSS at the fourth and eighth grade levels, four benchmarks were used: viz., advanced, high, intermediate, and low. The low international benchmark was not included in the TIMSS Advanced benchmarking analysis since, in all the participating countries, this is a highly select population of students.

The TIMSS & PIRLS International Study Center worked with a committee of experts[1] from several countries to conduct a detailed scale anchoring analysis to describe mathematics achievement at these benchmarks. Scale anchoring is a way of describing TIMSS Advanced 2008 performance at different points on the advanced mathematics scale in terms of the types of items students answered correctly. In addition to a data analysis component to identify items that discriminated between successive points on the scale,[2] the analysis also involved a judgmental component in which committee members examined the mathematics content and cognitive processing dimensions assessed by each item and generalized to describe students' knowledge and understandings.

This chapter presents the TIMSS Advanced 2008 mathematics achievement results at the international benchmarks for the participating countries. Then, benchmark by benchmark, there is a detailed description of the understanding of mathematics content and types of cognitive processing skills and strategies demonstrated by students at each of the international benchmarks, together with illustrative items. For each example item, the percent correct for each of the TIMSS Advanced 2008 participants is shown. For multiple-choice items, the correct answer is identified by a bullet, •, and the percent of students in each country who chose each response choice is also given. For constructed-response items, a copy of the scoring guide showing the percent of students choosing each correct or incorrect approach is provided, along with a student response that was given full credit.[3] The items published in this report were selected from the items released for public use.[4] Every effort was made to include examples which not

1 In addition to Robert A. Garden, the TIMSS Advanced Mathematics Coordinator, and Svein Lie, the TIMSS Physics Coordinator, committee members included Carl Angell, Wolfgang Dietrich, Liv Sissel Gronmo, Torgeir Onstad, and David F. Robitaille.

2 For example, in brief, a multiple-choice item anchored at the Advanced International Benchmark if at least 65 percent of students scoring at 625 answered the item correctly and fewer than 50 percent of students scoring at the High International Benchmark (550) answered correctly, and so on, for each successively lower benchmark. Since constructed-response questions nearly eliminate guessing, the criterion for the constructed-response items was simply 50 percent at the particular benchmark. For more information, see the *TIMSS Advanced 2008 Technical Report*.

3 All of the constructed-response items were scored according to detailed scoring guides containing descriptions and examples of the types of responses that should receive credit. Although most constructed-response items were worth 1 point, some were worth 2 points (with 1 point awarded for partial credit). If the example item was worth 2 points, the data are for responses receiving 2 points (full credit).

4 After each TIMSS assessment, a certain proportion of the items are released into the public domain and the rest of the items are kept secure for use in measuring trends over time in subsequent assessments. In the case of TIMSS Advanced, more than one-half of the items are being released.

only illustrated the particular benchmark under discussion, but also represented different item formats and content area domains.

How Do Countries Compare on the TIMSS Advanced 2008 International Benchmarks of Mathematics Achievement?

Exhibit 3.1 summarizes what students of advanced mathematics in the participating countries who score at the TIMSS international benchmarks typically know and can do in mathematics. The data show that that there were substantial differences in students' performance across the three benchmarks. Students at the Advanced International Benchmark demonstrated their understanding of concepts, mastery of procedures, and mathematical reasoning skills in algebra, trigonometry, geometry, and differential and integral calculus to solve problems in complex contexts. Students at the High International Benchmark used their knowledge of mathematical concepts and procedures in algebra, calculus, and geometry and trigonometry to analyze and solve multi-step problems set in routine and non-routine contexts. Those at the Intermediate International Benchmark demonstrated knowledge of concepts and procedures in algebra, calculus, and geometry.

Exhibit 3.2 displays the percent of advanced mathematics students in each country that reached each of the three international benchmarks. The percents displayed in each row corresponding to the three international benchmarks are cumulative. Every student who scored at the Advanced Benchmark is also included in the High and Intermediate Benchmark categories.

For each country, the exhibit shows the percent of advanced mathematics students who reached each international benchmark as well as the TIMSS Advanced Mathematics Coverage Index for that country (see Exhibit 1.2). In the table, the countries are listed in descending order of the percent of their students who reached the

Exhibit 3.1 **TIMSS Advanced 2008 International Benchmarks of Mathematics Achievement**

TIMSSAdvanced2008 Advanced Mathematics

SOURCE: IEA TIMSS Advanced 2008 ©

Advanced International Benchmark – 625

Summary

Students demonstrate their understanding of concepts, mastery of procedures, and mathematical reasoning skills in algebra, trigonometry, geometry, and differential and integral calculus to solve problems in complex contexts.

In algebra, students can solve word problems involving permutations and geometric sequences, and solve logarithmic equations. They demonstrate some facility with complex numbers and can find sums of infinite geometric series. In calculus, students demonstrate understanding of the concept of integration. They can integrate exponential functions, recognize the relationship between a definite integral and the area under a curve, and solve problems about areas between curves. They can identify from the graph of a function points where it is not differentiable. They can determine maxima, minima, and points of inflection of a function by analyzing the graph of its derivative or by finding the first and second derivatives. They can solve problems in kinematics, and find the maximum value of a quantity under given conditions. Students use geometric reasoning to solve problems. They can use trigonometric ratios to solve a non-routine practical problem, and demonstrate knowledge of the concepts of period and amplitude of trigonometric functions. They use vector sums and differences to express a relationship among three vectors. In the Cartesian plane, they can determine whether lines are parallel, show that the diagonals of a given quadrilateral bisect each other, and find the locus of points satisfying a given condition.

High International Benchmark – 550

Summary

Students can use their knowledge of mathematical concepts and procedures in algebra, calculus, and geometry and trigonometry to analyze and solve multi-step problems set in routine and non-routine contexts.

Students can solve algebra problems that require analysis, including problems set in a practical context and problems requiring interpretation of information related to functions and their graphs. They can determine a term in a geometric sequence, compare two simple mathematical models, solve quadratic inequalities, and analyze a proposed solution of a simple logarithmic equation. In calculus, students can analyze properties of functions and their graphs on the basis of the sign of the first and second derivatives. They can find the derivative of a function involving radicals. They can find definite and indefinite integrals of simple rational functions. In geometry, students can use basic properties of trigonometric functions to identify solutions of simple trigonometric equations and solve word problems involving angle of elevation. They can identify the equation of a line or a circle in the Cartesian plane, and use slopes of lines to solve problems. They can use properties of vectors to analyze equivalence of conditions involving the sum and difference of two vectors.

Exhibit 3.1 **TIMSS Advanced 2008 International Benchmarks of Mathematics Achievement (Continued)**

TIMSSAdvanced 2008
Advanced Mathematics

Intermediate International Benchmark – 475

Summary

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

Students can perform basic operations of algebra, including solving equations and inequalities, and simplifying polynomial and rational expressions. They can determine the sign of a rational function and find the function of a function in simple cases. In calculus, students show an understanding of the concepts of continuity and limit of a rational function. They can find the derivative of simple rational, exponential, and trigonometric functions. They can make connections between the graph of a function and the derivative of the function. Students use knowledge of basic properties of geometric figures and of the Cartesian plane to solve problems. They can add and subtract vectors in coordinate form. They can draw the image of a polygon under a reflection, and identify the shape traced by a line rotating in space.

SOURCE: IEA TIMSS Advanced 2008 ©

Exhibit 3.2 **Percent of Students Reaching the TIMSS Advanced 2008 International Benchmarks of Mathematics Achievement**

TIMSSAdvanced 2008 Advanced Mathematics

Country	Percent of Students Reaching the International Benchmarks			TIMSS Advanced Mathematics Coverage Index
	Advanced Benchmark (625)	High Benchmark (550)	Intermediate Benchmark (475)	
Russian Federation	24 (2.9)	55 (3.2)	83 (2.2)	1.4%
Iran, Islamic Rep. of	11 (1.8)	29 (3.0)	56 (2.8)	6.5%
Lebanon	9 (1.2)	47 (1.9)	88 (1.3)	5.9%
† Netherlands	6 (0.8)	52 (2.8)	95 (1.1)	3.5%
Italy	3 (1.0)	14 (2.0)	41 (3.0)	19.7%
Slovenia	3 (0.5)	14 (1.4)	41 (2.4)	40.5%
Armenia	2 (0.8)	13 (1.6)	33 (2.0)	4.3%
Norway	1 (0.4)	9 (1.0)	35 (2.2)	10.9%
Sweden	1 (0.4)	9 (1.2)	29 (1.9)	12.8%
Philippines	1 (0.3)	4 (0.7)	13 (1.5)	0.7%

SOURCE: IEA TIMSS Advanced 2008 ©

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

( ) Standard errors appear in parentheses.

Exhibit 3.3 **Trends in Percent of Students Reaching the TIMSS Advanced 2008 International Benchmarks of Mathematics Achievement**

TIMSSAdvanced 2008 Advanced Mathematics

Country	TIMSS Advanced Mathematics Coverage Index		Percent of Students Reaching the International Benchmarks					
			Advanced International Benchmark (625)		High International Benchmark (550)		Intermediate International Benchmark (475)	
	2008	1995	2008 Percent of Students	1995 Percent of Students	2008 Percent of Students	1995 Percent of Students	2008 Percent of Students	1995 Percent of Students
Russian Federation	1.4%	2.0%	24 (2.9)	22 (3.1)	55 (3.2)	51 (3.5)	83 (2.2)	78 (2.7)
Italy	19.7%	20.2%	3 (1.0)	5 (2.2)	14 (2.0)	22 (5.0)	41 (3.0) ▼	59 (4.9)
Slovenia	40.5%	75.4%	3 (0.5)	5 (1.3)	14 (1.4) ▼	23 (3.5)	41 (2.4) ▼	54 (4.5)
Sweden	12.8%	16.2%	1 (0.4) ▼	6 (1.4)	9 (1.2) ▼	30 (3.3)	29 (1.9) ▼	64 (3.1)

SOURCE: IEA TIMSS Advanced 2008 ©

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

( ) Standard errors appear in parentheses.

Advanced Benchmark. As might be expected, given that it had the highest mathematics achievement average, the Russian Federation had the greatest percentage of students (24%) reaching the Advanced International Benchmark. Next came Iran with 11 percent, then Lebanon with 9 percent, and the Netherlands with 6 percent. It is noteworthy that relatively more students reached the Advanced Benchmark in Iran and the Lebanon than in the Netherlands, even though average achievement was higher in the Netherlands. This is a reflection of the relatively narrow range of achievement in the Netherlands, evident in Exhibit 2.1, compared to most other participating countries. A more positive consequence of the Netherlands narrow achievement range is that it had the highest percentage of students (95%) reaching the Intermediate Benchmark.

The percent of students who scored at the Intermediate Benchmark ranges from a low of 13 percent in the Philippines to a high of 95 percent in the Netherlands. Results for Slovenia and Italy indicate that countries with a comparatively high TIMSS Advanced Mathematics Coverage Index are still able to obtain strong performance from many of their students. These results show that a system-wide policy of allowing a larger proportion of students to enroll in advanced courses in mathematics does not necessarily have a negative impact on overall students' performance. It can provide opportunities for further study in mathematics-related specialty areas to more students. In all of these kinds of comparisons, it is important to bear in mind the potential impact of the Mathematics Coverage Index on performance levels.

On the one hand, these students—the very best mathematics students in their respective countries—found the TIMSS advanced mathematics test to be challenging. In six countries the percent of students reaching the Advanced Benchmark was 3 percent or less. On the other hand, in six countries, more than 40 percent of students reached at least the Intermediate Benchmark which, as shown in Exhibit 3.1, means that those students demonstrated knowledge of the concepts and procedures in algebra, calculus, and geometry assessed by TIMSS Advanced 2008.

Exhibit 3.3 presents changes in the percent of students reaching the benchmarks between 1995 and 2008 for the four countries that participated in both studies. Countries are ranked in descending order of the percent of students who reached the Advanced International Benchmark. The display also shows the TIMSS Advanced Mathematics Coverage Index for each country in the 1995 and 2008 assessments. Over that period, the index declined in all four countries. The most dramatic drop in the Coverage Index occurred in Slovenia: from 75 percent coverage in 1995 to 40 percent in 2008.

The results reflect the overall changes in achievement for the four countries, with all experiencing declines since 1995 except the Russian Federation, which evidenced little, if any, change (see Exhibit 2.4). No country showed a significant improvement in the percent of students reaching any of the three international benchmarks. However, there were several significant declines. Sweden experienced declines at all three benchmarks even though the population appears to have become more specialized between 1995 and 2008. Also, Slovenia, with the broadest population coverage but still greatly reduced in scope compared to 1995, had significantly fewer students reaching the High and Intermediate Benchmarks. Italy had declines at the Intermediate Benchmark.

Mathematics: Achievement at the Advanced International Benchmark

The *TIMSS Advanced 2008 Assessment Frameworks* called for an almost equal partitioning of the items to be included in the advanced mathematics assessment among the three content domains: 35 percent for algebra, 35 percent for calculus, and 30 percent for geometry.

According to the framework, the algebra content domain includes much of the algebra and functions content that provides the foundation for mathematics at the college or university level. Students should be able to use properties of the real and complex number systems to solve problems set in real-world contexts or in abstract, mathematical ones. They should have facility in investigating basic characteristics of sequences and series, and skill in manipulating and using combinations and permutations. The ability to work with a variety of equations is fundamental for such students, providing a means of operating with mathematical concepts at an abstract level. The concept of function is an important unifying idea in mathematics, and students should be familiar with it.

Since the calculus content of national and system-level advanced mathematics curricula varies considerably across countries, the calculus content for TIMSS Advanced Mathematics 2008 was limited to material likely to be included in final year mathematics in almost all the participating countries. The focus was on understanding limits and finding the limit of a function, differentiation and integration of a range of functions, and using these skills in solving problems.

The TIMSS geometry items related to four strands or topics: Euclidean geometry (traditional or transformation), analytic geometry, trigonometry, and vectors. Euclidean geometry and analytic geometry have been important components of the secondary mathematics curriculum for centuries, and are still widely viewed as important prerequisites for the study of mathematics at the university level. Trigonometry is part of the mathematics curriculum in all countries, but not always as part of the geometry domain. Transformation geometry and vectors are more recent additions to the mathematics curriculum in many countries, and there is considerable variation both in the amount of emphasis given to them across countries, as well as the degree of rigor with which the area is approached. The TIMSS items related to these two areas dealt with fairly elementary topics.

In the algebra domain, the framework specifies that students should recognize representations of functions and be able to solve various kinds of equations, including quadratic equations. Exhibit 3.4 presents an algebra item likely to be solved correctly by students performing at the Advanced International Benchmark. In this example (Example Item 1), students were asked to find the numerical coefficients of a quadratic function having been given its graph and its x- and y-intercepts. An example of a correct solution to this constructed-response item is shown in the exhibit. According to the information provided in Chapter 1 on the topics that were in the intended curriculum and taught to the students (Exhibit 1.13), all countries included polynomial equations and functions in their curriculum, and taught these topics (except function of a function in the Philippines) to their students. Nevertheless, students found this item difficult, and this was true for all of the items that anchored at the Advanced Benchmark. The percent of students receiving full credit ranged from a high of 64 in Lebanon to a low of 8 in Sweden. After Lebanon, the next highest result was 39 percent correct in the Russian Federation.

The scoring guide for Example Item 1 shows the five correct- and the four incorrect-response categories used by the item scorers as well as the non-response category. Also shown are the percents of students in each category in each country. Category 13 refers to the use of a graphing calculator to find the coefficients of the equation. The total percent correct for a given country is the sum across the various correct-response categories.

The most frequently used correct solution method for Example 1, in every country except Armenia, was using simultaneous linear equations in three variables (*a, b,* and *c*) given three pairs of values for *x* and *f(x)*. The other four correct approaches were used by very few students. Non-response rates for this item ranged from a low of 10 percent in Lebanon, the country with the highest score on the item, to 55 percent in Sweden, 63 percent in Norway, and 70 percent in Armenia. The category 72 indicates that many students in some countries were able to find the value of the constant term, *c*, but not of *a* or *b*.

Exhibit 3.5 shows an example multiple-choice item from the calculus domain that anchored at the Advanced Benchmark (Example Item 2). The item was designed to test students' understanding of the definite integral, and the alternatives were chosen to reflect common errors or misconceptions. Students had to realize that the definite integral was not simply the sum of the three shaded areas, but the "signed" or algebraic sum, where the value of area B was negative. Not surprisingly, the incorrect response most frequently chosen in most countries was 7.6, the sum of the absolute values of the three areas identified on the graph.

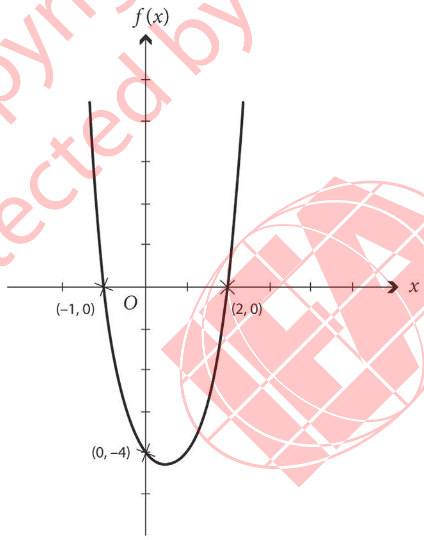
The percent correct in every country was rather low, and there was not as much variation in the proportion of students selecting the correct response across countries as was the case with many other items. The highest performance on this item was 46 percent in the Islamic Republic of Iran and 41 percent correct in the Russian Federation. About one-third of the students responded correctly in the Netherlands, Lebanon, and Slovenia. Understandably, the lowest

Exhibit 3.4 **TIMSS Advanced 2008 Advanced International Benchmark (625) of Mathematics Achievement – Example Item 1**

TIMSSAdvanced2008 Advanced Mathematics

Content Domain: Algebra

Description: Determines the coefficients of a quadratic function given the points of intersection between the graph and the axes



The graph of the function *f* is shown above. The equation of the function *f* is given by $f(x) = ax^2 + bx + c$. Find the values of *a*, *b*, and *c*.

Show your work.

$f(x) = ax^2 + bx + c$

$(0,-4)$
$(-1,0)$
$(2,0)$

$-4 = a(0)^2 + b(0) + c$

$\boxed{c = -4}$

$0 = a(-1)^2 + b(-1) + -4$

$a - b = 4 \rightarrow a = b + 4$

$0 = a(2)^2 + b(2) - 4$

$4a + 2b = 4$

$4(b+4) + 2b = 4$

$4b + 16 + 2b = 4$

$6b = -12$

$\boxed{b = -2}$

$a = -2 + 4$

$\boxed{a = 2}$

The answer shown is an example of a student response that was scored as correct

Country	Percent Correct
Lebanon	64 (2.9)
Russian Federation	39 (2.7)
Slovenia	32 (2.5)
Iran, Islamic Rep. of	32 (2.7)
Italy	22 (2.8)
† Netherlands	16 (1.8)
Armenia	16 (2.7)
Norway	10 (1.6)
Philippines	9 (1.7)
Sweden	8 (1.8)

SOURCE: IEA TIMSS Advanced 2008 ©

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

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

Exhibit 3.4 **TIMSS Advanced 2008 Advanced International Benchmark (625) of Mathematics Achievement – Example Item 1 (Continued)**

TIMSSAdvanced 2008 Advanced Mathematics

Scoring Guide

Code	Response	Item: MA23141
	Correct Student Responses	
10	$a = 2$, $b = -2$, $c = -4$ using factorization	
11	All values correct by solving three simultaneous equations	
12	All values correct using calculator to solve simultaneous equations	
13	All values correct using calculator for quadratic regression	
19	All values correct by other correct method.	
	Incorrect Student Responses	
70	Calculator used but incorrect or explanation inadequate	
71	All values correct but no correct method shown.	
72	$c = -4$ with values of a and b missing or incorrect.	
79	Other incorrect	
NR	No Response	

SOURCE: IEA TIMSS Advanced 2008 ©

Country	Percent of Students in Each Scoring Guide Category									
	Correct Student Responses					Incorrect Student Responses				
	10	11	12	13	19	70	71	72	79	NR
Lebanon	8 (1.7)	54 (2.9)	2 (0.7)	0 (0.2)	1 (0.4)	1 (0.6)	17 (2.1)	0 (0.0)	7 (1.6)	10 (1.7)
Russian Federation	1 (0.4)	31 (2.7)	0 (0.0)	0 (0.0)	6 (1.2)	0 (0.0)	2 (0.8)	14 (1.8)	14 (1.2)	31 (2.7)
Slovenia	8 (2.0)	24 (2.3)	0 (0.0)	0 (0.0)	1 (0.4)	0 (0.0)	0 (0.3)	28 (2.4)	23 (2.1)	16 (2.1)
Iran, Islamic Rep. of	1 (0.4)	29 (2.6)	0 (0.0)	0 (0.0)	1 (0.5)	0 (0.0)	1 (0.5)	12 (1.6)	15 (1.9)	40 (2.9)
Italy	7 (1.6)	14 (2.4)	0 (0.1)	0 (0.0)	0 (0.0)	0 (0.3)	1 (0.4)	12 (2.1)	7 (1.1)	58 (3.5)
† Netherlands	1 (0.6)	11 (1.8)	0 (0.0)	1 (0.7)	2 (0.7)	1 (0.6)	2 (0.7)	30 (2.2)	27 (2.6)	23 (2.1)
Armenia	8 (2.4)	6 (2.1)	0 (0.0)	0 (0.0)	1 (0.7)	0 (0.0)	0 (0.0)	5 (2.0)	10 (3.0)	70 (3.2)
Norway	1 (0.4)	1 (0.5)	0 (0.1)	6 (1.5)	1 (0.5)	2 (0.7)	1 (0.4)	9 (1.5)	15 (1.4)	63 (3.1)
Philippines	2 (0.5)	7 (1.3)	0 (0.1)	0 (0.0)	0 (0.0)	0 (0.2)	0 (0.1)	8 (1.0)	49 (2.3)	34 (2.5)
Sweden	2 (0.6)	5 (1.4)	0 (0.4)	0 (0.3)	0 (0.3)	0 (0.3)	0 (0.0)	18 (2.0)	19 (1.8)	55 (2.5)

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

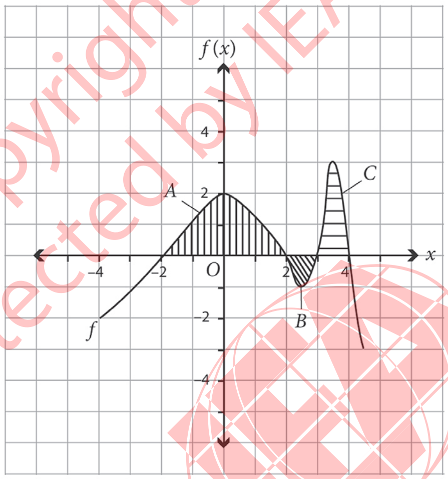
( ) Standard errors appear in parentheses. Because results are rounded to the nearest whole number, some totals may appear inconsistent.

Exhibit 3.5 **TIMSS Advanced 2008 Advanced International Benchmark (625) of Mathematics Achievement – Example Item 2**

TIMSSAdvanced 2008 Advanced Mathematics

Content Domain: Calculus

Description: Calculates the definite integral given the graph of a function and the areas between the curve and the x-axis



For the areas between the graph of $f(x)$ and the x-axis shown above, area $A = 4.8$ units, area $B = 0.8$ units, and area $C = 2$ units.

What is the value of the definite integral $\int_{-2}^{4} f(x)dx$?

Ⓐ 5.6

● 6.0

Ⓒ 6.8

Ⓓ 7.6

Country	Percent Correct
Iran, Islamic Rep. of	46 (3.1)
Russian Federation	41 (3.3)
† Netherlands	36 (2.6)
Lebanon	35 (2.7)
Slovenia	32 (2.7)
Italy	26 (2.8)
Sweden	26 (1.7)
Norway	23 (1.9)
Philippines	23 (1.8)
Armenia	18 (3.2)

SOURCE: IEA TIMSS Advanced 2008 ©

Country	Percent of Students				
	A	B Correct Response	C	D	NR*
Iran, Islamic Rep. of	3 (0.5)	46 (3.1)	6 (1.1)	12 (1.6)	32 (2.5)
Russian Federation	5 (0.8)	41 (3.3)	14 (1.4)	29 (2.2)	11 (1.3)
† Netherlands	4 (1.1)	36 (2.6)	13 (1.5)	30 (2.8)	18 (2.3)
Lebanon	3 (0.6)	35 (2.7)	7 (1.3)	36 (2.1)	19 (2.0)
Slovenia	3 (0.7)	32 (2.7)	15 (1.7)	28 (3.5)	21 (2.1)
Italy	5 (1.2)	26 (2.8)	14 (2.0)	20 (2.3)	34 (3.2)
Sweden	11 (1.1)	26 (1.7)	21 (1.8)	20 (1.9)	21 (2.1)
Norway	4 (1.1)	23 (1.9)	19 (2.4)	36 (2.3)	18 (1.6)
Philippines	12 (1.6)	23 (1.8)	24 (1.5)	35 (1.8)	6 (0.9)
Armenia	7 (1.9)	18 (3.2)	14 (2.9)	9 (2.3)	53 (3.7)

* No Response

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

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

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performance (18%) was in Armenia where this topic is not included in the advanced curriculum. Non-response rates for this item ranged from a low of 6 percent in the Philippines to a high of 53 percent in Armenia.

The third example of an item that anchored at the Advanced Benchmark comes from the geometry domain and is shown in Exhibit 3.6. Example Item 3 required students to solve a multi-step word problem involving trigonometric ratios to identify the length of a side of a regular polygon inscribed in a circle. All participants included trigonometry in their intended curriculum, and teachers reported teaching these topics to nearly all students in their advanced mathematics classes (94–100%). The problem was posed in a situation that was practical, yet novel for most students.

The best performance on this item was in the Russian Federation where 40 percent of students selected the correct response. In 6 of the 10 countries, the average percent correct was at the chance level, 25 percent, or lower. One method of solving this problem would be to drop a perpendicular bisector from the center of the circle to the base of the triangle formed by a pair of adjacent radii and one of the windows. The perpendicular divides the triangle into two right triangles, and the length of the base of each of those triangles is $r \sin 9°$. A second method would involve the use of the sine law.

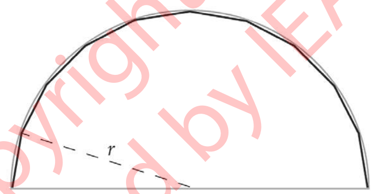
Non-response rates for this item were quite low in most countries, and response C was the most common incorrect response in all countries except the Islamic Republic of Iran. All three alternatives attracted significant numbers of students in all countries.

Exhibit 3.6 **TIMSS Advanced 2008 Advanced International Benchmark (625) of Mathematics Achievement – Example Item 3**

TIMSSAdvanced2008 Advanced Mathematics

Content Domain: Geometry

Description: Solves a multi-step word problem involving trignometric ratios to identify the length of a side of a regular polygon inscribed in a circle



The figure shows a semicircular room seen from above. An architect is placing 10 flat windows in the room as shown. If the radius of the circle is r, which of the following equations would allow the architect to determine the width of each window?

Ⓐ $w = r \sin 9°$

● $w = 2r \sin 9°$

Ⓒ $w = r \cos 18°$

Ⓓ $w = 2r \sin 18°$

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Country	Percent Correct
Russian Federation	40 (2.4)
† Netherlands	36 (2.7)
Iran, Islamic Rep. of	28 (2.4)
Slovenia	26 (2.0)
Lebanon	25 (2.5)
Italy	22 (2.5)
Sweden	22 (1.7)
Philippines	21 (1.4)
Armenia	20 (3.1)
Norway	18 (1.8)

SOURCE: IEA TIMSS Advanced 2008 ©

Country	Percent of Students				
	A	B Correct Response	C	D	NR*
Russian Federation	10 (1.3)	40 (2.4)	25 (1.8)	22 (1.7)	3 (0.6)
† Netherlands	8 (1.4)	36 (2.7)	32 (2.4)	22 (2.2)	2 (0.8)
Iran, Islamic Rep. of	11 (1.5)	28 (2.4)	15 (1.9)	22 (2.1)	24 (1.9)
Slovenia	10 (1.1)	26 (2.0)	40 (2.1)	20 (2.0)	4 (1.1)
Lebanon	11 (1.6)	25 (2.5)	29 (2.4)	22 (2.6)	13 (1.8)
Italy	12 (2.0)	22 (2.5)	28 (2.5)	21 (1.8)	16 (3.0)
Sweden	10 (1.4)	22 (1.7)	42 (2.2)	22 (1.7)	4 (0.8)
Philippines	21 (1.5)	21 (1.4)	36 (1.5)	21 (1.4)	1 (0.3)
Armenia	9 (2.8)	20 (3.1)	26 (3.3)	18 (2.4)	27 (2.8)
Norway	13 (1.5)	18 (1.8)	42 (1.9)	22 (1.9)	4 (1.0)

* No Response

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

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

Mathematics: Achievement at the High International Benchmark

Exhibit 3.7 shows a multiple-choice item from the algebra domain that anchored at the High International Benchmark. Example Item 4 required students to identify which of four given graphs represented the relationship between the volume of a sphere and its diameter. Performance on this item was best in the Netherlands, where 60 percent of students recognized that the correct response was the only one showing that the volume of a sphere increases monotonically without an upper bound in a non-linear fashion as its diameter increases. In more than half of the countries, the percent of students responding correctly was below 40 percent. The three alternatives all attracted significant numbers of students, and the non-response rates were quite low: 7 percent or less in 9 countries and 13 percent in Armenia.

Example Item 5, shown in Exhibit 3.8, is from the calculus domain and also anchored at the High International Benchmark. This constructed-response item showed students the graph of a trigonometric function and asked why the slopes of the tangent to the graph at two given points were equal. In order to answer the item correctly, students had to know that the slope of the tangent to a curve is given by the first derivative of the function. Then they had to calculate the derivative of the given function, , and know the values of sin π and sin 2π. It is not possible to tell from the incorrect response categories for this item what specific kinds of errors students made most frequently.

Students from the Netherlands had the best result on this item (53% correct, and only 3% non-response), but there was a considerable range across countries and the percent correct in six countries was less than 25. Referencing Exhibit 1.14 from Chapter 1, it can be seen that although all participants included derivatives in the intended

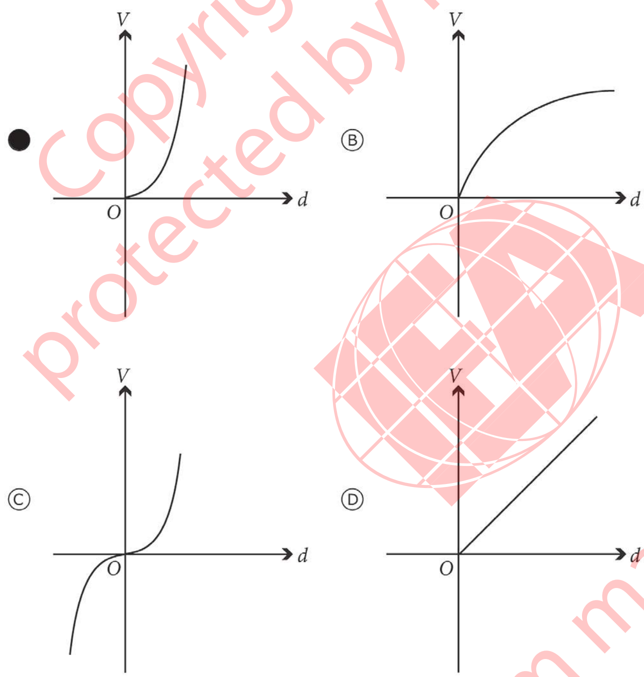
Exhibit 3.7 **TIMSS Advanced 2008 High International Benchmark (550) of Mathematics Achievement – Example Item 4**

TIMSS Advanced 2008
Advanced Mathematics

Content Domain: Algebra

Description: Identifies the graph that represents the relationship between the volume of a sphere and its diameter

A spherical balloon is blown up. Which graph shows the volume V as a function of the diameter d?



Country	Percent Correct
† Netherlands	60 (2.8)
Russian Federation	49 (2.7)
Iran, Islamic Rep. of	47 (2.9)
Sweden	42 (2.9)
Italy	38 (2.9)
Norway	37 (2.3)
Philippines	34 (2.0)
Armenia	31 (3.6)
Lebanon	30 (2.2)
Slovenia	29 (2.3)

SOURCE: IEA TIMSS Advanced 2008 ©

Country	Percent of Students				
	A Correct Response	B	C	D	NR*
† Netherlands	60 (2.8)	21 (1.8)	10 (1.6)	9 (1.5)	0 (0.0)
Russian Federation	49 (2.7)	9 (1.6)	15 (2.4)	25 (1.8)	1 (0.4)
Iran, Islamic Rep. of	47 (2.9)	10 (1.6)	19 (2.0)	17 (2.1)	7 (1.3)
Sweden	42 (2.9)	27 (2.7)	9 (1.2)	21 (1.7)	2 (0.6)
Italy	38 (2.9)	17 (2.0)	10 (2.1)	30 (2.3)	5 (1.2)
Norway	37 (2.3)	23 (2.0)	16 (1.9)	23 (1.7)	1 (0.4)
Philippines	34 (2.0)	21 (1.4)	11 (1.2)	33 (1.8)	1 (0.3)
Armenia	31 (3.6)	29 (3.6)	14 (2.9)	13 (2.3)	13 (1.7)
Lebanon	30 (2.2)	31 (2.5)	13 (1.9)	19 (2.1)	7 (1.3)
Slovenia	29 (2.3)	29 (2.3)	7 (1.6)	34 (2.0)	1 (0.5)

* No Response

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

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

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curriculum, this topic was not always covered in the implemented curriculum, with about 81 percent of the students in Lebanon taught the topic, about two-thirds in Armenia and Slovenia, and about half in the Philippines. Non-response rates varied widely across countries, and in Italy and Armenia more than 60 percent of students failed to provide an answer to this item.

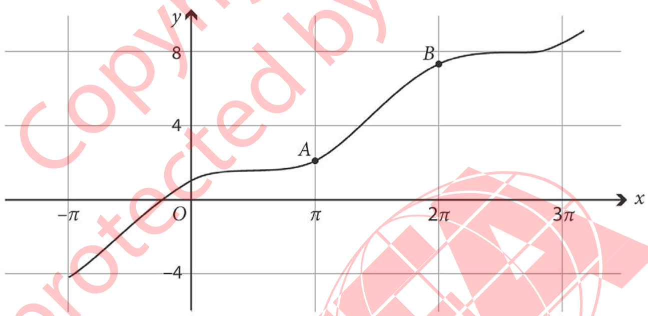
The third example of an item that anchored at the High Benchmark, Example Item 6, is from the geometry domain and is shown in Exhibit 3.9. To solve this multiple-choice item, students had to be familiar with some basic properties of the slopes of lines. Again, students from the Netherlands had the best performance on this item with 75 percent responding correctly. For 6 of the 10 countries, the percentage responding correctly was above 50 percent. Responses C and D were the most frequently chosen incorrect responses.

Exhibit 3.8 **TIMSS Advanced 2008 High International Benchmark (550) of Mathematics Achievement – Example Item 5**

TIMSSAdvanced2008 Advanced Mathematics

Content Domain: Calculus

Description: Justifies a statement about slopes at two points on the graph of a trigonometric function



Sophia is studying the graph of the function $y = x + \cos x$ shown above. She says that the slope at point A is the same as the slope at point B. Explain why she is correct.

$\text{SLOPE} = \frac{dy}{dx} = 1 - \sin x$

$= 1 - \sin \pi$

$= 1 - 0 = 1$

AT 2π = $1 - \sin x$

$= 1 - \sin 2\pi$

$= 1 - 0 = 1$

SOPHIA IS CORRECT AS SLOPE OF THIS FUNCTION IS 1 AT BOTH POINT A AND POINT B.

The answer shown is an example of a student response that was scored as correct

Country	Percent Correct
† Netherlands	53 (2.7)
Lebanon	48 (2.7)
Iran, Islamic Rep. of	45 (2.8)
Russian Federation	39 (3.3)
Sweden	22 (2.5)
Italy	19 (2.7)
Armenia	18 (2.7)
Slovenia	10 (1.5)
Norway	9 (1.2)
Philippines	2 (1.0)

SOURCE: IEA TIMSS Advanced 2008 ©

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

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

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Exhibit 3.8 **TIMSS Advanced 2008 High International Benchmark (550) of Mathematics Achievement – Example Item 5 (Continued)**

TIMSSAdvanced2008 Advanced Mathematics

Scoring Guide

Code	Response	Item: MA23198
	Correct Student Responses	
10	Differentiates or uses the cosine function to show gradient the same at $x = \pi$ and $x = 2\pi$	
11	Correct answer using calculator	
	Incorrect Student Responses	
70	Calculator used—answer incorrect or explanation inadequate	
71	Differentiates correctly—explanation inadequate	
79	Other incorrect	
NR	No Response	

SOURCE: IEA TIMSS Advanced 2008 ©

Country	Percent of Students in Each Scoring Guide Category					
	Correct Student Responses		Incorrect Student Responses			
	10	11	70	71	79	NR
† Netherlands	52 (2.9)	0 (0.5)	0 (0.0)	3 (0.9)	41 (2.8)	3 (0.8)
Lebanon	48 (2.7)	0 (0.0)	3 (0.7)	0 (0.0)	33 (2.4)	16 (2.4)
Iran, Islamic Rep. of	45 (2.8)	0 (0.0)	1 (0.6)	1 (0.4)	38 (2.6)	15 (1.7)
Russian Federation	39 (3.3)	0 (0.0)	0 (0.0)	2 (0.5)	37 (2.1)	22 (2.3)
Sweden	21 (2.5)	0 (0.1)	0 (0.4)	4 (0.6)	56 (2.3)	19 (1.9)
Italy	18 (2.8)	1 (0.0)	0 (0.0)	2 (0.8)	11 (1.5)	69 (3.2)
Armenia	18 (2.7)	0 (0.0)	0 (0.0)	1 (0.0)	20 (3.0)	61 (3.9)
Slovenia	10 (1.5)	0 (0.0)	0 (0.0)	2 (0.5)	64 (2.4)	24 (2.5)
Norway	9 (1.2)	0 (0.0)	0 (0.0)	1 (0.4)	61 (2.2)	30 (2.5)
Philippines	2 (1.0)	0 (0.0)	0 (0.0)	0 (0.0)	71 (1.8)	27 (1.6)

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

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

Exhibit 3.9 **TIMSS Advanced 2008 High International Benchmark (550) of Mathematics Achievement – Example Item 6**

TIMSSAdvanced 2008 Advanced Mathematics

Content Domain: Geometry

Description: Finds the sum of the slopes of the three sides of an equilateral triangle with one side along the x-axis

One side of an equilateral triangle lies along the x-axis. The sum of the slopes of the three sides is

- ● 0
- Ⓑ -1
- Ⓒ 1
- Ⓓ $2\sqrt{3}$
- Ⓔ $1+2\sqrt{3}$

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Country	Percent Correct
† Netherlands	75 (1.5)
Iran, Islamic Rep. of	61 (2.3)
Lebanon	54 (2.0)
Slovenia	53 (2.0)
Russian Federation	52 (2.5)
Norway	51 (2.1)
Sweden	45 (1.8)
Italy	42 (2.3)
Armenia	33 (2.2)
Philippines	29 (1.7)

SOURCE: IEA TIMSS Advanced 2008 ©

Country	Percent of Students				
	A Correct Response	B	C	D	NR*
† Netherlands	75 (1.5)	1 (0.5)	6 (0.9)	10 (1.1)	4 (0.6)
Iran, Islamic Rep. of	61 (2.3)	2 (0.5)	6 (0.9)	9 (1.0)	4 (0.7)
Lebanon	54 (2.0)	3 (0.5)	9 (1.1)	17 (1.5)	7 (0.9)
Slovenia	53 (2.0)	3 (0.6)	18 (1.4)	14 (1.6)	5 (0.7)
Russian Federation	52 (2.5)	3 (0.6)	11 (1.0)	22 (1.5)	6 (0.9)
Norway	51 (2.1)	1 (0.4)	18 (1.7)	14 (1.1)	6 (0.9)
Sweden	45 (1.8)	6 (0.8)	21 (1.5)	13 (1.3)	7 (0.7)
Italy	42 (2.3)	3 (0.5)	10 (1.0)	15 (1.5)	6 (0.7)
Armenia	33 (2.2)	6 (1.2)	11 (1.5)	19 (2.6)	9 (1.9)
Philippines	29 (1.7)	4 (0.4)	21 (1.2)	26 (1.2)	19 (1.3)

* No Response

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

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

Mathematics: Achievement at the Intermediate International Benchmark

Example Item 7, shown in Exhibit 3.10, is taken from the algebra domain. This constructed-response item required students to solve an inequality involving a rational expression in one variable. All countries included inequalities in their curricula, and teachers reported that nearly all students had been taught this topic (96–100%). In the Russian Federation, 80 percent of students responded correctly. In half the countries, the percent of students providing correct responses was greater than 50. Students were not required to show their work, and it is not possible to tell from the scoring guide how students attempted to solve the inequality.

The calculus item shown in Exhibit 3.11 is a constructed-response item requiring students to find the derivative of a rational function (Example Item 8). To find this derivative, students had to know and be able to apply the quotient rule. Students in several countries performed very well on this item, with the best performance being registered in Lebanon with 91 percent of students obtaining full credit for the item. Approximately three fourths of the Iranian and Russian students as well as two thirds of the Slovenian students also received full credit. On the other hand, students in Norway, the Philippines, and Sweden found the item much more difficult. The most frequent incorrect response in several countries was based on an attempt to use the quotient rule for differentation, but doing so incorrectly.

Example Item 9, a multiple-choice item shown in Exhibit 3.12, is taken from the geometry domain. One way to solve this problem is to visualize or draw a right triangle, and recall that the vertices of a right triangle can be inscribed in a circle with the hypotenuse, being the diameter of the circumcircle. This means that T, the mid-point of

Exhibit 3.10 **TIMSS Advanced 2008 Intermediate International Benchmark (475) of Mathematics Achievement – Example Item 7**

TIMSSAdvanced 2008
Advanced Mathematics

Content Domain: Algebra

Description: Solves a rational inequality with linear numerator and denominator

$$\frac{x+1}{x-2} > 1$$

For which values of x is the inequality shown above satisfied?

Answer: $x > 2$

The answer shown is an example of a student response that was scored as correct

Country	Percent Correct
Russian Federation	80 (1.8)
Armenia	74 (2.6)
Italy	60 (3.7)
Iran, Islamic Rep. of	54 (2.5)
Lebanon	51 (2.4)
† Netherlands	47 (2.4)
Sweden	30 (2.4)
Slovenia	26 (2.6)
Norway	16 (1.7)
Philippines	15 (1.7)

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

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

Exhibit 3.10 **TIMSS Advanced 2008 Intermediate International Benchmark (475) of Mathematics Achievement – Example Item 7 (Continued)**

TIMSSAdvanced 2008 Advanced Mathematics

Scoring Guide

Code	Response	Item: MA23135
	Correct Student Response	
10	$x > 2$	
	Incorrect Student Responses	
79	Incorrect	
NR	No Response	

SOURCE: IEA TIMSS Advanced 2008 ©

Country	Percent of Students in Each Scoring Guide Category		
	Correct Student Response	Incorrect Student Responses	
	10	79	NR
Russian Federation	80 (1.8)	19 (1.7)	1 (0.4)
Armenia	74 (2.6)	21 (2.1)	4 (1.3)
Italy	60 (3.7)	34 (3.3)	7 (1.4)
Iran, Islamic Rep. of	54 (2.5)	42 (2.5)	4 (0.9)
Lebanon	51 (2.4)	46 (2.3)	3 (1.0)
† Netherlands	47 (2.4)	48 (2.5)	5 (1.2)
Sweden	30 (2.4)	60 (2.2)	10 (1.4)
Slovenia	26 (2.6)	71 (2.7)	3 (1.1)
Norway	16 (1.7)	64 (2.1)	20 (2.0)
Philippines	15 (1.7)	78 (1.6)	8 (0.9)

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

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

Exhibit 3.11 **TIMSS Advanced 2008 Intermediate International Benchmark (475) of Mathematics Achievement – Example Item 8**

TIMSSAdvanced 2008 Advanced Mathematics

Content Domain: Calculus

Description: Differentiates a rational function where the numerator and denominator are both linear

Find $f'(x)$, when $f(x) = \frac{3x+2}{x-1}$.

Show your work.

$$f'(x) = \frac{(x-1)\frac{d}{dx}(3x+2) - (3x+2)\frac{d}{dx}(x-1)}{(x-1)^2}$$

$$= \frac{3(x-1) - (3x+2)(1)}{(x-1)^2}$$

$$= \frac{\cancel{3x} - 3 - \cancel{3x} - 2}{(x-1)^2}$$

$$f'(x) = \frac{-5}{(x-1)^2}$$

The answer shown is an example of a student response that was scored as correct

Country	Percent Correct
Lebanon	91 (1.6)
Iran, Islamic Rep. of	79 (2.2)
Russian Federation	75 (2.4)
Slovenia	67 (2.1)
Italy	60 (3.4)
Armenia	56 (3.6)
† Netherlands	48 (2.9)
Norway	29 (2.1)
Philippines	21 (2.1)
Sweden	20 (1.8)

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

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

Exhibit 3.11 **TIMSS Advanced 2008 Intermediate International Benchmark (475) of Mathematics Achievement – Example Item 8 (Continued)**

TIMSSAdvanced 2008 Advanced Mathematics

Scoring Guide

Code	Response	Item: MA23159
	Correct Student Responses	
10	$f'(x) = \dfrac{-5}{(x-1)^2}$ using $\left(\dfrac{u}{v}\right)' = \dfrac{(u'v - uv')}{v^2}$ or, $(uv)' = u'v + uv'$	
11	Correct expression using calculator	
	Incorrect Student Responses	
70	Calculator used—answer incorrect or explanation inadequate	
71	Correct answer—no working shown	
72	Using quotient rule but no correct expression	
73	Using product rule but no correct expression	
79	Other incorrect	
NR	No Response	

Note: Students were instructed that if they used a calculator they were to explain how and for what it was used.

SOURCE: IEA TIMSS Advanced 2008 ©

Country	Percent of Students in Each Scoring Guide Category							
	Correct Student Responses		Incorrect Student Responses					
	10	11	70	71	72	73	79	NR
Lebanon	91 (1.6)	0 (0.0)	0 (0.2)	4 (1.1)	0 (0.0)	0 (0.0)	4 (1.0)	1 (0.6)
Iran, Islamic Rep. of	79 (2.2)	0 (0.0)	0 (0.0)	0 (0.1)	10 (1.2)	0 (0.0)	9 (1.7)	2 (0.9)
Russian Federation	75 (2.4)	0 (0.0)	0 (0.0)	0 (0.0)	8 (1.7)	0 (0.0)	14 (2.1)	3 (0.6)
Slovenia	67 (2.1)	0 (0.0)	0 (0.0)	0 (0.0)	10 (1.3)	0 (0.0)	21 (1.7)	3 (0.8)
Italy	60 (3.4)	0 (0.1)	0 (0.0)	0 (0.0)	11 (1.6)	0 (0.0)	17 (2.7)	13 (2.1)
Armenia	55 (3.6)	2 (1.0)	1 (0.6)	0 (0.0)	2 (1.1)	0 (0.0)	25 (3.3)	15 (2.0)
† Netherlands	48 (2.9)	0 (0.0)	0 (0.0)	0 (0.0)	40 (2.9)	4 (1.1)	7 (1.3)	1 (0.4)
Norway	29 (2.2)	0 (0.3)	0 (0.2)	0 (0.0)	33 (3.0)	0 (0.0)	30 (2.9)	8 (1.4)
Philippines	21 (2.1)	0 (0.0)	0 (0.0)	0 (0.0)	10 (1.2)	0 (0.0)	57 (2.3)	12 (1.6)
Sweden	19 (1.7)	0 (0.2)	0 (0.0)	0 (0.0)	19 (2.0)	3 (0.9)	48 (2.3)	10 (1.4)

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

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

Exhibit 3.12 **TIMSS Advanced 2008 Intermediate International Benchmark (475) of Mathematics Achievement – Example Item 9**

TIMSSAdvanced2008 Advanced Mathematics

Content Domain: Geometry

Description: Uses properties of an isosceles right triangle to determine the length of a given median

Triangle PQR is an isosceles right triangle with a right angle at P. If PT is a median of the triangle, then PT has the same length as

Ⓐ PR

Ⓑ PQ

Ⓒ QR

● QT

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Country	Percent Correct
Lebanon	90 (1.4)
Russian Federation	87 (1.3)
† Netherlands	79 (1.7)
Iran, Islamic Rep. of	74 (1.8)
Italy	65 (2.2)
Slovenia	63 (2.0)
Armenia	60 (2.5)
Norway	49 (1.8)
Philippines	47 (1.8)
Sweden	41 (1.2)

SOURCE: IEA TIMSS Advanced 2008 ©

Country	Percent of Students				
	A	B	C	D Correct Response	NR*
Lebanon	2 (0.5)	3 (0.7)	3 (0.7)	90 (1.4)	2 (0.5)
Russian Federation	4 (0.7)	3 (0.5)	5 (0.7)	87 (1.3)	1 (0.3)
† Netherlands	4 (0.8)	4 (0.8)	10 (1.2)	79 (1.7)	4 (0.7)
Iran, Islamic Rep. of	5 (0.8)	5 (0.7)	7 (0.9)	74 (1.8)	10 (1.1)
Italy	7 (1.0)	11 (1.5)	8 (1.1)	65 (2.2)	9 (1.4)
Slovenia	10 (1.2)	11 (1.3)	13 (1.0)	63 (2.0)	4 (0.8)
Armenia	8 (1.5)	9 (1.4)	13 (1.8)	60 (2.5)	10 (1.3)
Norway	10 (0.8)	14 (1.4)	18 (1.2)	49 (1.8)	9 (0.9)
Philippines	19 (1.1)	17 (1.2)	17 (1.1)	47 (1.8)	1 (0.2)
Sweden	11 (1.0)	15 (1.3)	25 (1.1)	41 (1.2)	8 (1.0)

* No Response

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

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

the hypotenuse, *QR*, is the center of the circumscribed circle and that, since *PT* and *QT* are radii of that circle, they must be of equal length. The percent of students choosing the correct response to this item was at least 60 in 7 of the 10 participating countries, and in no country was the percent correct less than 40. The best results were in Lebanon (90%) and the Russian Federation (87%), and approximately three-fourths of the Dutch and Iranian students answered correctly. Non-response rates were quite low, and incorrect responses were distributed across the three alternatives.

Chapter 4

Mathematics Students' Backgrounds and Attitudes

The advanced mathematics that is the focus of this report is learned only through sustained study throughout the years of schooling; and it is the school context, including the curriculum, school and classroom resources, and instruction in the classroom that is the main object of study by TIMSS. Nonetheless, previous IEA studies of mathematics achievement[1] have shown that student achievement is related to home environment among students at fourth and eighth grades, and that students from advantaged homes have higher achievement than their less advantaged classmates. As evidenced by the TIMSS Advanced Mathematics Coverage Index presented in earlier chapters, the students taking the advanced mathematics courses assessed by TIMSS Advanced are clearly a select group in every country, and presumably among the most able students of their age cohort. Even in such a select group, however, it is likely that a positive relationship between home environment and mathematics achievement exists. Since information on such factors can be very important in interpreting the achievement results, this chapter summarizes students' reports on aspects of their home environments, how they spend their out of school time, computer use, preparation for examinations, attitudes toward mathematics, and expectations for further study.

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

Home Environments Supportive of Advanced Mathematics Achievement

Successive cycles of TIMSS and PIRLS have shown that students from homes well-endowed with literacy resources have higher achievement in mathematics, science, and reading than students from less advantaged homes. Exhibit 4.1, which presents students' reports about the number of books in their homes, shows that this is true of students taking advanced mathematics in their final year of secondary school also. The exhibit shows, for each TIMSS Advanced 2008 participating country, the percentage of students in five categories of book ownership, *more than 200 books, 101–200 books, 26–100 books, 11–25 books,* and *0–10 books*, together with their average mathematics achievement and changes in percentages since 1995.

As shown in the exhibit, and in line with differences in the Human Development Index described in Chapter 2, there was a range of book ownership across countries, from Norway and Sweden where 50 percent or more of students reported having more than 200 books at home to Lebanon with 11 percent and the Philippines with 6 percent. Compared with 1995, there was a pronounced downward trend in book ownership in 2008, with three of the four trend countries—the Russian Federation, Slovenia, and Sweden—showing decreases in the percentages of students from homes with many books (more than 200) and increases in the percentages from homes with fewer books (100 or less). Although the relationship is not identical in every country, in general there was a positive association between the number of books in the home and average achievement on the TIMSS advanced mathematics assessment. The relationship was most pronounced in Italy and Sweden, where the difference in average achievement between students from homes in the highest category of book ownership (more

Exhibit 4.1 **Books in the Home with Trends**

TIMSSAdvanced2008
Advanced Mathematics

Country	More than 200 Books			101–200 Books			26–100 Books		
	2008 Percent of Students	Average Achievement	Difference in Percent from 1995	2008 Percent of Students	Average Achievement	Difference in Percent from 1995	2008 Percent of Students	Average Achievement	Difference in Percent from 1995
Armenia	30 (2.1)	444 (5.1)	◊ ◊	22 (1.9)	462 (8.3)	◊ ◊	27 (1.9)	426 (6.9)	◊ ◊
Iran, Islamic Rep. of	19 (1.4)	528 (10.8)	◊ ◊	14 (1.0)	500 (10.5)	◊ ◊	28 (1.1)	499 (6.1)	◊ ◊
Italy	33 (2.1)	475 (7.1)	3 (3.5)	18 (1.2)	460 (9.4)	−7 (3.8)	27 (1.3)	438 (7.8)	−4 (3.3)
Lebanon	11 (0.7)	566 (5.2)	◊ ◊	12 (0.8)	559 (5.4)	◊ ◊	31 (1.2)	548 (3.7)	◊ ◊
Netherlands	36 (1.9)	556 (2.9)	◊ ◊	21 (1.0)	555 (4.1)	◊ ◊	26 (1.4)	549 (3.2)	◊ ◊
Norway	52 (1.6)	454 (4.8)	◊ ◊	21 (1.1)	438 (5.5)	◊ ◊	16 (1.0)	424 (5.9)	◊ ◊
Philippines	6 (0.8)	387 (17.3)	◊ ◊	12 (0.7)	377 (10.9)	◊ ◊	38 (1.3)	371 (5.3)	◊ ◊
Russian Federation	38 (1.5)	575 (6.5)	−8 (2.6) ▼	31 (1.0)	561 (8.5)	−2 (2.0)	25 (1.1)	548 (8.9)	6 (2.0) ▲
Slovenia	21 (1.3)	467 (7.7)	−9 (2.5) ▼	25 (0.9)	461 (6.4)	−6 (2.3) ▼	38 (1.2)	456 (4.5)	5 (2.8) ▲
Sweden	50 (1.6)	439 (5.7)	−8 (2.5) ▼	19 (0.9)	410 (7.9)	−4 (1.9) ▼	19 (1.1)	379 (7.0)	5 (1.6) ▲

Country	11–25 Books			0–10 Books		
	2008 Percent of Students	Average Achievement	Difference in Percent from 1995	2008 Percent of Students	Average Achievement	Difference in Percent from 1995
Armenia	13 (1.3)	418 (10.0)	◊ ◊	7 (1.2)	376 (14.4)	◊ ◊
Iran, Islamic Rep. of	26 (1.2)	486 (6.1)	◊ ◊	13 (1.1)	465 (8.1)	◊ ◊
Italy	16 (1.1)	420 (10.6)	2 (2.6)	7 (0.8)	400 (15.7)	5 (1.0) ▲
Lebanon	26 (0.9)	542 (4.6)	◊ ◊	20 (1.0)	523 (3.8)	◊ ◊
Netherlands	12 (0.9)	552 (3.8)	◊ ◊	5 (0.6)	544 (8.2)	◊ ◊
Norway	7 (0.8)	387 (16.3)	◊ ◊	4 (0.5)	406 (14.7)	◊ ◊
Philippines	31 (1.0)	336 (6.6)	◊ ◊	13 (1.0)	323 (9.2)	◊ ◊
Russian Federation	6 (0.6)	525 (11.3)	3 (0.8) ▲	1 (0.2)	~ ~	0 (0.3)
Slovenia	14 (0.9)	448 (7.0)	8 (1.2) ▲	3 (0.4)	428 (15.4)	2 (0.6) ▲
Sweden	8 (0.8)	371 (14.1)	4 (1.3) ▲	4 (0.6)	362 (12.9)	4 (0.6) ▲

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

Data provided by students.

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

A diamond (◊) indicates the country did not participate in the 1995 assessment.
A tilde (~) indicates insufficient data to report achievement.

SOURCE: IEA TIMSS Advanced 2008 ©

than 200 books) and students from the lowest category (0–10 books) was 75 scale-score points or more in both countries. In contrast, the average achievement difference between students from the highest and lowest categories of book ownership in the Netherlands was just 12 score points.

In 5 of the 10 participating countries—Armenia, Italy, the Netherlands, the Russian Federation, and Slovenia—almost all of the students assessed by TIMSS Advanced (96% or more) reported that they always or almost always spoke the language of the TIMSS advanced mathematics test at home, and in Norway and Sweden the percentages were 94 and 93, respectively (see Exhibit 4.2). Among countries with large majorities of students routinely speaking the language of the test at home and with enough data to support a comparison—these include the Netherlands, Norway, the Russian Federation, and Sweden—average mathematics achievement was usually lower among students speaking the language of the test sometimes or never at home than among those speaking it more frequently.

In Iran, 80 percent of the advanced mathematics students reported always or almost always speaking Farsi, the language of the test, and 20 percent sometimes or never. In Lebanon, where the TIMSS Advanced assessment was administered in French while Arabic is the language of everyday life for most people, only 10 percent of students reported speaking French frequently at home. Mathematics achievement was somewhat lower (13–15 scale-score points) among those reporting never speaking French at home compared to those who sometimes or always spoke it. In the Philippines, TIMSS Advanced was administered in English as the language of instruction for advanced academics, although only 15 percent of the students assessed reported speaking English frequently at home. Average mathematics

Exhibit 4.2 **Students Speak Language of the Test at Home with Trends**

TIMSSAdvanced 2008 Advanced Mathematics

Country	Always or Almost Always			Sometimes			Never		
	2008 Percent of Students	Average Achievement	Difference in Percent from 1995	2008 Percent of Students	Average Achievement	Difference in Percent from 1995	2008 Percent of Students	Average Achievement	Difference in Percent from 1995
Armenia	97 (0.9)	436 (3.7)	◊ ◊	2 (0.9)	~ ~	◊ ◊	1 (0.2)	~ ~	◊ ◊
Iran, Islamic Rep. of	80 (2.3)	498 (7.1)	◊ ◊	10 (1.4)	473 (12.7)	◊ ◊	9 (1.4)	509 (12.1)	◊ ◊
Italy	99 (0.2)	449 (7.2)	2 (0.8) ▲	1 (0.2)	~ ~	−3 (0.8) ▼	0 (0.1)	~ ~	0 (0.2)
Lebanon	10 (0.8)	547 (5.7)	◊ ◊	66 (1.4)	549 (2.7)	◊ ◊	24 (1.3)	534 (4.1)	◊ ◊
Netherlands	96 (0.6)	553 (2.7)	◊ ◊	3 (0.4)	532 (8.9)	◊ ◊	1 (0.3)	~ ~	◊ ◊
Norway	94 (0.5)	442 (5.1)	◊ ◊	5 (0.5)	411 (13.9)	◊ ◊	1 (0.3)	~ ~	◊ ◊
Philippines	15 (1.0)	371 (10.0)	◊ ◊	81 (1.1)	350 (5.4)	◊ ◊	4 (0.3)	402 (11.4)	◊ ◊
Russian Federation	97 (0.8)	562 (7.3)	−3 (0.8) ▼	3 (0.6)	527 (14.7)	2 (0.6) ▲	1 (0.3)	~ ~	0 (0.4)
Slovenia	97 (0.4)	460 (4.3)	0 (0.6)	2 (0.4)	~ ~	0 (0.5)	1 (0.2)	~ ~	0 (0.3)
Sweden	93 (1.0)	418 (5.4)	−3 (1.3) ▼	6 (0.8)	355 (13.0)	2 (1.1) ▲	2 (0.4)	~ ~	1 (0.5)

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

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

A diamond (◊) indicates the country did not participate in the 1995 assessment.
A tilde (~) indicates insufficient data to report achievement.

SOURCE: IEA TIMSS Advanced 2008 ©

Exhibit 4.3 **Students and Parents Born in the Country with Trends**

TIMSSAdvanced 2008 Advanced Mathematics

Country	Both Parents and the Student Born in the Country			At Least One of the Parents or the Student Born in the Country			Neither the Parents Nor the Student Born in the Country		
	2008 Percent of Students	Average Achievement	Difference in Percent from 1995	2008 Percent of Students	Average Achievement	Difference in Percent from 1995	2008 Percent of Students	Average Achievement	Difference in Percent from 1995
Armenia	89 (1.4)	432 (3.6)	◊ ◊	11 (1.3)	460 (15.4)	◊ ◊	0 (0.2)	~ ~	◊ ◊
Iran, Islamic Rep. of	98 (0.5)	497 (6.5)	◊ ◊	2 (0.5)	~ ~	◊ ◊	0 (0.1)	~ ~	◊ ◊
Italy	93 (0.6)	449 (7.2)	−2 (1.4)	5 (0.6)	448 (14.5)	1 (1.4)	1 (0.2)	~ ~	1 (0.4)
Lebanon	85 (1.0)	545 (2.5)	◊ ◊	15 (1.0)	547 (4.6)	◊ ◊	0 (0.1)	~ ~	◊ ◊
Netherlands	86 (1.2)	554 (2.7)	◊ ◊	13 (1.0)	549 (5.1)	◊ ◊	2 (0.5)	~ ~	◊ ◊
Norway	81 (1.5)	444 (4.7)	◊ ◊	14 (1.4)	426 (11.9)	◊ ◊	5 (0.8)	401 (14.5)	◊ ◊
Philippines	97 (1.5)	356 (5.6)	◊ ◊	3 (1.2)	356 (15.7)	◊ ◊	0 (0.3)	~ ~	◊ ◊
Russian Federation	80 (2.3)	562 (6.9)	1 (4.2)	17 (1.9)	561 (9.7)	−3 (3.9)	3 (0.5)	546 (20.5)	2 (0.7) ▲
Slovenia	84 (1.2)	462 (4.6)	1 (1.9)	15 (1.2)	443 (6.3)	−1 (1.8)	1 (0.2)	~ ~	0 (0.4)
Sweden	76 (1.8)	423 (5.1)	−8 (2.2) ▼	17 (1.2)	395 (10.2)	5 (1.7) ▲	7 (0.9)	355 (14.4)	3 (1.1) ▲

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

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

A diamond (◊) indicates the country did not participate in the 1995 assessment.
A tilde (~) indicates insufficient data to report achievement.

SOURCE: IEA TIMSS Advanced 2008 ©

achievement was higher for these students than for the 81 percent that reported sometimes speaking English.

Related to the issue of the language spoken in the home in many countries is whether students and their parents were native to their countries or were recent immigrants. As shown in Exhibit 4.3, more than 90 percent of the advanced mathematics students in Iran, Italy, and the Philippines reported that they and both their parents were born in the country; and, in the other countries, with the exception of Sweden, the corresponding figures were between 80 and 90 percent. In Sweden, 76 percent of students reported that they and their parents were born in the country, with 7 percent reporting that neither they nor their parents were born in the country, and 17 percent that they and at least one of their parents were native born. Sweden also was the only country where the percent of native-born students declined from 1995 (by 8 percentage points). In Norway, Slovenia, and Sweden, advanced mathematics students who were born in the country and whose parents also were native born had higher average mathematics achievement than others.

Out of School Time and Computer Usage Among Mathematics Students

Exhibit 4.4 presents advanced mathematics students' reports about how they spent their time outside of school. On a normal school day, they spread their time outside of school across a range of activities, including doing schoolwork, taking part in organized activities, using a computer for things other than schoolwork, spending time with friends, working at a paid job, and watching movies or television. Most advanced mathematics students reported spending between 1 and 2 hours on each of these activities. Students in Iran, Italy, Lebanon, and the Russian Federation reported spending more than 2 hours daily

Exhibit 4.4 **Time in Hours Mathematics Students Spend on Various Activities Outside of School on a Normal School Day**

TIMSSAdvanced 2008
Advanced Mathematics

Country	Doing Schoolwork	Taking Part in Organized Activities	Using a Computer for Things Other than Schoolwork	Spending Time with Friends	Working at a Paid Job	Watching Movies or TV
Armenia	1.9 (0.06)	r 1.0 (0.04)	r 1.1 (0.04)	r 2.1 (0.05)	r 0.2 (0.04)	r 1.6 (0.06)
Iran, Islamic Rep. of	3.3 (0.04)	0.8 (0.02)	0.8 (0.03)	1.0 (0.04)	0.1 (0.01)	1.5 (0.03)
Italy	2.1 (0.08)	1.4 (0.04)	1.5 (0.04)	1.9 (0.06)	0.4 (0.04)	1.2 (0.03)
Lebanon	2.2 (0.04)	1.1 (0.03)	1.4 (0.03)	1.7 (0.04)	0.5 (0.03)	1.4 (0.03)
Netherlands	1.0 (0.03)	1.5 (0.03)	1.9 (0.04)	1.1 (0.03)	1.2 (0.04)	1.3 (0.03)
Norway	1.3 (0.04)	1.4 (0.03)	1.7 (0.03)	1.8 (0.04)	1.3 (0.06)	1.3 (0.02)
Philippines	1.9 (0.04)	1.2 (0.04)	1.5 (0.04)	2.6 (0.04)	0.1 (0.01)	2.0 (0.05)
Russian Federation	2.1 (0.04)	1.5 (0.02)	1.9 (0.04)	2.6 (0.04)	0.2 (0.02)	1.1 (0.03)
Slovenia	1.6 (0.04)	– –	1.7 (0.05)	2.0 (0.04)	0.6 (0.03)	1.3 (0.04)
Sweden	1.1 (0.04)	1.2 (0.03)	2.1 (0.05)	1.7 (0.05)	0.6 (0.04)	1.3 (0.03)

SOURCE: IEA TIMSS Advanced 2008 ©

Data provided by students.
( ) Standard errors appear in parentheses.

A dash (–) indicates comparable data are not available.
An "r" indicates data are available for at least 70% but less than 85% of the students.

on schoolwork (outside of school). Spending time with friends, using a computer, and watching movies or TV were popular pastimes in all countries, whereas working at a paid job was less common.

Exhibit 4.5 presents more detailed information on the amount of time advanced mathematics students spent using a computer each day. It is clear from these reports that students in all countries except Armenia and Iran were frequent computer users, with 30–50 percent of students spending more than 2 hours using a computer each day. Computer usage in Armenia and Iran was relatively less, and in these countries approximately one student in four reported spending no time at all using a computer. There was no clear relationship across the countries between spending time using a computer and achievement in mathematics.

To provide information about whether computer use by advanced mathematics students was a home or school activity or whether they used computers somewhere else, Exhibit 4.6 summarizes students' reports on the frequency of computer usage at home, at school, and elsewhere. According to the results, the home was the principal locus of computer usage among advanced mathematics students, with a large majority (more than 80%) in 6 of the 10 participating countries—Italy, the Netherlands, Norway, the Russian Federation, Slovenia, and Sweden—reporting that they used a computer at home "a lot". The majority of students in these countries reported sometimes using a computer in school also. In Armenia and Lebanon, relatively fewer students reported frequently using a computer at home (63% and 68%, respectively), and in Iran and the Philippines less than half (47% and 48%, respectively). The relatively low level of home computer usage in these countries was offset somewhat by use in school (Armenia and the Philippines) and elsewhere (Armenia, Lebanon, and the Philippines). "Elsewhere" includes locations such as a public library, an Internet cafe,

Exhibit 4.5 **Time Students Spend Using a Computer Each Day**

TIMSSAdvanced 2008
Advanced Mathematics

Country		No Time		Less than 1 Hour		1–2 Hours	
		Percent of Students	Average Achievement	Percent of Students	Average Achievement	Percent of Students	Average Achievement
Armenia	r	26 (1.5)	428 (8.8)	31 (1.8)	447 (7.1)	29 (1.8)	439 (8.0)
Iran, Islamic Rep. of		25 (1.3)	497 (6.9)	40 (1.4)	513 (7.6)	26 (1.3)	485 (8.1)
Italy		2 (0.4)	~ ~	27 (1.4)	455 (8.5)	38 (1.4)	453 (7.8)
Lebanon		3 (0.5)	524 (17.5)	23 (1.1)	552 (4.3)	41 (1.3)	545 (3.3)
Netherlands		0 (0.1)	~ ~	14 (0.9)	551 (4.2)	42 (1.4)	549 (3.2)
Norway		0 (0.1)	~ ~	18 (1.2)	437 (6.6)	40 (1.6)	441 (6.2)
Philippines		4 (0.4)	301 (12.1)	18 (1.0)	336 (8.8)	43 (1.2)	350 (5.8)
Russian Federation		2 (0.3)	~ ~	24 (1.2)	561 (9.3)	41 (1.3)	565 (7.8)
Slovenia		1 (0.2)	~ ~	28 (2.0)	464 (5.3)	40 (1.3)	457 (5.9)
Sweden		0 (0.1)	~ ~	14 (1.0)	410 (11.5)	34 (1.1)	418 (6.6)

SOURCE: IEA TIMSS Advanced 2008 ©

Country		More than 2 but Less than 4 Hours		4 or More Hours	
		Percent of Students	Average Achievement	Percent of Students	Average Achievement
Armenia	r	8 (1.1)	439 (12.2)	5 (0.8)	426 (17.3)
Iran, Islamic Rep. of		7 (0.8)	481 (11.9)	2 (0.4)	~ ~
Italy		22 (1.1)	444 (9.8)	11 (0.9)	431 (10.3)
Lebanon		23 (1.2)	546 (4.4)	11 (0.9)	539 (5.5)
Netherlands		30 (1.4)	556 (4.0)	15 (1.0)	559 (4.3)
Norway		27 (1.1)	434 (6.5)	15 (1.8)	450 (6.9)
Philippines		24 (1.1)	369 (7.2)	12 (1.0)	401 (11.3)
Russian Federation		21 (1.1)	563 (7.7)	12 (0.9)	554 (7.9)
Slovenia		23 (1.1)	454 (5.3)	8 (0.8)	453 (9.8)
Sweden		31 (1.1)	412 (6.6)	20 (1.3)	411 (8.3)

Data provided by students.

( ) 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.

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

Exhibit 4.6 **Computer Use at Home and at School**

TIMSSAdvanced 2008 Advanced Mathematics

Country		Use a Computer at Home					
		A Lot		Sometimes		Never	
		Percent of Students	Average Achievement	Percent of Students	Average Achievement	Percent of Students	Average Achievement
Armenia	s	63 (3.1)	448 (9.4)	28 (2.9)	437 (14.4)	9 (1.1)	418 (12.1)
Iran, Islamic Rep. of		47 (1.8)	505 (9.1)	51 (1.7)	496 (7.2)	2 (0.5)	~ ~
Italy		81 (1.0)	452 (7.0)	18 (1.0)	438 (9.6)	1 (0.2)	~ ~
Lebanon		68 (1.3)	548 (2.5)	29 (1.4)	546 (4.0)	3 (0.6)	516 (11.9)
Netherlands		91 (0.8)	553 (2.8)	9 (0.8)	549 (4.2)	0 (0.1)	~ ~
Norway		83 (1.0)	441 (5.0)	17 (1.0)	434 (6.7)	0 (0.1)	~ ~
Philippines		48 (2.2)	385 (6.9)	20 (1.1)	364 (7.4)	32 (1.9)	327 (6.9)
Russian Federation		88 (0.9)	564 (7.1)	11 (0.9)	544 (8.1)	1 (0.2)	~ ~
Slovenia		94 (0.6)	459 (4.4)	6 (0.6)	449 (7.8)	0 (0.1)	~ ~
Sweden		85 (0.8)	416 (5.4)	15 (0.7)	406 (9.1)	0 (0.1)	~ ~

Country		Use a Computer at School					
		A Lot		Sometimes		Never	
		Percent of Students	Average Achievement	Percent of Students	Average Achievement	Percent of Students	Average Achievement
Armenia	s	18 (2.1)	420 (11.8)	62 (3.1)	459 (10.7)	20 (2.3)	404 (11.6)
Iran, Islamic Rep. of	r	1 (0.3)	~ ~	20 (2.5)	536 (13.3)	79 (2.5)	497 (6.6)
Italy		5 (1.1)	386 (23.8)	64 (2.3)	448 (7.4)	31 (2.6)	462 (9.7)
Lebanon	r	1 (0.2)	~ ~	54 (2.0)	554 (3.0)	45 (1.9)	542 (3.6)
Netherlands		6 (0.8)	555 (7.3)	90 (0.8)	553 (2.6)	4 (0.8)	544 (7.2)
Norway		22 (2.9)	439 (9.6)	74 (2.6)	442 (5.0)	4 (0.6)	409 (13.2)
Philippines		10 (1.1)	331 (11.6)	79 (1.3)	363 (5.7)	11 (1.6)	382 (12.0)
Russian Federation		6 (0.5)	558 (11.4)	84 (0.9)	563 (7.3)	9 (0.9)	563 (9.5)
Slovenia		2 (0.5)	~ ~	62 (2.5)	465 (5.2)	36 (2.5)	453 (5.9)
Sweden		15 (2.0)	415 (9.0)	82 (1.9)	415 (5.9)	3 (0.6)	398 (17.8)

SOURCE: IEA TIMSS Advanced 2008 ©

Data provided by students.

( ) 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.

An "r" indicates data are available for at least 70% but less than 85% of the students. An "s" indicates data are available for at least 50% but less than 70% of the students.

Exhibit 4.6 **Computer Use at Home and at School (Continued)**

TIMSSAdvanced 2008
Advanced Mathematics

Country		Use a Computer Elsewhere					
		A Lot		Sometimes		Never	
		Percent of Students	Average Achievement	Percent of Students	Average Achievement	Percent of Students	Average Achievement
Armenia	s	22 (2.5)	429 (9.5)	61 (2.5)	442 (6.8)	17 (2.2)	456 (13.9)
Iran, Islamic Rep. of	r	4 (0.6)	474 (17.8)	52 (2.0)	497 (8.3)	44 (1.9)	509 (8.0)
Italy		2 (0.3)	~ ~	36 (1.5)	449 (8.2)	62 (1.5)	449 (6.9)
Lebanon		16 (1.1)	541 (4.9)	67 (1.2)	548 (3.0)	17 (0.9)	556 (3.7)
Netherlands		0 (0.2)	~ ~	32 (1.3)	551 (3.3)	68 (1.2)	554 (3.0)
Norway		2 (0.4)	~ ~	56 (1.7)	438 (5.0)	42 (1.7)	446 (5.9)
Philippines		24 (1.5)	351 (5.7)	70 (1.1)	359 (6.2)	6 (0.7)	404 (13.1)
Russian Federation		4 (0.3)	548 (11.4)	54 (1.1)	560 (7.2)	42 (1.1)	569 (7.5)
Slovenia		2 (0.4)	~ ~	53 (2.3)	460 (4.9)	45 (2.1)	460 (5.0)
Sweden		1 (0.3)	~ ~	43 (1.0)	411 (6.0)	55 (1.1)	417 (6.2)

SOURCE: IEA TIMSS Advanced 2008 ©

Data provided by students.

( ) 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.

An "r" indicates data are available for at least 70% but less than 85% of the students. An "s" indicates data are available for at least 50% but less than 70% of the students.

or a friend's home. In line with the previous exhibit, computer usage, whether at home, in school, or elsewhere, was lowest among students in Iran.

Because of the immense potential of the computer as an educational tool, TIMSS asked the advanced mathematics students about the ways they used computers in doing their schoolwork. As shown in Exhibit 4.7, computer usage for schoolwork was widespread in all countries, with researching information from the Internet the most popular activity, followed by word processing, and analyzing and processing data. In the Netherlands, Norway, the Russian Federation, Slovenia, and Sweden, more than 90 percent of the advanced mathematics students reported using computers for researching information on the Internet and for word processing.

Despite the reported widespread use of computers for schoolwork, the advanced mathematics students reported relatively little computer use for mathematics outside of class. As presented in Exhibit 4.8, the majority of students in almost every country reported never or almost never doing mathematics on a computer outside class. Even in countries with very high levels of computer usage generally, such as the Netherlands, Norway, and Sweden, mathematics students reported only sporadic use for mathematics outside of class.

Exhibit 4.7 **Various Ways Mathematics Students Use Computers for Schoolwork**

TIMSSAdvanced 2008 Advanced Mathematics

Country	Percent of Students Using Computers in Various Ways for Schoolwork				
	Researching Information from the Internet	Word Processing	Analyzing and Presenting Data	Using Specialized Programs	Other
Armenia	r 71 (1.8)	r 67 (2.1)	r 30 (2.1)	s 37 (2.6)	s 35 (3.1)
Iran, Islamic Rep. of	81 (1.1)	38 (1.4)	23 (1.4)	13 (0.9)	68 (1.5)
Italy	95 (0.6)	38 (1.5)	51 (2.3)	24 (1.6)	72 (1.3)
Lebanon	88 (0.8)	40 (1.4)	41 (1.5)	33 (1.3)	70 (1.3)
Netherlands	99 (0.3)	97 (0.6)	65 (1.9)	34 (1.8)	27 (1.2)
Norway	99 (0.2)	96 (0.5)	57 (1.6)	17 (2.0)	73 (1.5)
Philippines	98 (0.4)	88 (0.9)	63 (1.3)	27 (1.0)	84 (0.7)
Russian Federation	91 (0.8)	92 (0.7)	46 (1.2)	32 (1.3)	64 (1.0)
Slovenia	99 (0.2)	96 (0.4)	75 (1.5)	26 (1.2)	r 42 (2.0)
Sweden	100 (0.1)	94 (0.7)	51 (1.3)	17 (1.3)	66 (1.2)

SOURCE: IEA TIMSS Advanced 2008 ©

Data provided by students.
( ) Standard errors appear in parentheses.

An "r" indicates data are available for at least 70% but less than 85% of the students. An "s" indicates data are available for at least 50% but less than 70% of the students.

Exhibit 4.8 **Frequency of Computer Use for Mathematics Outside of Class**

TIMSSAdvanced 2008 Advanced Mathematics

Country	Almost Every Day		Once or Twice a Week		About Once a Month		Never or Almost Never	
	Percent of Students	Average Achievement	Percent of Students	Average Achievement	Percent of Students	Average Achievement	Percent of Students	Average Achievement
Armenia	12 (1.4)	469 (17.3)	14 (1.2)	444 (10.9)	10 (1.1)	448 (13.2)	65 (1.7)	428 (4.1)
Iran, Islamic Rep. of	1 (0.2)	~ ~	4 (0.4)	488 (15.8)	12 (0.7)	492 (10.1)	83 (0.8)	499 (6.0)
Italy	3 (0.4)	436 (18.7)	10 (0.9)	447 (13.3)	13 (1.0)	464 (10.7)	73 (1.4)	447 (7.3)
Lebanon	4 (0.6)	530 (10.0)	14 (1.2)	528 (5.3)	22 (0.8)	554 (3.9)	60 (1.3)	548 (2.8)
Netherlands	2 (0.4)	~ ~	7 (0.9)	561 (7.2)	19 (1.5)	558 (3.7)	72 (1.8)	551 (3.0)
Norway	4 (1.0)	431 (15.7)	8 (1.3)	452 (11.7)	9 (0.9)	439 (11.8)	79 (2.5)	438 (4.7)
Philippines	2 (0.3)	~ ~	24 (1.1)	337 (7.1)	28 (1.0)	350 (7.7)	46 (1.5)	369 (6.0)
Russian Federation	6 (0.5)	545 (9.4)	19 (1.3)	565 (9.7)	19 (1.1)	574 (8.9)	56 (1.9)	557 (7.2)
Slovenia	10 (0.7)	462 (6.8)	13 (0.9)	451 (7.9)	19 (1.5)	457 (8.6)	59 (1.6)	460 (4.3)
Sweden	1 (0.2)	~ ~	3 (0.4)	447 (14.2)	7 (0.7)	416 (11.8)	88 (0.9)	413 (5.3)

SOURCE: IEA TIMSS Advanced 2008 ©

Data provided by students.
( ) 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.

Working with a Mathematics Tutor and Preparing for Mathematics Tests

As described in Chapter 1, in almost all of the 10 countries participating in TIMSS Advanced 2008, mathematics students write public examinations that have serious consequences for their future educational opportunities and life chances. In this situation, students may have recourse to mathematics tutors or other outside support to help them improve their mathematics knowledge and understanding. Exhibit 4.9 shows, however, that the practice is relatively rare among the advanced mathematics students in the TIMSS Advanced 2008 countries, with only Armenia and the Russian Federation having appreciable percentages of students working with a mathematics tutor as often as once a week (41% and 45%, respectively). In all countries except Armenia, the students who never or almost never work with a tutor had higher mathematics achievement that those who sought help even occasionally.

According to Exhibit 4.10, advanced mathematics students in the TIMSS Advanced countries prepare for tests or examinations quite frequently. In 7 of the 10 countries, the majority of students reported preparing for a test at least once a month; and, of these, in Armenia, Lebanon, and the Philippines, the majority of students reported preparing for a test about once a week. Studying for a test was less common in the Netherlands, Norway, and Sweden, where the majority of students reported preparing for a test about five times a year. Across the participating countries, there was no discernible relationship between frequency of testing and mathematics achievement.

Exhibit 4.9 Frequency of Working with Mathematics Tutor

TIMSSAdvanced 2008 Advanced Mathematics

Country	More than Once a Week		About Once a Week		About Once a Month	
	Percent of Students	Average Achievement	Percent of Students	Average Achievement	Percent of Students	Average Achievement
Armenia	36 (1.9)	469 (5.9)	5 (1.1)	450 (31.5)	1 (0.2)	~ ~
Iran, Islamic Rep. of	8 (1.1)	483 (15.9)	8 (0.8)	494 (13.4)	1 (0.3)	~ ~
Italy	5 (0.5)	427 (14.5)	11 (1.3)	417 (10.0)	3 (0.6)	400 (15.8)
Lebanon	7 (0.7)	505 (6.6)	7 (0.6)	503 (6.1)	3 (0.5)	506 (8.2)
Netherlands	1 (0.2)	~ ~	4 (0.7)	533 (8.7)	1 (0.3)	~ ~
Norway	– –	– –	– –	– –	– –	– –
Philippines	2 (0.6)	~ ~	2 (0.3)	~ ~	1 (0.2)	~ ~
Russian Federation	17 (1.2)	544 (10.1)	28 (1.7)	554 (8.9)	1 (0.2)	~ ~
Slovenia	1 (0.2)	~ ~	5 (0.8)	400 (12.8)	4 (0.5)	393 (10.9)
Sweden	– –	– –	– –	– –	– –	– –

SOURCE: IEA TIMSS Advanced 2008 ©

Country	Once in a While When I Need Extra Help		Never or Almost Never	
	Percent of Students	Average Achievement	Percent of Students	Average Achievement
Armenia	14 (1.2)	421 (12.5)	45 (2.2)	417 (5.3)
Iran, Islamic Rep. of	12 (0.9)	482 (9.5)	71 (1.6)	503 (6.5)
Italy	34 (1.5)	425 (8.8)	47 (1.5)	479 (8.1)
Lebanon	16 (1.0)	532 (4.3)	67 (1.2)	559 (2.8)
Netherlands	12 (1.0)	529 (4.9)	82 (1.3)	559 (3.0)
Norway	– –	– –	– –	– –
Philippines	29 (1.2)	340 (7.5)	66 (1.2)	364 (5.8)
Russian Federation	11 (0.8)	549 (9.1)	43 (2.1)	575 (8.4)
Slovenia	27 (1.2)	418 (5.4)	62 (1.4)	486 (4.1)
Sweden	– –	– –	– –	– –

Data provided by students.

A dash (–) indicates comparable data are not available. Norway and Sweden did not collect this information. According to the NRCs of these countries, tutors are not used.

( ) 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.

Exhibit 4.10 **Frequency of Preparing for Mathematics Test or Examination**

TIMSSAdvanced2008 Advanced Mathematics

Country	About Once a Week		About Once a Month		About 5 Times a Year	
	Percent of Students	Average Achievement	Percent of Students	Average Achievement	Percent of Students	Average Achievement
Armenia	53 (2.1)	442 (5.3)	22 (2.0)	435 (9.5)	4 (0.7)	474 (20.9)
Iran, Islamic Rep. of	27 (1.7)	523 (9.8)	54 (1.6)	498 (6.7)	9 (0.9)	489 (6.8)
Italy	38 (1.8)	442 (5.9)	49 (1.8)	464 (8.7)	8 (0.9)	431 (11.5)
Lebanon	50 (1.2)	543 (3.0)	40 (1.1)	550 (3.8)	5 (0.7)	547 (8.4)
Netherlands	9 (0.9)	543 (4.3)	15 (1.6)	543 (3.9)	64 (2.3)	555 (3.2)
Norway	1 (0.4)	~ ~	39 (4.0)	437 (6.6)	55 (3.8)	444 (5.9)
Philippines	76 (1.3)	350 (5.5)	16 (1.0)	367 (8.9)	4 (0.4)	393 (16.6)
Russian Federation	43 (1.9)	541 (7.4)	38 (1.2)	565 (7.4)	9 (0.8)	586 (7.7)
Slovenia	30 (1.4)	444 (6.8)	44 (1.5)	463 (4.7)	21 (1.6)	466 (4.8)
Sweden	0 (0.1)	~ ~	21 (2.0)	397 (8.6)	60 (1.9)	428 (5.6)

Country	About Twice a Year		Never	
	Percent of Students	Average Achievement	Percent of Students	Average Achievement
Armenia	9 (1.1)	421 (13.1)	11 (1.2)	414 (8.9)
Iran, Islamic Rep. of	8 (1.1)	448 (13.4)	3 (0.4)	431 (14.8)
Italy	2 (0.3)	~ ~	3 (0.6)	401 (18.1)
Lebanon	3 (0.4)	530 (12.8)	1 (0.3)	~ ~
Netherlands	10 (1.9)	560 (5.2)	1 (0.3)	~ ~
Norway	4 (0.7)	425 (15.0)	1 (0.2)	~ ~
Philippines	1 (0.2)	~ ~	3 (0.4)	363 (15.9)
Russian Federation	7 (0.9)	611 (11.6)	3 (0.4)	597 (15.4)
Slovenia	3 (0.5)	456 (15.1)	2 (0.3)	~ ~
Sweden	11 (1.8)	435 (7.0)	8 (0.8)	332 (10.2)

SOURCE: IEA TIMSS Advanced 2008 ©

Data provided by students.

( ) 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.

Students' Reasons for Studying Advanced Mathematics

As discussed earlier, the students studying the advanced mathematics assessed by TIMSS Advanced were a very select group in all countries, representing the most mathematically educated students in their age groups. Since it is very important to attract these students to study advanced mathematics in the first place, and then to retain them for tertiary-level study of mathematics and a career involving mathematics, it is useful to know what factors attracted them to the study of mathematics. Exhibits 4.11, 4.12, and 4.13 present student reports on three reasons for studying advanced mathematics—having a positive affect toward mathematics, good teachers and teaching, and advice from others.

Exhibit 4.11 summarizes students' responses to three statements about having a positive orientation toward mathematics as a reason for studying advanced mathematics:

- I enjoy solving mathematical problems.
- I usually do well in mathematics.
- Advanced mathematics lessons are interesting.

Students were asked to indicate the degree of importance of each reason in deciding to study advanced mathematics. In Exhibit 4.11, students were assigned to one of four categories of the positive orientation factor—*very important, important, unimportant*, and *very unimportant*—according to their average response across the three statements based on a 4-point Likert scale. The exhibit shows the percentage of students in each of the four categories for each country, together with the average mathematics achievement for each category. Countries are ordered by the percentage of students in the "very important" category.

Exhibit 4.11 Students' Reasons for Studying Advanced Mathematics – Students Have Positive Affect Toward Mathematics

TIMSSAdvanced 2008 Advanced Mathematics

Country		Very Important		Important		Unimportant		Very Unimportant	
		Percent of Students	Average Achievement	Percent of Students	Average Achievement	Percent of Students	Average Achievement	Percent of Students	Average Achievement
Lebanon		64 (1.4)	551 (2.7)	31 (1.3)	536 (3.8)	4 (0.5)	536 (9.7)	0 (0.2)	~ ~
Philippines		38 (1.4)	366 (7.0)	50 (1.0)	349 (6.1)	10 (0.7)	347 (7.8)	2 (0.3)	~ ~
Armenia	r	38 (2.2)	470 (5.1)	37 (2.5)	434 (8.7)	18 (1.7)	394 (7.3)	8 (0.8)	418 (18.3)
Iran, Islamic Rep. of		38 (1.2)	522 (8.0)	39 (1.0)	493 (6.2)	18 (1.0)	471 (8.7)	5 (0.6)	447 (10.7)
Russian Federation		24 (0.9)	588 (7.3)	49 (1.0)	561 (8.7)	22 (1.1)	538 (6.8)	4 (0.4)	527 (11.0)
Norway		24 (1.1)	481 (6.0)	47 (1.1)	440 (5.3)	23 (0.9)	411 (5.2)	6 (0.7)	384 (8.3)
Slovenia		23 (0.9)	496 (5.9)	44 (1.2)	464 (4.4)	24 (1.3)	437 (5.7)	9 (0.8)	393 (8.6)
Sweden		22 (1.2)	490 (7.8)	37 (1.6)	433 (5.9)	26 (1.5)	372 (6.0)	15 (1.3)	329 (6.8)
Italy		18 (1.1)	493 (8.3)	38 (1.4)	459 (8.4)	25 (1.3)	438 (8.3)	19 (1.3)	399 (9.3)
Netherlands		17 (1.3)	580 (4.8)	53 (1.4)	554 (3.2)	25 (1.4)	537 (3.1)	5 (0.7)	523 (5.5)

SOURCE: IEA TIMSS Advanced 2008 ©

Based on students' responses to three statements about why students study advanced mathematics: 1) I enjoy solving mathematical problems; 2) I usually do well in mathematics; and 3) Advanced mathematics lessons are interesting. Average is computed across three statements based on a 4-point Likert scale: 1. Very important; 2. Important; 3. Unimportant; 4. Very unimportant. Very important indicates an average response score of 1 to less than 1.75. Important indicates an average of 1.75 through 2.5. Unimportant indicates an average response score of greater than 2.5 through 3.25. Very unimportant indicates an average greater than 3.25 through 4.

( ) 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.

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

Exhibit 4.12 Students' Reasons for Studying Advanced Mathematics – Good Teachers and Teaching

TIMSSAdvanced 2008 Advanced Mathematics

Country		Very Important		Important		Unimportant		Very Unimportant	
		Percent of Students	Average Achievement	Percent of Students	Average Achievement	Percent of Students	Average Achievement	Percent of Students	Average Achievement
Armenia	r	60 (2.0)	447 (5.2)	30 (2.1)	426 (9.8)	6 (1.3)	439 (19.2)	4 (0.8)	463 (18.8)
Russian Federation		55 (2.0)	559 (7.3)	37 (1.5)	565 (8.5)	5 (0.6)	560 (10.2)	3 (0.5)	551 (17.8)
Philippines		54 (1.4)	346 (6.1)	40 (1.0)	364 (6.3)	4 (0.6)	398 (14.2)	1 (0.2)	~ ~
Lebanon		47 (1.3)	540 (2.8)	35 (1.3)	547 (3.6)	10 (0.7)	558 (5.2)	8 (0.6)	561 (7.6)
Iran, Islamic Rep. of		29 (1.4)	486 (6.7)	38 (1.2)	501 (6.9)	14 (0.9)	507 (10.0)	19 (1.3)	503 (9.0)
Slovenia		29 (1.9)	472 (6.0)	47 (1.1)	458 (4.6)	16 (1.3)	452 (7.0)	8 (0.7)	426 (7.8)
Sweden		28 (1.9)	429 (7.0)	45 (1.5)	421 (5.9)	16 (1.1)	405 (8.2)	12 (1.2)	365 (8.8)
Italy		24 (1.5)	454 (8.5)	43 (2.0)	451 (7.7)	16 (1.1)	452 (10.3)	17 (1.8)	433 (10.1)
Norway		20 (1.6)	435 (7.2)	47 (1.5)	441 (5.2)	20 (1.1)	450 (6.4)	13 (1.4)	426 (10.1)
Netherlands		15 (1.6)	552 (5.7)	50 (1.3)	553 (2.8)	23 (1.1)	554 (3.6)	12 (1.0)	550 (4.9)

SOURCE: IEA TIMSS Advanced 2008 ©

Based on students' responses to the two statements about why students study advanced mathematics: 1) Advanced mathematics has good teachers; and 2) I like the way advanced mathematics is taught in my school. Average is computed across the two statements based on a 4-point Likert scale: 1. Very important; 2. Important; 3. Unimportant; and 4. Very unimportant. Very important indicates an average response score of 1 to less than 1.75. Important indicates an average of 1.75 through 2.5. Unimportant indicates an average response score of greater than 2.5 through 3.25. Very unimportant indicates an average greater than 3.25 through 4.

( ) 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.

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

Perhaps not surprisingly, students in all countries considered having a positive orientation toward mathematics to be important in choosing to study advanced mathematics. In every country, the majority of students (ranging from 56% in Italy to 95% in Lebanon) considered a positive orientation to be important or very important to their decision. Across the participating countries, students who considered a positive orientation to be important for choosing to study mathematics had higher average mathematics achievement than students who thought it less important.

Having mathematics teachers who are good mentors and role models and being exposed to good teaching are obvious positive sources of influence on the decision to study advanced mathematics. Exhibit 4.12 presents students' responses to two statements about good teachers and teaching as reasons for studying advanced mathematics:

- ► Advanced mathematics has good teachers.
- ► I like the way advanced mathematics is taught in my school.

Again, students were asked to indicate the degree of importance of each one in deciding to study advanced mathematics. As in the previous exhibit, students were assigned to one of four categories of the good teaching factor—*very important, important, unimportant,* and *very unimportant*—according to their average response based on a 4-point Likert scale. Exhibit 4.12 shows the percentage of students in each of the four categories for each country, together with the average mathematics achievement for each category. Countries are ranked by the percentage of students in the "very important" category.

Although, in general, a large majority of students in all countries were in agreement that good teaching was an important reason to study advanced mathematics, there was a wide range in the degree of emphasis across countries, ranging from Armenia, where 60 percent of students considered good teaching to be very important, to the Netherlands, where the corresponding figure was just 15 percent. In Iran, Sweden, Italy, Norway, and the Netherlands, about one fourth to one third of the advanced mathematics students indicated that good teaching was unimportant in the decision to study advanced mathematics. There was no consistent relationship across countries between mathematics achievement and reporting that good teaching was an important reason for studying advanced mathematics.

The third set of students' reasons for choosing to study advanced mathematics involved advice from others—parents, teachers, school advisors—as well as simply doing what their friends were doing. More specifically, there were four statements about advice from others as reasons for studying advanced mathematics:

- My parents advised me to study advanced mathematics.
- A teacher advised me to study advanced mathematics.
- My friends also are studying advanced mathematics.
- The <study coordinator/mentor>[2] of my school advised me to study advanced mathematics.

As with the other sets of reasons, students were asked to indicate the degree of importance of each reason in choosing to study advanced mathematics. As in the previous exhibits, students were assigned to one of four categories of the advice-from-others factor—*very important, important, unimportant*, and *very unimportant*—according to their average response based on a 4-point Likert scale. Exhibit 4.13 shows the percentage of students in each of the four categories for each country, together with the average mathematics achievement for each category. Countries are ordered by the percentage of students in the "very important" category.

2 National Research Coordinators replaced the term <study coordinator/mentor> with a culturally appropriate term.

Exhibit 4.13 **Students' Reasons for Studying Advanced Mathematics – Advice from Others**

TIMSSAdvanced 2008 Advanced Mathematics

Country		Very Important		Important		Unimportant		Very Unimportant	
		Percent of Students	Average Achievement	Percent of Students	Average Achievement	Percent of Students	Average Achievement	Percent of Students	Average Achievement
Armenia	r	29 (1.6)	436 (5.4)	48 (2.1)	435 (6.5)	17 (1.4)	441 (10.0)	7 (1.2)	497 (16.3)
Philippines		14 (0.9)	304 (6.6)	51 (1.3)	341 (6.1)	28 (1.6)	392 (6.0)	6 (0.6)	423 (9.9)
Iran, Islamic Rep. of		9 (0.8)	451 (8.7)	30 (1.2)	474 (7.2)	34 (1.3)	497 (6.7)	27 (1.3)	541 (8.1)
Lebanon		6 (0.7)	519 (6.4)	27 (1.2)	533 (4.0)	38 (1.2)	547 (3.2)	29 (1.4)	561 (4.1)
Russian Federation		5 (0.6)	555 (11.1)	37 (1.1)	551 (8.0)	43 (1.1)	565 (7.7)	16 (1.0)	577 (7.9)
Italy		3 (0.4)	440 (25.9)	16 (0.9)	442 (5.9)	33 (1.3)	447 (7.6)	48 (1.5)	453 (8.3)
Slovenia		1 (0.3)	~ ~	17 (1.2)	457 (7.9)	48 (1.3)	456 (4.6)	33 (1.2)	462 (5.8)
Norway		1 (0.3)	~ ~	21 (1.0)	421 (6.3)	50 (1.5)	438 (5.3)	28 (1.3)	458 (6.5)
Sweden		1 (0.3)	~ ~	12 (1.0)	400 (9.2)	42 (1.4)	409 (6.4)	45 (1.5)	424 (5.9)
Netherlands		0 (0.1)	~ ~	13 (0.8)	546 (4.9)	51 (1.8)	551 (3.0)	36 (1.8)	558 (3.4)

SOURCE: IEA TIMSS Advanced 2008 ©

Based on students' responses to the four statements about why students study advanced mathematics: 1) My parents advised me to study advanced mathematics; 2) A teacher advised me to study advanced mathematics; 3) My friends also are studying advanced mathematics; and 4) The <study coordinator/mentor> of my school advised me to study advanced mathematics. Average is computed across the four statements based on a 4-point Likert scale: 1. Very important; 2. Important; 3. Unimportant; and 4. Very unimportant. Very important indicates an average response score of 1 to less than 1.75. Important indicates an average of 1.75 through 2.5. Unimportant indicates an average response score of greater than 2.5 through 3.25. Very unimportant indicates an average greater than 3.25 through 4.

( ) 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.

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

In general, students considered advice from others to be a relatively less important reason for studying advanced mathematics than having a positive orientation or good teaching, with the majority of students in all countries except Armenia and the Philippines indicating that advice from others was unimportant or very unimportant. In Italy, Slovenia, Sweden, and the Netherlands, more than 80 percent of students were in these categories. Furthermore, it appears that the less able students were more likely to rely on advice from others in deciding to study advanced mathematics, as in every country, the students with the highest achievement were those reporting that advice from others was very unimportant.

Areas of Future Study for Students of Advanced Mathematics

A solid grounding in mathematics is a prerequisite for future study in mathematics and engineering, as well as branches of many other disciplines such as science, computer and information science, business, and the health and social sciences. Students' reports of the areas in which they intended to pursue further study are summarized in Exhibit 4.14. Almost all (96% or more) advanced mathematics students in the participating countries, with the exception of Italy (86%), indicated that they planned to continue their education after finishing secondary school.

It is clear from Exhibit 4.14 that students who studied advanced mathematics in secondary school planned to study a variety of subjects in their post-secondary careers. Engineering was the most popular choice, with more students choosing it than any other in half of the 10 countries—Iran, Lebanon, the Netherlands, Norway, and Sweden. In addition, 20 percent or more of the students in Italy, the Philippines, and the Russian Federation chose engineering for their future area of study. After engineering, business was the next most popular choice,

Exhibit 4.14 **Advanced Mathematics Students' Aspirations for Future Study**

TIMSSAdvanced 2008 Advanced Mathematics

Country	Percent of Students Intending to Continue Education	Percent of Students with Intended Area of Study							
		Science	Health Science	Engineering	Business	Computer and Information Science	Mathematics	Social Science	Other Field of Study
Armenia	96 (0.6)	4 (0.7)	11 (0.9)	3 (0.9)	26 (2.4)	13 (1.8)	7 (0.9)	4 (0.7)	31 (1.6)
Iran, Islamic Rep. of	100 (0.1)	4 (0.4)	1 (0.3)	82 (0.9)	3 (0.5)	4 (0.5)	1 (0.3)	1 (0.2)	5 (0.6)
Italy	86 (1.5)	9 (0.9)	17 (0.8)	20 (1.3)	13 (1.1)	4 (0.6)	2 (0.5)	10 (0.8)	25 (1.3)
Lebanon	100 (0.1)	4 (0.5)	3 (0.4)	66 (1.3)	4 (0.4)	7 (0.6)	7 (0.8)	1 (0.2)	9 (0.8)
Netherlands	100 (0.1)	15 (0.9)	15 (1.1)	41 (1.5)	9 (0.9)	6 (0.6)	5 (0.5)	4 (0.4)	7 (0.6)
Norway	99 (0.2)	8 (0.7)	18 (1.2)	32 (1.6)	14 (1.0)	5 (0.7)	1 (0.3)	9 (0.6)	12 (1.1)
Philippines	100 (0.1)	7 (0.5)	23 (1.3)	21 (1.2)	21 (1.3)	11 (0.9)	2 (0.4)	6 (0.7)	9 (0.9)
Russian Federation	100 (0.0)	6 (0.5)	4 (0.8)	22 (1.0)	25 (1.1)	19 (1.4)	5 (0.6)	10 (0.7)	9 (0.5)
Slovenia	100 (0.1)	14 (1.1)	8 (0.8)	13 (1.2)	12 (1.2)	5 (0.7)	3 (0.4)	34 (1.5)	10 (0.8)
Sweden	99 (0.2)	16 (1.4)	17 (1.0)	22 (1.4)	9 (0.7)	9 (1.3)	2 (0.4)	8 (0.6)	16 (1.5)

SOURCE: IEA TIMSS Advanced 2008 ©

Data provided by students.

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

with more than 20 percent of students in Armenia, the Philippines, and the Russian Federation choosing this option. Relatively few students in any country (less than 20 percent) chose science, computer and information science, or mathematics as their area of future study; only the Philippines had more than 20 percent choosing health science, and only Slovenia more than 20 percent choosing social science. More than 20 percent of students in Armenia (31%) and Italy (25%) chose a field of study other than those listed above.

To provide a more detailed perspective on the subject areas that advanced mathematics students planned to study after secondary school, Exhibit 4.15 presents the percentage of females choosing each subject area for each country and the percentage of males. If there were no differences in gender preferences, the percentages for females and males in a subject area for a country would be the same (and would be equal to the corresponding entry in Exhibit 4.14). Engineering and computer and information science were the subject areas with the greatest gender differences in students planning to study them, with the percentage of males exceeding the percentage of females in every country in engineering and in computer and information science in all countries except Iran and Lebanon. In contrast, health science and social science were the areas of choice for females more often than by males in most countries—in 7 of the 10 countries for health science and in 8 countries for social science. In science, the only gender difference was in Slovenia, with a greater percentage of males than females planning future study in this area. Similarly, there were few gender differences in business, although more males than females chose this area in Armenia, and more females than males in the Philippines and the Russian Federation. In mathematics, the only difference was in Lebanon, where the percentage of females was higher. Finally, more females than males chose the "other" field of study in 5 of the 10 countries, including Armenia, Iran, the Philippines, the Russian Federation, and Sweden.

Exhibit 4.15 **Advanced Mathematics Students' Aspirations for Future Study by Gender**

TIMSSAdvanced2008 Advanced Mathematics

Country	Percent of Students by Intended Area of Study							
	Science		Health Science		Engineering		Business	
	Females	Males	Females	Males	Females	Males	Females	Males
Armenia	3 (1.0)	5 (1.0)	13 (1.2) ▲	8 (1.3)	2 (0.8)	6 (1.5) ▲	21 (2.7)	32 (3.3) ▲
Iran, Islamic Rep. of	4 (0.6)	3 (0.5)	2 (0.5)	1 (0.3)	79 (1.7)	85 (1.0) ▲	3 (0.8)	2 (0.5)
Italy	9 (1.2)	9 (1.3)	26 (2.0) ▲	12 (0.9)	8 (1.6)	27 (1.6) ▲	11 (1.8)	13 (1.4)
Lebanon	5 (0.9)	3 (0.6)	4 (1.0)	2 (0.5)	55 (2.5)	70 (1.5) ▲	5 (1.0)	4 (0.6)
Netherlands	16 (1.6)	15 (1.2)	36 (2.5) ▲	9 (1.0)	23 (2.7)	46 (1.6) ▲	6 (1.4)	9 (1.0)
Norway	9 (1.2)	8 (0.9)	31 (2.2) ▲	9 (1.0)	20 (1.6)	40 (2.2) ▲	13 (1.5)	15 (1.3)
Philippines	7 (0.6)	8 (0.9)	27 (1.5) ▲	15 (1.5)	13 (1.2)	35 (1.8) ▲	24 (1.4) ▲	17 (1.7)
Russian Federation	6 (0.7)	6 (0.7)	5 (0.9) ▲	3 (0.9)	10 (0.9)	32 (1.4) ▲	36 (1.3) ▲	16 (1.1)
Slovenia	11 (1.4)	18 (1.8) ▲	10 (1.2)	7 (1.2)	6 (0.9)	25 (2.6) ▲	12 (1.4)	11 (1.5)
Sweden	17 (1.5)	16 (2.0)	29 (1.6) ▲	9 (0.8)	10 (1.3)	31 (1.8) ▲	9 (1.4)	10 (0.8)

Country	Percent of Students by Intended Area of Study							
	Computer and Information Science		Mathematics		Social Science		Other Field of Study	
	Females	Males	Females	Males	Females	Males	Females	Males
Armenia	10 (1.4)	16 (2.8) ▲	6 (1.2)	9 (1.4)	6 (1.2) ▲	2 (0.9)	39 (2.2) ▲	22 (1.8)
Iran, Islamic Rep. of	4 (0.9)	3 (0.5)	1 (0.5)	1 (0.4)	1 (0.4)	1 (0.3)	6 (1.2) ▲	3 (0.5)
Italy	1 (0.4)	7 (1.0) ▲	3 (0.8)	2 (0.7)	15 (1.4) ▲	6 (0.7)	27 (2.2)	24 (1.7)
Lebanon	7 (1.0)	7 (0.8)	12 (1.8) ▲	5 (0.8)	2 (0.5)	1 (0.2)	11 (1.6)	8 (1.0)
Netherlands	1 (0.6)	7 (0.7) ▲	5 (1.2)	5 (0.6)	6 (1.1) ▲	3 (0.4)	8 (1.5)	6 (0.7)
Norway	1 (0.3)	8 (1.0) ▲	1 (0.8)	1 (0.4)	12 (1.2) ▲	8 (0.8)	13 (1.6)	11 (1.3)
Philippines	10 (1.1)	14 (1.0) ▲	2 (0.4)	2 (0.6)	8 (0.9) ▲	4 (0.8)	10 (1.0) ▲	6 (0.8)
Russian Federation	8 (0.8)	27 (1.8) ▲	6 (0.8)	5 (0.7)	17 (1.2) ▲	5 (0.5)	13 (0.9) ▲	6 (0.6)
Slovenia	2 (0.6)	11 (1.4) ▲	3 (0.7)	3 (0.5)	45 (1.9) ▲	18 (1.6)	11 (1.3)	9 (0.9)
Sweden	1 (0.3)	14 (1.8) ▲	2 (0.6)	2 (0.5)	13 (1.1) ▲	5 (0.6)	19 (2.1) ▲	14 (1.5)

▲ Significantly higher than other gender

Data provided by students.

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

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

SOURCE: IEA TIMSS Advanced 2008 ©

Chapter 5

Advanced Mathematics Teachers and Instruction in Mathematics

To help place students' achievement in advanced mathematics in the context of their school and classroom situations, TIMSS Advanced asked students' teachers to complete questionnaires about their educational preparation to teach advanced mathematics, their school and classroom situations, and the instructional practices they used in teaching advanced mathematics to the students assessed. This chapter begins by presenting teachers' reports about their background characteristics, education, and participation in professional activities and development. The second part of the chapter provides information about a number of aspects of their pedagogical approach to the teaching of mathematics, including the predominant learning activities and technology used as well as the roles of homework and assessment.

Results are generally shown as the percentages of students whose teachers reported various situations. That is, the student is the unit of analysis so that TIMSS Advanced 2008 can describe the students' classroom contexts. The exhibits have special notations when relatively large percentages of students did not have teacher questionnaire information. For a country where teacher responses were available for 70 to 84 percent of the students, an "r" is included next to its data, and in rare cases where teacher responses were available for 50 to 69 percent of students, an “s” is included.

Background Characteristics of Advanced Mathematics Teachers

This section presents information about the background characteristics of the teachers of advanced mathematics, including gender, age, and years of teaching experience. As shown in Exhibit 5.1, Italy was the only country in which approximately equal proportions of advanced mathematics students were taught by male and female mathematics teachers: 54 percent female, and 46 percent male. In the other participating countries there was a clear majority in favor of one gender over the other. In Armenia, the Philippines, the Russian Federation, and Slovenia, most teachers at this level were women. In Iran, Lebanon, the Netherlands, Norway, and Sweden, most were men. At the extremes, in the Russian Federation, 90 percent of the advanced mathematics students were taught by women; while in Lebanon, 90 percent were taught by men.

Exhibit 5.1 also presents teachers’ reports about their age and teaching experience. Perhaps the most striking feature of these results is that two thirds or more of the advanced mathematics students in Lebanon, the Netherlands, and Norway were taught by teachers who were at least 50 years old. In Sweden, the figure was almost 60 percent and in Armenia and Italy was about 45 percent. On the other hand, 55 percent of Iranian students and 61 percent of Philippine students were taught by teachers less than 40 years old. The Philippines had by far the greatest percent of students being taught by teachers less than 30 years old.

As might be expected, the advanced mathematics students were taught by highly experienced teachers. Reported years of experience ranged from a low of 14 years in the Philippines, who had a much

Exhibit 5.1 **Advanced Mathematics Teachers' Gender, Age, and Number of Years Teaching**

TIMSSAdvanced 2008 Advanced Mathematics

Country	Percent of Students by Teacher Characteristics						Average Number of Years Teaching		
	Gender		Age						
	Female	Male	29 Years or Under	30–39 Years	40–49 Years	50 Years or Older	Teaching Altogether		Teaching Mathematics at the Advanced Level
Armenia	76 (4.6)	24 (4.6)	0 (0.0)	10 (2.4)	44 (5.4)	46 (5.4)	25 (0.9)	s	13 (1.2)
Iran, Islamic Rep. of	33 (2.5)	67 (2.5)	6 (2.3)	49 (3.8)	31 (3.4)	13 (2.5)	17 (0.6)		9 (0.3)
Italy	54 (5.4)	46 (5.4)	2 (1.4)	10 (3.0)	43 (4.7)	45 (4.6)	22 (0.9)		12 (0.8)
Lebanon	10 (1.5)	90 (1.5)	3 (0.9)	13 (1.9)	20 (2.0)	65 (2.4)	27 (0.5)		25 (0.5)
Netherlands	14 (3.5)	86 (3.5)	3 (2.0)	10 (2.1)	20 (4.8)	67 (5.2)	27 (1.1)		17 (1.1)
Norway	18 (3.9)	82 (3.9)	1 (0.7)	8 (2.3)	19 (4.2)	73 (4.3)	27 (0.9)		26 (0.9)
Philippines	63 (4.4)	37 (4.4)	25 (4.2)	36 (4.4)	25 (4.5)	14 (3.8)	14 (1.0)		5 (0.5)
Russian Federation	90 (2.7)	10 (2.7)	1 (0.6)	13 (3.0)	36 (5.2)	51 (5.2)	26 (0.8)		12 (0.8)
Slovenia	76 (5.1)	24 (5.1)	4 (1.9)	34 (5.8)	32 (5.9)	30 (5.5)	18 (1.1)		14 (0.7)
Sweden	19 (3.8)	81 (3.8)	2 (1.1)	18 (4.0)	22 (3.3)	58 (4.0)	22 (1.0)		9 (0.7)

SOURCE: IEA TIMSS Advanced 2008 ©

Data provided by teachers.

( ) Standard errors appear in parentheses.

An "s" indicates data are available for at least 50% but less than 70% of the students.

Exhibit 5.2 **Teachers' Plans to Continue Teaching Advanced Mathematics**

TIMSSAdvanced 2008 Advanced Mathematics

Country	Percent of Students by Their Teachers' Plans to Continue Teaching			
	Plan to Continue Teaching as Long as I Can	Plan to Continue Teaching Until the Opportunity for a Better Job in Education Comes Along	Plan to Continue Teaching for Awhile But Probably Will Leave the Field of Education	Undecided at This Time
Armenia	87 (2.7)	1 (0.0)	0 (0.0)	12 (2.7)
Iran, Islamic Rep. of	84 (2.9)	10 (2.4)	2 (1.1)	4 (1.4)
Italy	84 (3.7)	8 (2.5)	3 (2.2)	5 (2.2)
Lebanon	80 (1.9)	12 (1.5)	3 (0.9)	5 (1.2)
Netherlands	93 (2.6)	2 (1.8)	2 (1.7)	2 (1.7)
Norway	79 (5.2)	1 (1.0)	2 (1.4)	18 (5.0)
Philippines	75 (4.8)	17 (4.1)	3 (1.1)	5 (2.7)
Russian Federation	73 (4.1)	1 (1.0)	8 (2.2)	18 (3.7)
Slovenia	58 (5.6)	5 (2.0)	1 (1.0)	35 (5.7)
Sweden	67 (3.8)	4 (2.3)	6 (2.6)	24 (4.3)

SOURCE: IEA TIMSS Advanced 2008 ©

Data provided by teachers.

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

larger proportion of younger teachers than was the case in other countries, to a high of 27 years in Lebanon, the Netherlands, and Norway. Teachers in Armenia (25 years) and the Russian Federation (26 years) were nearly as experienced. Interestingly, teachers in Lebanon and Norway had spent nearly all of their careers teaching advanced mathematics, while in other countries teachers typically reported that only about half of their total years teaching had been spent teaching advanced mathematics.

Teachers were also asked about their plans for the future, insofar as teaching advanced mathematics was concerned. The results, shown in Exhibit 5.2, indicate that most of the advanced mathematics teachers in these countries plan to continue their teaching careers, although significant percentages in some countries—18 percent in Norway and the Russian Federation, 24 percent in Sweden, and 35 percent in Slovenia—were undecided about their future plans. Few teachers in any of the participating countries indicated that they planned to leave the field of education or even that they planned to look for a different position within the field of education. It appears that teachers of advanced mathematics in these countries like their jobs and plan to continue in them at least for a while.

Teacher Education for Teaching Advanced Mathematics

Exhibit 5.3 indicates that virtually every teacher of advanced mathematics in all of the participating countries had a university degree, either at the undergraduate or graduate level. Students in all countries had highly educated teachers (with the possible exception of 5 percent in Lebanon and 1 percent in Norway). In general, the teachers of advanced mathematics in the participating countries who had completed postgraduate university degrees had from five to seven years of university study or even more. Essentially all advanced

Exhibit 5.3 **Highest Educational Level of Advanced Mathematics Teachers***

TIMSSAdvanced2008 Advanced Mathematics

Country	Percent of Students by Their Teachers' Educational Level		
	Completed Postgraduate University Degree**	Completed University But Not a Postgraduate Degree***	Did Not Complete University
Armenia	97 (0.1)	3 (0.1)	0 (0.0)
Iran, Islamic Rep. of	27 (3.3)	73 (3.3)	0 (0.0)
Italy	12 (3.2)	88 (3.2)	0 (0.0)
Lebanon	43 (2.4)	52 (2.5)	5 (0.9)
[a] Netherlands	65 (5.2)	35 (5.2)	0 (0.0)
[b] Norway	71 (4.7)	29 (4.7)	1 (0.6)
Philippines	32 (4.5)	68 (4.5)	0 (0.0)
[c] Russian Federation	79 (3.6)	21 (3.6)	0 (0.0)
[d] Slovenia	100 (0.0)	0 (0.0)	0 (0.0)
Sweden	48 (5.2)	52 (5.2)	0 (0.0)

SOURCE: IEA TIMSS Advanced 2008 ©

Data provided by teachers.

* Based on countries' categorization to UNESCO's International Standard Classification of Education (Operational Manual for ISCED–1997).

** Level 5A, second degree or higher on the ISCED scale.

*** Level 5A, first degree on the ISCED scale.

a In the Netherlands, most teachers who have completed a postgraduate university degree have a university degree in mathematics or physics requiring 3 years of study at the bachelor's level and 2 years at the master's level, and one year of special teacher training. Recently, it has been possible to obtain a 2-year "education master" equivalent to a master's degree. Also, a few teachers in this category have a PhD. Teachers who have completed university but not a postgraduate degree have completed 4 years at a teacher training institute (or college) and obtained a diploma equivalent to a bachelor's degree. To be a teacher at the advanced level of the pre-university track, it also is necessary to complete postgraduate work at a teacher training institute, but this is not considered equivalent to a university's master's degree.

b Norwegian teachers who have completed postgraduate study typically have master's degrees requiring 5–7 years of university study.

c In the Russian Federation, teachers with a postgraduate university degree have completed 5–6 years of higher education, ending with defending a thesis to obtain a diploma (equivalent to a master's degree), and also have passed state examinations. Some teachers in this category may have two diplomas or a doctoral degree.

d Slovenian teachers all have obtained a diploma based on completing 4 years of university study followed by a successful thesis (equivalent to a master's degree). Some have a master's degree based on an additional 2 years of study or a doctoral degree based on 4 years of additional study.

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

mathematics students in Armenia and Slovenia had teachers who had completed postgraduate study as did 79 percent in the Russian Federation, 71 percent in Norway, and 65 percent in the Netherlands.

Teachers were asked to indicate which, from a list of several choices, had been a "major or main area(s) of study" for them in their post-secondary studies. The options available were mathematics, mathematics education, physics, science education, engineering, general education, and other. Teachers were free to identify more than one main area of study, so the percents for each country total more than 100. The results are presented in Exhibit 5.4.

Eighty-five percent or more of the students in six countries had teachers that had specialized in mathematics, including Armenia, Iran, Norway, the Russian Federation, Slovenia, and Sweden. Also, two thirds or more had teachers that had specialized in mathematics education in six countries, including Armenia, Lebanon, the Netherlands, the Philippines, the Russian Federation, and Sweden. The results indicate that the majority of students in all of the participating countries had teachers with mathematics or mathematics education or both as major or main areas of concentration in their post-secondary education. In Norway (63%) and Sweden (70%), substantial proportions of advanced mathematics students had teachers that also said that physics had been a main area of their program. The teachers of Italian students, for the most part, appear to have specialized either in mathematics or physics.

Exhibit 5.5 presents brief descriptions of national requirements for being a teacher of advanced mathematics in each of the participating countries. There is a high degree of commonality across all of these descriptions. Basically, teachers of advanced mathematics in all of these countries are required to have an extensive tertiary level academic background in mathematics and in teacher education. Passing an examination is a requirement in four of the countries—Italy, Lebanon, the Philippines, and Slovenia.

Exhibit 5.4 Teachers' Major or Main Area(s) of Study

TIMSSAdvanced 2008 Advanced Mathematics

Country	Percentage of Students by Their Teachers' Major or Main Area(s) of Study in Their Post-secondary Education						
	Mathematics	Education–Mathematics	Physics	Education–Science	Engineering	Education–General	Other
Armenia	96 (1.6)	77 (3.6)	24 (4.2)	4 (2.4)	0 (0.0)	25 (4.9)	13 (4.2)
Iran, Islamic Rep. of	85 (3.0)	46 (3.9)	1 (0.9)	5 (1.8)	9 (2.7)	6 (2.1)	6 (1.8)
Italy	64 (5.3)	– –	30 (4.8)	– –	5 (2.3)	– –	35 (5.2)
Lebanon	62 (2.2)	82 (1.9)	12 (1.2)	6 (1.3)	4 (1.1)	12 (1.5)	12 (1.5)
Netherlands	49 (5.1)	72 (4.1)	13 (3.7)	2 (1.1)	4 (2.0)	– –	19 (4.7)
Norway	98 (1.2)	6 (2.7)	63 (4.6)	1 (1.1)	12 (3.2)	24 (4.8)	65 (4.4)
Philippines	65 (4.4)	71 (5.1)	6 (2.1)	3 (1.6)	12 (3.3)	22 (5.0)	11 (4.9)
Russian Federation	100 (0.2)	68 (4.0)	16 (2.7)	12 (2.7)	12 (3.1)	46 (4.6)	12 (2.6)
Slovenia	92 (3.2)	9 (3.1)	3 (1.9)	3 (1.9)	3 (1.8)	0 (0.0)	1 (0.6)
Sweden	86 (3.4)	67 (4.5)	70 (4.3)	41 (5.3)	14 (4.1)	20 (4.1)	19 (4.9)

Data provided by teachers.

( ) Standard errors appear in parentheses.

A dash (–) indicates comparable data are not available.

SOURCE: IEA TIMSS Advanced 2008 ©

Exhibit 5.5 National Requirements for Being a Teacher of Advanced Mathematics

TIMSSAdvanced 2008 Advanced Mathematics

Country	Requirements
Armenia	Teachers need the Certificate of Higher Education, with certificates of mathematics education and of professional development in advanced mathematics highly desirable.
Iran, Islamic Rep. of	Teachers need at least a bachelor's degree in mathematics.
Italy	Teachers need to have taken a national examination and completed a degree in mathematics, physics, or engineering.
Lebanon	Teachers must have a degree in mathematics, pass an admission examination to a Faculty of Pedagogy at Lebanese University, and complete 2 years of pedagogical study.
Netherlands	Teachers either have a university master's degree in mathematics followed by a 1-year university education course, or have attended a polytechnic college obtaining a bachelor's degree in mathematics (education) followed by a master's course in mathematics education.
Norway	Teachers are required to have a university bachelor's degree consisting of 1 full year (60 credit points) of mathematics courses. They also need 1 year of teacher education courses, consisting of general pedagogy, mathematics education, and teaching practice in schools.
Philippines	Teachers must be at least an education graduate, major in mathematics, pass the licensure exam for teachers (LET), and be literate in using ICT technology in teaching.
Russian Federation	Teachers need the Certificate of Higher Education, with certificates of mathematics education and of professional development in advanced mathematics highly desirable.
Slovenia	To obtain a teaching license, it is necessary to complete mathematics study together with some pedagogical courses at the Faculty for Mathematics and Physics, teach under supervision of a seminar teacher for 1 year, and pass a teaching certification examination organized by the ministry.
Sweden	Teachers of advanced mathematics have at least 1 year of university study in mathematics as well as a total of at least 3.5–4 years of study in academic subject areas. A degree in teacher education is also expected.

Data provided by National Research Coordinators.

SOURCE: IEA TIMSS Advanced 2008 ©

Advanced Mathematics Teachers' Professional Activities and Development

Teachers in most countries have a choice of a number of professional associations or organizations available to them. They may, as a condition of employment, be required to join, or at least pay membership dues to, the teachers' union that bargains with their employers regarding salaries, working conditions, and the like. However, they may also choose to become members of a professional association, either local or national, that brings together teachers with similar backgrounds and interests to discuss professional matters and promote the cause of mathematics education, for example.

As the results in Exhibit 5.6 make clear, teachers of advanced mathematics in the countries participating were unlikely to belong to a professional organization of mathematics teachers and even less likely to participate regularly in activities sponsored by such organizations. The Netherlands had the largest percentage of students (69%) being taught advanced mathematics by a teacher who belonged to a professional organization of mathematics teachers, and in six countries less than 40 percent of the students were taught by teachers belonging to such an organization. Results regarding participation in professional activities were not any more encouraging. Apparently, teachers of advanced mathematics in these countries do not have the opportunity to join professional organizations or do not see much need to join such organizations or to participate in activities sponsored by them.

The teachers of advanced mathematics were presented with five statements relating to their participation in a range of professional activities. The activities included attending workshops or conferences, making a presentation at a workshop or conference, having an article published in a journal or magazine directed at teachers, taking part in

Exhibit 5.6 **Teachers' Participation in a Professional Organization for Mathematics Teachers**

TIMSSAdvanced 2008 Advanced Mathematics

Country	Percent of Students Whose Teacher Was a Member of a Professional Organization for Mathematics Teachers	Percent of Students Whose Teacher Regularly Participated in Activities Sponsored by a Professional Organization for Mathematics Teachers
Armenia	33 (3.4)	40 (3.2)
Iran, Islamic Rep. of	34 (3.8)	26 (3.6)
Italy	18 (3.7)	29 (4.9)
Lebanon	26 (2.2)	38 (2.2)
Netherlands	69 (5.9)	34 (5.5)
Norway	15 (5.0)	8 (3.1)
Philippines	57 (5.4)	67 (5.2)
Russian Federation	55 (3.6)	18 (3.0)
Slovenia	51 (5.7)	43 (5.5)
Sweden	24 (5.1)	12 (3.3)

SOURCE: IEA TIMSS Advanced 2008 ©

Data provided by teachers.

( ) Standard errors appear in parentheses.

an innovative project for curriculum and instruction, and exchanging information online about teaching mathematics. Students whose teachers had participated in three or more of these activities were categorized at the high level of participation. Those whose teachers had not participated in any of these activities were categorized at the low level, and all the rest were categorized at the medium level.

The information about teachers' participation in professional activities is summarized in Exhibit 5.7. In the table, the countries are presented in descending order of the percentage of students whose teachers were classified at the high level of participation. Also, the results are presented in relation to students' average achievement, although there was little relationship between more participation by teachers and higher achievement except in the Russian Federation.

In the Russian Federation, Slovenia, and the Philippines, less than 10 percent of students were taught by teachers who were classified at the low level of participation in professional activities; all the rest, over 90 percent, were taught by teachers who reported a high or medium level of participation. Results from the other countries were rather disappointing, with over 20 percent of students in six countries taught by teachers who had low levels of participation. In Norway, this was the case for 44 percent of the students.

Another questionnaire item asked teachers whether or not they had participated in professional development in one or more of six areas related to mathematics teaching in the previous two years. The areas were: mathematics content, mathematics pedagogy or instruction, mathematics curriculum, integrating information technology into mathematics, improving students' critical thinking or problem-solving skills, and mathematics assessment.

The results presented in Exhibit 5.8 indicate that in 8 of the 10 countries (everywhere except Lebanon and Norway) the most

Exhibit 5.7 **Index of Teachers' Participation in Professional Activities in Mathematics (PAM)**

TIMSSAdvanced 2008 Advanced Mathematics

Country	High PAM		Medium PAM		Low PAM	
	Percent of Students	Average Achievement	Percent of Students	Average Achievement	Percent of Students	Average Achievement
Russian Federation	46 (4.6)	575 (9.4)	49 (4.6)	552 (10.0)	5 (1.8)	524 (12.3)
Slovenia	30 (5.9)	460 (10.3)	61 (5.9)	458 (6.0)	8 (2.8)	450 (11.2)
Philippines	24 (4.5)	350 (13.4)	68 (4.8)	359 (7.9)	8 (3.2)	342 (32.4)
Iran, Islamic Rep. of	22 (3.1)	502 (16.6)	61 (3.6)	487 (7.3)	18 (2.8)	524 (11.7)
Lebanon	17 (2.1)	548 (5.7)	45 (2.4)	546 (3.0)	38 (2.0)	543 (3.9)
Norway	13 (3.6)	447 (8.5)	43 (5.1)	444 (8.1)	44 (5.7)	432 (7.6)
Armenia	12 (3.4)	440 (31.7)	56 (4.5)	437 (10.0)	32 (2.9)	429 (7.3)
Sweden	12 (3.9)	411 (26.5)	63 (5.4)	417 (6.1)	25 (4.9)	413 (8.3)
Italy	10 (3.1)	427 (24.1)	65 (4.7)	453 (8.4)	25 (4.4)	445 (15.9)
Netherlands	9 (3.2)	553 (9.1)	71 (5.1)	554 (2.4)	20 (4.1)	550 (4.7)

SOURCE: IEA TIMSS Advanced 2008 ©

Based on teachers' responses to five statements about their participation in professional activities: 1) Attended a workshop or conference; 2) Gave a presentation at a workshop or conference; 3) Published an article in a journal or magazine for teachers (print or online); 4) Took part in an innovative project for curriculum and instruction; and 5) Exchanged information online about how to teach mathematics. Students whose teachers participated in three or more of the five activities were assigned to the high level. Students whose teachers did not participate in any activities were assigned to the low level. All other students were assigned to the medium level.

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

Exhibit 5.8 **Teachers' Participation in Professional Development**

TIMSSAdvanced 2008 Advanced Mathematics

Country	Percent of Students Whose Teachers Participated in Professional Development in Various Areas of Mathematics in the Past Two Years					
	Mathematics Content	Mathematics Pedagogy/ Instruction	Mathematics Curriculum	Integrating Information Technology into Mathematics	Improving Students' Critical Thinking or Problem-solving Skills	Mathematics Assessment
Armenia	81 (3.4)	87 (1.7)	75 (4.3)	44 (4.2)	57 (5.0)	67 (4.5)
Iran, Islamic Rep. of	45 (3.7)	63 (3.7)	34 (3.7)	25 (3.1)	29 (3.2)	24 (3.3)
Italy	46 (5.4)	50 (5.6)	19 (4.2)	39 (4.5)	15 (3.6)	19 (3.9)
Lebanon	33 (2.3)	36 (2.4)	27 (2.1)	29 (1.9)	41 (2.3)	42 (2.8)
Netherlands	62 (4.7)	36 (5.9)	41 (6.6)	25 (4.9)	12 (3.6)	6 (2.4)
Norway	42 (4.6)	31 (4.8)	47 (4.5)	53 (5.3)	6 (2.1)	26 (4.0)
Philippines	84 (3.8)	75 (3.9)	70 (4.0)	58 (4.0)	58 (4.9)	– –
Russian Federation	79 (5.1)	68 (3.8)	66 (4.3)	72 (4.3)	55 (4.5)	57 (4.5)
Slovenia	88 (3.4)	81 (3.6)	52 (5.8)	66 (5.3)	42 (6.7)	68 (5.9)
Sweden	51 (5.3)	52 (6.0)	33 (4.3)	34 (5.2)	32 (3.8)	52 (4.6)

SOURCE: IEA TIMSS Advanced 2008 ©

Data provided by teachers.

( ) Standard errors appear in parentheses.

A dash (–) indicates comparable data are not available.

common professional development activities for teachers focused on either mathematics content or mathematics pedagogy and instruction. In general, significantly greater percentages of students in Armenia, the Philippines, the Russian Federation, and Slovenia were taught by teachers who had participated in professional development related to mathematics teaching within the past two years than in the other six countries.

Previous cycles of TIMSS have shown that the extent of professional collaboration among mathematics teachers in the same school varies widely across countries, and Exhibit 5.9 shows that the same is true for teachers of advanced mathematics in the participating countries. On a positive note, the results show that the majority of students in every country were taught by teachers who consulted with colleagues in their school about pedagogical matters several times each month. In fact, in six countries, more than 80 percent of students had teachers that met with their colleagues at least several times a month or even weekly. On the other hand, more than a third of students in Iran, Italy, the Netherlands, and Slovenia were taught by teachers who rarely, if ever, consulted with colleagues in their school about pedagogical matters such as how to teach a particular concept, worked collegially to prepare instructional materials, observed a colleague's teaching, or invited a colleague to observe their teaching.

Exhibit 5.10 presents school principals' reports about how teachers of advanced mathematics were evaluated in each of the participating countries. The results are shown in terms of the percentage of students in each country taught by teachers who were evaluated on the basis of classroom observations by the school principal or a senior staff member, classroom observations by an external examiner or inspector, student achievement, or teacher peer reviews.

Exhibit 5.9 Frequency of Collaboration Among Advanced Mathematics Teachers

TIMSSAdvanced2008 Advanced Mathematics

Country	Percent of Students by Their Teachers' Frequency of Collaboration with Other Teachers		
	At Least Weekly	2 or 3 Times per Month	Never or Almost Never
Armenia	30 (3.5)	70 (3.6)	1 (1.0)
Iran, Islamic Rep. of	7 (2.3)	59 (4.2)	35 (4.2)
Italy	7 (2.7)	53 (3.9)	39 (4.2)
Lebanon	17 (1.9)	64 (1.9)	19 (1.7)
Netherlands	0 (0.0)	55 (5.0)	44 (5.0)
Norway	9 (2.1)	72 (4.4)	19 (4.1)
Philippines	16 (3.9)	73 (3.9)	12 (3.1)
Russian Federation	35 (3.5)	59 (4.2)	6 (2.0)
Slovenia	4 (1.6)	53 (5.9)	43 (5.8)
Sweden	9 (3.1)	75 (5.4)	17 (5.0)

SOURCE: IEA TIMSS Advanced 2008 ©

Based on teachers' responses to four statements about types of interactions among advanced mathematics teachers: discussion about how to teach a particular concept, working on preparing instruction materials, visit to another teachers' classroom to observe his/her teaching, and informal observation of my classroom by another teacher. Responses were provided on a 4-point Likert scale: 1) Never or almost never; 2) 2 or 3 times per month; 3) 1-3 times per week; 4) Daily or almost daily.

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

Exhibit 5.10 Schools' Reports on Ways They Evaluate Mathematics Teachers' Practices

TIMSSAdvanced2008 Advanced Mathematics

Country	Percent of Students by Ways Their Schools Evaluate Mathematics Teachers' Practice			
	Observations by the Principal or Senior Staff	Observations by Inspectors or Other Persons External to the School	Student Achievement	Teacher Peer Review
Armenia	96 (0.4)	45 (0.7)	96 (0.1)	91 (0.4)
Iran, Islamic Rep. of	74 (4.5)	43 (5.2)	98 (1.4)	41 (5.1)
Italy	62 (6.4)	3 (1.8)	93 (3.1)	30 (5.9)
Lebanon	89 (1.9)	42 (2.4)	95 (1.0)	60 (2.4)
Netherlands	r 19 (5.2)	r 29 (5.2)	r 85 (3.5)	r 36 (5.7)
Norway	26 (4.7)	3 (2.1)	81 (5.5)	35 (6.4)
Philippines	99 (0.7)	68 (4.3)	97 (1.1)	83 (3.8)
Russian Federation	99 (0.9)	68 (4.0)	100 (0.0)	89 (2.6)
Slovenia	91 (2.4)	8 (2.4)	84 (3.3)	48 (5.9)
Sweden	58 (5.3)	11 (3.9)	90 (3.7)	44 (5.7)

SOURCE: IEA TIMSS Advanced 2008 ©

Data provided by schools.

( ) Standard errors appear in parentheses.

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

Evaluation of teachers on the basis of their students' achievement is frequently portrayed, by teachers and others, as inherently unjust since it does not take into account differences in students' abilities, work habits, and the like. In spite of such opposition, for these teachers of advanced students, it was by far the most commonly used approach for teacher evaluation in these countries. Over 80 percent of students in every one of the participating countries were taught by teachers who were being evaluated, at least in part, on the basis of how well those students performed in advanced mathematics. The second most popular approach to teacher evaluation was classroom observations by the school principal or a senior staff member. Classroom observations by inspectors and peer reviews were less widely used. There appeared to be less emphasis given to teacher evaluation in the Netherlands and Norway than in the other participating countries, and much more in Armenia, the Philippines, and the Russian Federation.

Characteristics of Advanced Mathematics Classes

Exhibit 5.11 addresses the issue of class size and the relationship between class size and student achievement in advanced mathematics, using data supplied by the participating teachers about their TIMSS Advanced 2008 mathematics classes. The table first shows the average size of advanced mathematics classes in each country. The rest of the table is divided into four sections, one for each of four ranges of class size: viz., 1–24 students, 25–32 students, 33–40 students, and more than 40 students. For each of the four class-size categories, the table indicates the percentage of students in that country who were in an advanced mathematics class within that size range and the average TIMSS Advanced 2008 mathematics scale score for those students.

Only in the Philippines was the average class size greater than 30. In fact, the average was less than 25 in seven countries. The smallest

Exhibit 5.11 Achievement and Class Size for Advanced Mathematics Instruction

TIMSSAdvanced 2008 Advanced Mathematics

Country		Overall Average Class Size	1–24 Students		25–32 Students		33–40 Students		41 or More Students	
			Percent of Students	Average Achievement	Percent of Students	Average Achievement	Percent of Students	Average Achievement	Percent of Students	Average Achievement
Armenia	r	23 (0.3)	67 (3.2)	443 (7.3)	25 (3.1)	429 (13.0)	8 (0.3)	359 (26.6)	0 (0.0)	~ ~
Iran, Islamic Rep. of		30 (1.0)	28 (3.5)	482 (9.3)	41 (4.1)	506 (11.2)	12 (2.9)	496 (17.4)	19 (3.7)	504 (14.8)
Italy		21 (0.3)	80 (4.0)	444 (8.6)	20 (4.0)	465 (10.0)	0 (0.0)	~ ~	0 (0.0)	~ ~
Lebanon		18 (0.2)	78 (1.1)	548 (2.8)	15 (1.0)	533 (3.5)	4 (0.2)	540 (4.1)	4 (0.1)	540 (7.5)
Netherlands		17 (0.6)	82 (4.2)	555 (2.9)	16 (3.8)	547 (4.4)	2 (2.1)	~ ~	0 (0.0)	~ ~
Norway		21 (0.5)	70 (5.4)	437 (6.7)	30 (5.4)	443 (7.4)	0 (0.0)	~ ~	0 (0.0)	~ ~
Philippines		37 (0.7)	4 (1.1)	362 (33.8)	27 (4.1)	379 (11.9)	35 (4.3)	371 (11.4)	35 (5.1)	321 (10.7)
Russian Federation		23 (0.4)	58 (5.9)	565 (7.8)	42 (5.9)	555 (10.7)	0 (0.0)	~ ~	0 (0.0)	~ ~
Slovenia		28 (0.4)	17 (3.3)	400 (10.2)	73 (4.4)	469 (5.2)	11 (3.6)	473 (15.8)	0 (0.0)	~ ~
Sweden		24 (0.6)	46 (6.1)	405 (7.9)	51 (6.3)	420 (7.5)	2 (1.6)	~ ~	0 (0.0)	~ ~

SOURCE: IEA TIMSS Advanced 2008 ©

Data provided by teachers.

( ) 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.

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

Exhibit 5.12 Index of Student Factors Limiting Instruction in Advanced Mathematics

TIMSSAdvanced 2008 Advanced Mathematics

Country		High (Few or No Limitations)		Medium (Some Limitations)		Low (Many Limitations)	
		Percent of Students	Average Achievement	Percent of Students	Average Achievement	Percent of Students	Average Achievement
Norway		52 (5.2)	444 (5.4)	45 (4.9)	435 (8.0)	4 (2.3)	421 (48.6)
Netherlands		47 (4.6)	555 (3.5)	53 (4.6)	551 (3.5)	0 (0.0)	~ ~
Sweden		44 (5.5)	422 (6.8)	53 (5.6)	407 (7.5)	3 (1.4)	389 (17.2)
Armenia	r	35 (4.4)	441 (17.1)	56 (4.7)	426 (11.0)	9 (1.5)	444 (17.8)
Slovenia		34 (6.0)	484 (7.7)	64 (5.9)	445 (6.2)	2 (1.4)	~ ~
Lebanon		33 (2.3)	549 (4.0)	61 (2.4)	542 (2.9)	6 (1.0)	535 (9.4)
Russian Federation		32 (3.7)	585 (11.2)	56 (4.1)	549 (9.6)	12 (2.7)	552 (19.3)
Philippines		29 (4.7)	371 (9.4)	57 (4.7)	347 (9.1)	14 (3.1)	359 (14.1)
Italy		22 (5.5)	482 (12.6)	70 (5.5)	443 (9.0)	8 (2.8)	404 (17.8)
Iran, Islamic Rep. of		11 (2.4)	522 (18.9)	58 (3.8)	498 (8.0)	32 (3.8)	487 (10.1)

SOURCE: IEA TIMSS Advanced 2008 ©

Based on teachers' responses to five statements about student factors limiting mathematics instruction: 1) Students with different academic abilities; 2) Students who come from a wide range of backgrounds; 3) Students with special needs; 4) Uninterested students; and 5) Disruptive students. Responses were provided on a 4-point scale: 1. Not at all; 2. A little; 3. Some; and 4. A lot. Students in the high category had teachers who reported few (if any) limitations, on average (less than 2), and those in the low category had teachers that reported their instruction was limited a lot, on average (greater than 3). The remaining students fell into the medium category.

( ) 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.

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

average class size, 17 students, was found in the Netherlands. The finding of relatively small class sizes is further illustrated in the table by the low percentages of students registered in classes with 33 or more students. The results do not show any consistent relationship between class size and students' average achievement except perhaps in an association of higher achievement with smaller classes in Armenia and the Netherlands.

Many factors are known to present challenges to effective teaching, including the student composition of the classes. The teachers of advanced mathematics were asked to estimate to what extent five student-related factors limited their approaches to teaching. The five factors were: students with different academic abilities, students who came from a wide range of backgrounds, students with special needs, uninterested students, and disruptive students. Responses were given on a 4-point scale: *not at all*, *a little*, *some*, and *a lot*. TIMSS Advanced used the teachers' responses to construct an Index of Student Factors Limiting Instruction in Advanced Mathematics. Students were included in the high category if, on average, their teacher reported that there were few, if any, limitations of their instruction due to student factors. They were in the low category if, on average, teachers reported that student factors placed many limitations on their instruction. The remaining students constituted the medium category.

The results are presented in Exhibit 5.12. In the table, the countries are presented in descending order of the percentage of students in the high category. Considering that the students taking advanced mathematics are a select group and are in relatively small classes, it might be surprising that teachers said the composition of their classes did limit their teaching at least somewhat for substantial percentages of students. In general, students in the high category had higher achievement than students in the medium and low categories. However, only in Norway were the slim majority of advanced mathematics students in classes in the high category where teachers reported that characteristics of the students presented few, if any limitations on their teaching. In the rest of the participating countries, the majority of students were in the medium category where teachers reported some limitations on average. In Iran, 32 percent of advanced mathematics students were taught by teachers who felt that the student factors presented many limitations on their instruction.

Activities in Advanced Mathematics Lessons

Exhibits 5.13 and 5.14 summarize the reports by students and by their teachers, respectively, about the frequency of occurrence of six instructional activities related to thinking skills covered in the TIMSS Advanced 2008 cognitive domains. The activities included memorizing formulas and procedures, solving problems like the ones in the student textbook, using mathematical terms to represent relationships, discussing problem-solving strategies, deciding which procedures to use in solving complex problems, and communicating arguments. Students were also asked about how frequently they watched the teacher demonstrate mathematics on a computer.

Exhibit 5.13 shows the percentages of students reporting that an activity occurred in at least half the lessons in their advanced mathematics class. The three activities identified by most students in nine countries as having occurred in at least half of their advanced mathematics classes were solving problems like the examples in their textbooks, using mathematical terminology to represent relationships, and discussing problem-solving strategies. The first and third of these activities are closely related and, taken together, likely indicate that working on mathematics problems in some fashion is a prevalent activity in advanced mathematics classes in these countries. In

Exhibit 5.13 Students' Reports on Frequency of Various Learning Activities in Advanced Mathematics Lessons

TIMSSAdvanced2008 Advanced Mathematics

Country	Percent of Students Who Reported Doing the Activity in About Half the Lessons or More						
	Memorize Formulas and Procedures	Solve Problems Like the Examples in Our Textbook	Use Mathematical Terms to Represent Relationships	Discuss Problem-solving Strategies	Decide Procedures for Solving Complex Problems	Communicate Arguments	Watch the Teacher Demonstrate Mathematics on a Computer
Armenia	71 (1.8)	74 (1.8)	r 59 (2.0)	r 75 (2.1)	r 52 (2.5)	r 57 (2.3)	r 15 (1.8)
Iran, Islamic Rep. of	78 (1.3)	70 (1.2)	66 (1.3)	41 (1.3)	43 (1.5)	47 (1.3)	5 (0.9)
Italy	26 (1.2)	68 (2.2)	50 (1.6)	57 (1.9)	23 (1.6)	42 (2.4)	5 (0.8)
Lebanon	63 (1.4)	77 (1.2)	80 (0.9)	82 (1.1)	63 (1.2)	71 (1.2)	12 (1.0)
Netherlands	14 (1.4)	94 (0.7)	69 (1.5)	45 (2.2)	32 (1.7)	22 (1.5)	11 (2.2)
Norway	15 (1.0)	76 (1.4)	36 (1.5)	21 (1.1)	19 (1.0)	16 (1.1)	7 (1.6)
Philippines	78 (1.4)	76 (1.3)	82 (0.7)	85 (0.9)	47 (1.1)	58 (1.5)	7 (0.9)
Russian Federation	54 (1.7)	68 (1.9)	73 (1.3)	91 (0.9)	65 (1.5)	73 (1.2)	10 (1.2)
Slovenia	23 (1.2)	83 (1.3)	59 (1.6)	63 (1.6)	37 (1.9)	37 (1.8)	29 (1.4)
Sweden	82 (1.0)	84 (1.1)	69 (1.3)	43 (1.7)	39 (1.3)	23 (1.5)	6 (1.8)

SOURCE: IEA TIMSS Advanced 2008 ©

Data provided by students.

( ) Standard errors appear in parentheses.

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

Exhibit 5.14 Teachers' Reports on Frequency of Various Learning Activities in Advanced Mathematics Lessons

TIMSSAdvanced2008 Advanced Mathematics

Country	Percent of Students Whose Teachers Reported Students Doing the Activity in About Half the Lessons or More					
	Memorize Formulas and Procedures	Solve Problems Like the Examples in Their Textbooks	Use Mathematical Terms to Represent Relationships	Discuss Problem-solving Strategies	Decide Procedures for Solving Complex Problems	Communicate Arguments
Armenia	r 75 (4.2)	r 93 (1.4)	r 57 (3.1)	r 74 (3.3)	r 52 (3.0)	r 48 (4.4)
Iran, Islamic Rep. of	49 (4.0)	92 (2.4)	85 (2.9)	74 (3.5)	68 (3.8)	67 (3.8)
Italy	14 (3.2)	73 (5.0)	75 (4.0)	86 (3.4)	49 (6.4)	73 (3.6)
Lebanon	57 (2.1)	83 (2.2)	83 (1.8)	91 (0.9)	63 (2.3)	86 (1.6)
Netherlands	17 (5.1)	95 (2.3)	40 (5.8)	65 (4.4)	43 (4.4)	63 (4.5)
Norway	24 (5.9)	83 (3.9)	42 (4.9)	36 (4.9)	36 (4.8)	43 (5.0)
Philippines	39 (6.0)	62 (5.5)	76 (4.2)	78 (4.1)	68 (5.0)	73 (4.9)
Russian Federation	24 (3.3)	51 (3.4)	79 (3.9)	98 (1.6)	50 (6.3)	78 (4.6)
Slovenia	31 (5.7)	78 (4.3)	66 (5.7)	61 (5.4)	57 (6.9)	74 (5.2)
Sweden	17 (3.6)	70 (4.7)	71 (4.3)	65 (5.1)	50 (5.7)	45 (4.2)

SOURCE: IEA TIMSS Advanced 2008 ©

Data provided by teachers.

( ) Standard errors appear in parentheses.

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

Sweden, Iran, the Philippines, and Armenia, students also reported that memorizing formulas and procedures was a prevalent activity. Interestingly, according to Norwegian students, the only one of these activities that occurred in half or more of their advanced mathematics classes was solving problems similar to those in their textbooks. Watching the teacher demonstrate mathematics on a computer was selected by the smallest proportion of students in every country except Slovenia where it ranked second to last before memorizing rules and procedures.

Exhibit 5.14 shows the percentages of students whose teachers reported that an activity occurred in at least half the lessons. In agreement with the students, their teachers identified that the same three activities occurred with the largest percentages of students—solving problems like the examples in the textbooks, using mathematical terms to represent relationships, and discussing problem-solving strategies. Also, according to teachers' reports, memorizing formulas and procedures was not used nearly as extensively as reported by the students except in Armenia and Lebanon. In Sweden, the difference between teachers' and students' estimates was 65 percentage points: 83 percent for students and 18 for teachers. Iran, the Philippines, and the Russian Federation also had large differences on this point.

Exhibit 5.15 presents information about the use of textbooks in advanced mathematics classes in the participating countries. At least 83 percent of students in every country were taught by teachers who used one or more textbooks in their teaching. In fact, nearly all students (98 to 100%) were taught using a textbook in five countries: Armenia, Italy, the Netherlands, Norway, and Sweden. The table also shows that textbooks were authorized for use in the schools by a national authority in six countries, but this was not the case in the other four.

Exhibit 5.15 **Policy and Usage of Textbooks**

TIMSS Advanced 2008
Advanced Mathematics

Country	Textbooks Certified by National Authority	Percent of Students		Percent of Students Whose Teachers Require Them to Do the Following Activities in Half of the Lessons or More		
		Whose Teachers Use Textbooks for Teaching	Who Have Their Own Textbooks	Do Problems or Exercises from Their Textbooks	Read the Textbook Examples of How to Do Problems or Exercises	Read About Mathematical Theory from Their Textbooks
Armenia	●	r 100 (0.0)	r 95 (0.1)	r 95 (1.8)	r 71 (3.4)	r 65 (5.3)
Iran, Islamic Rep. of	●	96 (1.4)	98 (1.0)	96 (1.7)	92 (2.0)	81 (3.4)
Italy	○	98 (1.3)	94 (2.0)	96 (2.5)	58 (5.0)	55 (5.4)
Lebanon	●	87 (1.4)	89 (1.6)	91 (1.9)	69 (2.4)	69 (2.2)
Netherlands	○	100 (0.0)	100 (0.0)	98 (1.5)	66 (5.8)	56 (5.7)
Norway	○	100 (0.0)	100 (0.0)	99 (0.9)	64 (4.9)	53 (5.0)
Philippines	●	85 (3.3)	32 (4.1)	61 (6.2)	51 (6.2)	45 (5.5)
Russian Federation	●	83 (3.1)	97 (1.7)	86 (3.7)	40 (4.3)	41 (4.6)
Slovenia	●	94 (2.8)	91 (2.7)	68 (5.8)	28 (4.1)	16 (4.1)
Sweden	○	98 (1.8)	100 (0.0)	100 (0.4)	45 (5.5)	27 (4.7)

● Yes ○ No

SOURCE: IEA TIMSS Advanced 2008 ©

Data provided by National Research Coordinators and by teachers.
( ) Standard errors appear in parentheses.

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

The rightmost three data columns in the table provide information about how textbooks were used in advanced mathematics classrooms. Over 85 percent of students in eight of the participating countries—all but the Philippines and Slovenia—were taught by teachers who had them solve problems from the textbook. The other two alternatives for textbook use, reading examples of problem or exercise solutions provided in the textbook and reading about mathematical theory from the textbook, had much less support. Iran was the only country where more than 80 percent of the students had teachers who required these activities in at least half their advanced mathematics lessons.

The final exhibit in this section, Exhibit 5.16, focuses on the percentage of class time allocated by teachers of advanced mathematics to each of several activities. The activities listed were teaching new material to whole class, students working on problems or exercises either on their own or with other students, reviewing and summarizing what has been taught for the whole class, reviewing homework, reteaching and clarifying content or procedures for the whole class, oral or written tests or quizzes, classroom management tasks not related to the content or purpose of the lesson, and other activities. In responding to this item, teachers were asked to ensure that the total across all eight categories of activities came to 100 percent.

For students in every one of these countries, two activities—teaching new material to the class as a whole and students working on problems on their own or with other students—accounted for over 40 percent of the time in advanced mathematics classes. The whole class activities of reviewing what has been taught and reteaching or clarifying content and procedures each accounted for about 7 to 13 percent of the time, with reviewing homework accounting for as little as 5 percent of the time in Slovenia or Sweden to as much as 14 percent of the time in the Netherlands. The most variation across countries was

Exhibit 5.16 **Teachers' Reports of the Percent of Time in Mathematics Lessons Spent on Various Activities in a Typical Week**

TIMSSAdvanced 2008
Advanced Mathematics

Country		Teaching New Material to the Whole Class		Students Working on Problems on Their Own or with Other Students		Reviewing and Summarizing What Has Been Taught for the Whole Class		Reviewing Homework
Armenia	r	27 (0.6)	r	23 (0.3)	r	10 (0.4)	r	7 (0.2)
Iran, Islamic Rep. of		43 (1.4)		15 (0.8)		8 (0.6)		7 (0.4)
Italy		27 (1.3)		13 (0.9)		11 (0.6)		13 (0.9)
Lebanon		23 (0.5)		22 (0.5)		11 (0.3)		10 (0.3)
Netherlands		21 (1.3)		43 (1.6)		8 (0.5)		14 (1.1)
Norway		28 (1.1)		39 (1.6)		8 (0.4)		9 (0.6)
Philippines		26 (1.3)		21 (0.9)		10 (0.6)		8 (0.4)
Russian Federation		23 (1.0)		29 (1.1)		12 (0.6)		8 (0.4)
Slovenia		37 (1.7)		18 (1.2)		13 (1.0)		5 (0.3)
Sweden		26 (0.6)		42 (1.1)		10 (0.6)		5 (0.4)

Country		Reteaching and Clarifying Content/Procedures for the Whole Class		Oral or Written Tests or Quizzes		Classroom Management Tasks not Related to the Lesson's Content/Purpose (e.g., Interruptions and Keeping Order)		Other Activities
Armenia	r	12 (0.5)	r	15 (0.4)	r	5 (0.2)	r	3 (0.1)
Iran, Islamic Rep. of		7 (0.4)		10 (0.5)		5 (0.4)		4 (0.3)
Italy		12 (0.7)		18 (0.9)		3 (0.4)		2 (0.5)
Lebanon		12 (0.3)		11 (0.3)		5 (0.2)		5 (0.2)
Netherlands		7 (0.4)		1 (0.3)		2 (0.3)		3 (0.7)
Norway		7 (0.8)		7 (0.5)		1 (0.3)		1 (0.2)
Philippines		10 (0.5)		16 (0.6)		5 (0.3)		4 (0.4)
Russian Federation		9 (0.4)		16 (0.7)		1 (0.1)		2 (0.3)
Slovenia		8 (0.8)		12 (0.6)		3 (0.3)		4 (0.4)
Sweden		9 (0.4)		6 (0.5)		2 (0.3)		1 (0.2)

SOURCE: IEA TIMSS Advanced 2008 ©

Data provided by teachers.

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

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

in the time devoted to tests or quizzes, ranging from only 1 percent in the Netherlands to 18 percent of the time in Italy. Very little time was taken up with classroom management tasks, at most 5 percent, and the "other" category also accounted for only a small proportion of time.

Technology Use in Advanced Mathematics Classes

Exhibit 5.17 focuses on the extent to which different technologies were used in advanced mathematics classes in the participating countries. The exhibit is divided into three parts: the first part dealing with calculators, the second with computers, and the third with other computing technology. Students were asked to indicate how frequently each of the three was used: in every or almost every lesson, in about half the lessons, in some lessons, or never. The table shows, for each country and for each frequency-of-usage category, the percent of students who chose that category and the average advanced mathematics achievement for those students.

In three countries—the Netherlands, Norway, and Sweden—most students (91 to 92%) said that they used calculators in every or almost every advanced mathematics class. In another three countries, about half (48 to 52%) the students said that they used calculators this frequently—Lebanon, the Philippines, and Slovenia. At the other extreme, significant proportions of students in Iran (30%) and the Russian Federation (24%) indicated that they never used calculators in their advanced mathematics classes.

In most countries, there was no obvious link between the extent of calculator use and students' achievement. With few exceptions, the differences in average scale scores across usage categories were often small and the patterns across countries were inconsistent. In Slovenia, where calculators were used by all students at least in some lessons, there was an association between more frequent use of calculators and

Exhibit 5.17 **Students' Reports of Frequency of Using Different Technologies in Advanced Mathematics Lessons**

TIMSSAdvanced 2008 Advanced Mathematics

Country		Frequency of Using Calculators							
		Every or Almost Every Lesson		About Half the Lessons		Some Lessons		Never	
		Percent of Students	Average Achievement	Percent of Students	Average Achievement	Percent of Students	Average Achievement	Percent of Students	Average Achievement
Armenia	r	36 (2.3)	446 (8.3)	16 (1.9)	442 (14.6)	37 (2.2)	432 (7.2)	11 (1.2)	432 (13.3)
Iran, Islamic Rep. of		5 (0.6)	461 (11.8)	16 (1.2)	456 (7.2)	50 (1.2)	493 (5.9)	30 (1.6)	534 (8.6)
Italy		28 (2.0)	460 (8.0)	21 (1.1)	461 (8.3)	38 (1.5)	442 (8.5)	13 (1.2)	426 (11.7)
Lebanon		48 (1.5)	547 (2.6)	27 (1.1)	549 (4.5)	24 (1.2)	538 (4.8)	1 (0.3)	~ ~
Netherlands		92 (0.8)	553 (2.7)	6 (0.7)	557 (5.0)	2 (0.4)	~ ~	0 (0.1)	~ ~
Norway		92 (1.9)	442 (4.5)	4 (0.5)	393 (16.2)	2 (0.7)	~ ~	3 (1.1)	438 (22.2)
Philippines		49 (2.4)	350 (7.8)	27 (1.3)	356 (6.2)	23 (1.8)	360 (6.8)	1 (0.3)	~ ~
Russian Federation		22 (2.1)	549 (12.1)	16 (0.7)	555 (10.0)	38 (2.0)	562 (7.5)	24 (2.0)	574 (8.0)
Slovenia		52 (2.6)	474 (5.2)	32 (1.8)	449 (5.1)	15 (1.3)	427 (7.1)	1 (0.2)	~ ~
Sweden		91 (1.5)	416 (5.0)	5 (0.9)	412 (18.8)	2 (0.6)	~ ~	1 (0.3)	~ ~

Country		Frequency of Using Computers							
		Every or Almost Every Lesson		About Half the Lessons		Some Lessons		Never	
		Percent of Students	Average Achievement	Percent of Students	Average Achievement	Percent of Students	Average Achievement	Percent of Students	Average Achievement
Armenia	r	2 (0.7)	~ ~	2 (0.5)	~ ~	14 (1.6)	461 (15.0)	82 (1.9)	438 (5.3)
Iran, Islamic Rep. of		1 (0.3)	~ ~	2 (0.3)	~ ~	17 (1.0)	499 (10.1)	80 (1.2)	500 (6.2)
Italy		1 (0.2)	~ ~	2 (0.5)	~ ~	15 (1.9)	461 (13.8)	82 (2.1)	448 (7.4)
Lebanon		2 (0.4)	~ ~	4 (0.5)	506 (8.4)	19 (1.2)	547 (5.1)	74 (1.2)	549 (2.6)
Netherlands		1 (0.3)	~ ~	2 (0.7)	~ ~	30 (3.0)	554 (3.7)	67 (3.2)	553 (2.8)
Norway		7 (2.6)	450 (11.4)	2 (0.7)	~ ~	8 (1.6)	450 (11.9)	83 (3.5)	438 (4.9)
Philippines		1 (0.2)	~ ~	4 (0.6)	354 (17.8)	27 (1.6)	347 (8.2)	68 (1.9)	359 (5.6)
Russian Federation		1 (0.3)	~ ~	3 (0.4)	557 (14.0)	19 (2.1)	586 (11.5)	78 (2.4)	555 (6.7)
Slovenia		1 (0.6)	~ ~	4 (0.9)	443 (17.0)	28 (4.0)	462 (7.3)	66 (4.2)	457 (5.1)
Sweden		0 (0.1)	~ ~	0 (0.2)	~ ~	10 (1.7)	414 (11.9)	89 (1.7)	414 (5.4)

SOURCE: IEA TIMSS Advanced 2008 ©

Data provided by students.

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

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

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

Exhibit 5.17 **Students' Reports of Frequency of Using Different Technologies in Advanced Mathematics Lessons (Continued)**

TIMSSAdvanced 2008 Advanced Mathematics

Country		Frequency of Using Other Computing Technology							
		Every or Almost Every Lesson		About Half the Lessons		Some Lessons		Never	
		Percent of Students	Average Achievement	Percent of Students	Average Achievement	Percent of Students	Average Achievement	Percent of Students	Average Achievement
Armenia	r	2 (0.8)	~ ~	3 (0.8)	365 (30.2)	11 (1.6)	455 (17.9)	85 (2.3)	441 (5.0)
Iran, Islamic Rep. of		1 (0.2)	~ ~	2 (0.3)	~ ~	13 (0.9)	481 (10.3)	84 (1.0)	503 (6.1)
Italy		0 (0.1)	~ ~	1 (0.2)	~ ~	6 (0.9)	411 (14.9)	92 (1.0)	452 (7.2)
Lebanon		2 (0.4)	~ ~	4 (0.6)	512 (9.7)	15 (1.1)	535 (4.8)	79 (1.3)	551 (2.7)
Netherlands		3 (0.5)	545 (7.5)	2 (0.5)	~ ~	13 (1.0)	548 (4.7)	83 (1.3)	554 (2.8)
Norway		1 (0.4)	~ ~	0 (0.2)	~ ~	9 (1.0)	451 (9.4)	90 (1.1)	440 (4.9)
Philippines		1 (0.2)	~ ~	6 (0.5)	328 (8.9)	29 (1.2)	341 (6.8)	64 (1.5)	366 (5.6)
Russian Federation		3 (0.5)	531 (10.2)	4 (0.5)	555 (12.5)	18 (1.2)	568 (9.2)	75 (1.6)	561 (7.3)
Slovenia		2 (0.6)	~ ~	2 (0.5)	~ ~	14 (2.0)	461 (9.1)	82 (2.4)	457 (4.2)
Sweden		– –	– –	– –	– –	– –	– –	– –	– –

SOURCE: IEA TIMSS Advanced 2008 ©

Data provided by students.

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

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

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

higher achievement. Students reporting calculator use in every lesson had the highest achievement, followed by those using calculators in half the lessons, and then, only some lessons. Interestingly, in the Russian Federation there were significant numbers of students in each of the four usage categories, with a slight category-by-category progression of higher achievement corresponding to less calculator use. Of the Iranian students, those who reported never using calculators in class had the highest average achievement.

The second part of Exhibit 5.17 deals with computer use in advanced mathematics classes, and the results show that computer use remains far from prevalent in these countries. At least two thirds of students from every participating country said that computers were never used in their advanced mathematics classes. Conversely, from 10 to 33 percent of students said that they used computers in at least some of their mathematics classes. This finding may have been anticipated since many of the topics in advanced mathematics courses at this level likely do not lend themselves well to the use of computers. Once again, most of the between-group differences in average achievement were small and did not consistently favor one group over the others.

The third part of Exhibit 5.17 concerns what was called "other computing technology" in the student questionnaire, and that term might not have been familiar to many students. In any case, the data show that such technologies are not in widespread use. Seventy-five percent or more of students in every country except the Philippines said that they never used other computing technology of any kind in their advanced mathematics classes.

Students were also asked to indicate what type of calculator they usually used, if they did use a calculator in their advanced mathematics class. Four types of calculators were listed and accompanied by brief descriptions, as follows:

- Simple calculator – basic functions only (+, –, ×, ÷, %, or √), without functions like log, sin, cos
- Scientific calculator – basic functions (+, –, ×, ÷, %, or √), and also functions like log, sin, cos
- Graphing calculator – scientific and also able to display some graphs
- Symbolic calculator – graphing and also able to solve expressions in symbolic terms

Exhibit 5.18 presents the percentage of students in each country who reported using each type of calculator. As discussed under 5.17 and reproduced here for reference (in the last data column), Iran and the Russian Federation were the only countries in which significant numbers of students reported that they never used calculators in advanced mathematics classes. Everywhere else, almost all students reported that they used some type of calculator in class. Norway (18%) and Sweden (11%) were the only countries in which appreciable numbers of students indicated that they used symbolic calculators. Most of the rest of students in Norway (76%) and Sweden (85%), as well as nearly all students in the Netherlands (95%), reported using a graphing calculator. Most students used a scientific calculator in Italy (79%), Lebanon (88%), the Philippines (95%), and Slovenia (93%).

Teachers were also asked about the kinds of calculators their students used during advanced mathematics classes, and their responses are presented in Exhibit 5.19. On the whole, teachers' responses about calculator use in their classes coincided with those of their students; however, there were a few differences, most no doubt stemming from a difference of opinion about what constituted, say, a symbolic calculator as opposed to a graphing calculator. For example, in Norway, both students and teachers agreed that there was an

Exhibit 5.18 **Students' Reports on Types of Calculators Used During Advanced Mathematics Lessons**

TIMSSAdvanced2008 Advanced Mathematics

Country		Percent of Students Using				Percent of Students Who Never Used a Calculator
		Simple Calculator	Scientific Calculator	Graphing Calculator	Symbolic Calculator	
Armenia	r	60 (2.1)	26 (2.2)	1 (0.4)	2 (0.7)	11 (1.2)
Iran, Islamic Rep. of		41 (1.7)	27 (1.3)	1 (0.2)	1 (0.2)	30 (1.6)
Italy		5 (0.8)	79 (1.4)	2 (0.3)	1 (0.2)	13 (1.2)
Lebanon		5 (0.6)	88 (0.9)	3 (0.5)	3 (0.4)	1 (0.3)
Netherlands		0 (0.1)	0 (0.1)	95 (0.7)	5 (0.6)	0 (0.1)
Norway		0 (0.1)	3 (0.5)	76 (3.1)	18 (2.5)	3 (1.1)
Philippines		1 (0.2)	95 (1.3)	2 (1.2)	1 (0.2)	1 (0.3)
Russian Federation		33 (1.9)	42 (2.0)	1 (0.2)	0 (0.1)	24 (2.0)
Slovenia		4 (0.6)	93 (0.7)	1 (0.2)	1 (0.2)	1 (0.2)
Sweden		0 (0.1)	2 (0.5)	85 (1.5)	11 (1.4)	1 (0.3)

SOURCE: IEA TIMSS Advanced 2008 ©

Data provided by students.

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

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

Exhibit 5.19 **Teachers' Reports on the Types of Calculators Used by Students in the TIMSS Class During Advanced Mathematics Lessons**

TIMSSAdvanced2008 Advanced Mathematics

Country		Percent of Students Using				Percent of Students Who Never Used a Calculator
		Simple Calculator	Scientific Calculator	Graphing Calculator	Symbolic Calculator	
Armenia	r	62 (4.9)	29 (3.8)	3 (2.0)	1 (0.0)	5 (3.3)
Iran, Islamic Rep. of		37 (4.2)	35 (4.1)	0 (0.0)	0 (0.0)	28 (3.7)
Italy		3 (1.8)	91 (3.1)	6 (2.6)	0 (0.0)	0 (0.0)
Lebanon		6 (1.0)	87 (1.6)	3 (0.5)	3 (1.0)	1 (0.7)
Netherlands		0 (0.3)	0 (0.0)	99 (1.0)	1 (0.0)	0 (0.0)
Norway		2 (1.9)	0 (0.0)	92 (3.1)	5 (2.2)	1 (1.0)
Philippines		0 (0.0)	95 (2.0)	4 (1.8)	1 (0.6)	1 (0.0)
Russian Federation		30 (3.9)	57 (4.4)	0 (0.0)	0 (0.0)	13 (2.8)
Slovenia		10 (3.2)	90 (3.2)	0 (0.0)	0 (0.0)	0 (0.0)
Sweden		0 (0.0)	0 (0.1)	99 (0.8)	1 (0.6)	0 (0.0)

SOURCE: IEA TIMSS Advanced 2008 ©

Data provided by teachers.

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

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

extremely high usage of graphing or symbolic calculators, even though they differed as to how that total was partitioned between the two types. In Italy, though, there was a discrepancy in reports about use—teachers reported use for all students compared to 13 percent of the students reporting they never used calculators in their lessons.

Exhibit 5.20 presents data from teachers about the kinds of situations in which students were most likely to use calculators or computers in their advanced mathematics classes. The data are presented in terms of the percentage of students taught by teachers who estimated that their students used calculators or computers in a given situation in half of the lessons or more. The given situations were drawing graphs of functions, solving equations, modeling and simulation, numerical integration, and processing and analyzing data.

According to the teachers, calculators or computers were used in more classrooms and for more different activities in the Netherlands, Norway, and Sweden than they were elsewhere. In general, calculators or computers were reported to be used most heavily for drawing graphs of functions in the Netherlands, Norway, and Sweden and more generally across countries for solving equations. The least supported category across countries was using calculators or computers for modeling and simulation.

The last page of each TIMSS Advanced 2008 mathematics test booklet asked students to indicate whether or not they had used a calculator during the test, what type and brand of calculator they had used, and how extensively they had made use of it. They were given three choices for the last item: very little (for fewer than 5 questions), somewhat (for between 5 and 10 questions), and quite a lot (for more than 10 questions). The results are displayed in Exhibit 5.21, together with trend data on changes between the two cycles of TIMSS Advanced

Exhibit 5.20 Teachers' Reports on Calculator or Computer Usage in Advanced Mathematics Class

TIMSSAdvanced 2008
Advanced Mathematics

Country	Percent of Students Whose Teachers Reported on Calculator or Computer Usage in About Half of the Lessons or More				
	Drawing Graphs of Functions	Solving Equations	Modeling and Simulation	Numerical Integration	Processing and Analyzing Data
Armenia	r 15 (4.3)	r 25 (3.0)	r 6 (0.3)	r 4 (0.2)	r 10 (0.3)
Iran, Islamic Rep. of	6 (2.1)	10 (1.9)	4 (1.7)	6 (2.1)	10 (2.7)
Italy	10 (3.3)	17 (4.3)	4 (2.4)	4 (2.1)	13 (3.6)
Lebanon	r 10 (1.7)	r 41 (2.8)	s 11 (2.4)	r 10 (1.5)	r 13 (2.1)
Netherlands	82 (4.1)	57 (5.8)	4 (1.9)	14 (3.5)	21 (4.6)
Norway	69 (3.9)	49 (5.5)	7 (2.9)	25 (4.3)	11 (3.6)
Philippines	9 (3.0)	47 (5.6)	11 (3.5)	19 (3.5)	24 (5.2)
Russian Federation	8 (2.5)	19 (3.4)	5 (1.9)	13 (2.8)	26 (3.6)
Slovenia	12 (4.2)	16 (4.3)	7 (3.5)	7 (2.8)	18 (4.0)
Sweden	88 (3.0)	42 (5.4)	23 (5.3)	46 (5.5)	48 (4.7)

SOURCE: IEA TIMSS Advanced 2008 ©

Data provided by teachers.

( ) Standard errors appear in parentheses.

An "r" indicates data are available for at least 70% but less than 85% of the students. An "s" indicates data are available for at least 50% but less than 70% of the students.

Exhibit 5.21 **Trends in Students' Reports of Calculator Use During the TIMSS Advanced Mathematics Test**

TIMSSAdvanced2008 Advanced Mathematics

Country		Used Calculator Quite a Lot (More than 10 Questions)				Used Calculator Somewhat (5–10 Questions)			
		2008 Percent of Students	1995 Percent of Students	2008 Average Achievement	1995 Average Achievement	2008 Percent of Students	1995 Percent of Students	2008 Average Achievement	1995 Average Achievement
Armenia	s	3 (0.6)	◊ ◊	417 (23.3)	◊ ◊	10 (1.7)	◊ ◊	458 (18.2)	◊ ◊
Iran, Islamic Rep. of		0 (0.1)	◊ ◊	~ ~	◊ ◊	4 (0.5)	◊ ◊	442 (19.0)	◊ ◊
Italy		3 (0.4)	2 (0.5)	442 (16.5)	~ ~	17 (1.2)	13 (2.8)	449 (7.9) ▼	480 (10.8)
Lebanon		2 (0.4)	◊ ◊	~ ~	◊ ◊	20 (1.3)	◊ ◊	552 (4.3)	◊ ◊
Netherlands		34 (1.7)	◊ ◊	556 (3.5)	◊ ◊	45 (1.4)	◊ ◊	553 (2.9)	◊ ◊
Norway		19 (1.3)	◊ ◊	472 (5.9)	◊ ◊	43 (1.1)	◊ ◊	446 (5.1)	◊ ◊
Philippines		9 (0.7)	◊ ◊	349 (11.7)	◊ ◊	35 (1.6)	◊ ◊	359 (7.4)	◊ ◊
Russian Federation	r	1 (0.2)	1 (0.3)	~ ~	~ ~	13 (0.7) ▲	8 (1.0)	558 (9.8) ▲	522 (10.9)
Slovenia		6 (1.0) ▲	1 (0.4)	479 (11.6)	~ ~	31 (1.5) ▲	10 (1.3)	468 (5.1)	483 (13.3)
Sweden		16 (1.1) ▲	11 (1.2)	455 (7.6) ▼	513 (11.9)	34 (1.4) ▼	46 (2.1)	437 (4.7) ▼	508 (4.3)

Country		Used Calculator Very Little (Less than 5 Questions)				Did Not Use a Calculator			
		2008 Percent of Students	1995 Percent of Students	2008 Average Achievement	1995 Average Achievement	2008 Percent of Students	1995 Percent of Students	2008 Average Achievement	1995 Average Achievement
Armenia	s	25 (1.6)	◊ ◊	477 (8.3)	◊ ◊	63 (2.2)	◊ ◊	420 (5.9)	◊ ◊
Iran, Islamic Rep. of		31 (1.8)	◊ ◊	499 (8.7)	◊ ◊	65 (1.9)	◊ ◊	503 (6.9)	◊ ◊
Italy		50 (1.8)	47 (3.6)	458 (7.9) ▼	496 (10.4)	31 (1.9)	38 (5.1)	434 (10.4)	472 (19.9)
Lebanon		58 (1.5)	◊ ◊	550 (2.9)	◊ ◊	20 (1.4)	◊ ◊	540 (4.6)	◊ ◊
Netherlands		20 (1.3)	◊ ◊	554 (3.3)	◊ ◊	1 (0.4)	◊ ◊	~ ~	◊ ◊
Norway		34 (1.3)	◊ ◊	422 (5.7)	◊ ◊	5 (0.5)	◊ ◊	379 (15.0)	◊ ◊
Philippines		41 (1.5)	◊ ◊	362 (4.8)	◊ ◊	15 (1.9)	◊ ◊	331 (12.1)	◊ ◊
Russian Federation	r	54 (1.3) ▲	41 (2.0)	565 (7.2)	558 (8.8)	32 (1.5) ▼	50 (2.4)	555 (8.4)	557 (9.5)
Slovenia		46 (1.3) ▼	64 (2.4)	466 (4.8) ▼	494 (9.8)	16 (1.6) ▼	26 (2.4)	416 (6.5)	438 (10.9)
Sweden		38 (1.2)	39 (2.0)	396 (7.2) ▼	497 (9.1)	11 (1.5) ▲	3 (0.7)	339 (10.4) ▼	468 (25.1)

▲ 2008 significantly higher than 1995

▼ 2008 significantly lower than 1995

Data provided by students.

Depending on the booklet assigned, students responded to 36-38 mathematics items. Items were designed to be answered without a calculator, and students were asked to show their work for constructed-response items. However, about half the items could be answered using a graphing or symbolic calculator.

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

A diamond (◊) indicates the country did not participate in the 1995 assessment.

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

An "r" indicates data are available for at least 70% but less than 85% of the students. An "s" indicates data are available for at least 50% but less than 70% of the students.

SOURCE: IEA TIMSS Advanced 2008 ©

for the four countries that participated in both 1995 and 2008: Italy, the Russian Federation, Slovenia, and Sweden.

As would be anticipated based on the heavy use of calculators in their instruction, the most use of calculators on the TIMSS Advanced 2008 mathematics test was reported by students in the Netherlands, Norway, and Sweden. Slightly more than a third of Dutch students said they had used their calculators on at least 10 of the test items, and between 15 and 20 percent of Norwegian and Swedish students said the same. In five of the seven other countries—Armenia, Iran, Italy, Lebanon, and the Russian Federation—more than three fourths of students said that they had either not used their calculators on the test at all, or had used them on fewer than five items.

In the four countries that participated in both cycles of the study—Italy, the Russian Federation, Slovenia, and Sweden—the trend data showed increases in the proportions of students using calculators in 2008 compared to 1995 in the Russian Federation and Slovenia. The Slovenian students moved into the higher use categories and those in the Russian Federation moved into the middle use categories. There was essentially no change in use for Italian students. Interestingly, in Sweden the percentage of students in the "somewhat" category decreased while the percentages increased in the two extremes of using the calculator "quite a lot" or "very little." The students' average achievement associated with the usage categories basically reflects students' overall patterns and changes between the two assessment cycles.

The Role of Homework in Advanced Mathematics Instruction

Exhibit 5.22 contains teachers' reports about their emphasis on homework. For the Index of Teachers' Emphasis on Mathematics Homework, students in the high category had teachers who reported

Exhibit 5.22 **Index of Teachers' Emphasis on Advanced Mathematics Homework (EMH)**

TIMSSAdvanced 2008 Advanced Mathematics

Country	High EMH		Medium EMH		Low EMH	
	Percent of Students	Average Achievement	Percent of Students	Average Achievement	Percent of Students	Average Achievement
Russian Federation	95 (2.2)	559 (7.3)	5 (2.2)	587 (19.4)	0 (0.0)	~ ~
Italy	88 (3.5)	454 (7.3)	11 (3.3)	425 (22.5)	1 (1.1)	~ ~
Lebanon	83 (1.8)	546 (2.5)	10 (1.4)	528 (4.5)	7 (1.2)	552 (14.9)
Armenia	82 (0.7)	428 (6.0)	13 (0.6)	466 (6.8)	4 (0.2)	434 (15.3)
Iran, Islamic Rep. of	79 (3.0)	502 (7.5)	10 (2.0)	481 (12.6)	12 (2.3)	473 (16.2)
Norway	70 (4.0)	440 (5.7)	16 (4.2)	442 (12.0)	14 (2.4)	430 (9.7)
Netherlands	53 (5.5)	553 (3.4)	27 (5.3)	552 (4.4)	20 (4.1)	552 (6.5)
Slovenia	47 (5.6)	467 (7.3)	46 (5.7)	453 (9.3)	7 (3.0)	435 (13.3)
Sweden	39 (4.8)	426 (7.1)	23 (4.5)	419 (10.3)	38 (5.7)	397 (8.8)
Philippines	34 (4.5)	383 (10.2)	53 (4.7)	343 (9.1)	13 (2.6)	329 (17.5)

SOURCE: IEA TIMSS Advanced 2008 ©

Based on teachers' responses to three questions about whether they assign mathematics homework, how often they usually assign mathematics homework and how many minutes of mathematics homework they usually assign. Students in the high category were assigned more than 30 minutes of homework about half of the lessons or more, and those in low category were assigned less than 30 minutes of homework about half of the lessons or less. The medium category includes all other possible combinations of responses.

( ) 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.

giving relatively long homework assignments (more than 30 minutes) on a relatively frequent basis (in about half the lessons or more). Students in the low category had teachers who gave short assignments (less than 30 minutes) relatively infrequently (in about half the lessons or less). The medium level includes all other possible combinations of teachers' responses. The exhibit shows, for each country, the percentage of students in each category together with their average TIMSS Advanced 2008 mathematics scale score. The countries are listed in descending order of the proportion of students in the high category.

Nearly all students in the Russian Federation were in the high category (95%), followed by Italy (88%). Approximately 80 percent of the students were in the high category in Lebanon, Armenia, and Iran. With 38 percent, Sweden had the most students whose teachers assigned very little, if any homework (i.e., they assigned 30 minutes or less of homework in no more than half their lessons). The Netherlands also had 20 percent of its students in this category. Teachers in the other countries responded such that 86 percent or more of their students were in either the high or medium group. The data concerning a relationship between amount of homework assigned and students' achievement differed across countries. In half of the countries, there was a positive relationship between the amount of homework assigned and students' achievement (Italy, Iran, Slovenia, Sweden, and the Philippines). Interestingly, in Norway and the Netherlands average achievement was essentially the same across the high, medium, and low homework classifications.

Teachers were also asked about how frequently they included, as part of a homework assignment for their students, each of five activities: doing problem/question sets; reading the textbook; memorizing formulas and procedures; gathering, analyzing, and reporting data; and finding one or more applications of the content covered. The results are presented in Exhibit 5.23 in terms of the percentage of students in

Exhibit 5.23 **Teachers' Reports on the Kinds of Mathematics Homework Assigned to the TIMSS Advanced Mathematics Class**

TIMSSAdvanced2008 Advanced Mathematics

Country	Percent of Students by Types of Homework Assigned by Their Teachers								
	Doing Problem/Question Sets			Reading the Textbook			Memorizing Formulas and Procedures		
	Always or Almost Always	Sometimes	Never or Almost Never	Always or Almost Always	Sometimes	Never or Almost Never	Always or Almost Always	Sometimes	Never or Almost Never
Armenia	r 89 (2.4)	11 (2.4)	0 (0.0)	r 50 (6.3)	40 (6.1)	9 (1.6)	r 70 (5.3)	19 (5.2)	11 (0.5)
Iran, Islamic Rep. of	70 (3.8)	29 (3.7)	1 (0.7)	50 (4.1)	46 (4.3)	3 (1.5)	33 (4.5)	50 (4.6)	16 (2.6)
Italy	93 (3.6)	6 (2.9)	2 (1.3)	36 (5.1)	50 (5.5)	15 (4.0)	10 (3.2)	56 (5.6)	34 (4.8)
Lebanon	83 (1.6)	16 (1.6)	1 (0.1)	37 (2.2)	55 (2.6)	8 (1.8)	37 (2.4)	51 (2.3)	12 (1.2)
Netherlands	100 (0.0)	0 (0.0)	0 (0.0)	22 (5.8)	42 (5.7)	36 (6.0)	0 (0.0)	48 (6.0)	52 (6.0)
Norway	87 (3.3)	13 (3.3)	0 (0.0)	32 (4.1)	52 (4.5)	17 (3.7)	10 (5.1)	46 (5.9)	44 (5.0)
Philippines	62 (5.7)	38 (5.7)	0 (0.0)	15 (3.5)	68 (4.2)	17 (3.7)	30 (5.2)	57 (5.2)	13 (3.6)
Russian Federation	97 (1.7)	3 (1.7)	0 (0.0)	46 (4.4)	46 (4.8)	8 (2.7)	39 (3.9)	53 (4.3)	8 (2.5)
Slovenia	95 (3.3)	5 (3.3)	0 (0.0)	0 (0.0)	38 (6.2)	62 (6.2)	5 (1.6)	43 (7.3)	52 (7.3)
Sweden	87 (3.5)	11 (3.9)	2 (1.6)	17 (3.9)	52 (5.8)	31 (5.6)	1 (0.8)	34 (6.5)	66 (6.4)

Country	Percent of Students by Types of Homework Assigned by Their Teachers					
	Gathering, Analyzing, and Reporting Data			Finding One or More Applications of the Content Covered		
	Always or Almost Always	Sometimes	Never or Almost Never	Always or Almost Always	Sometimes	Never or Almost Never
Armenia	r 33 (4.3)	52 (4.0)	15 (2.3)	r 10 (2.6)	69 (3.8)	21 (2.9)
Iran, Islamic Rep. of	31 (4.2)	58 (4.6)	11 (2.1)	18 (3.2)	64 (4.2)	18 (3.0)
Italy	4 (2.1)	43 (5.1)	52 (5.1)	22 (3.9)	56 (6.3)	23 (5.1)
Lebanon	36 (3.0)	50 (2.9)	15 (1.5)	27 (2.2)	61 (2.3)	12 (1.2)
Netherlands	1 (0.1)	21 (5.2)	78 (5.3)	2 (1.2)	13 (4.3)	86 (4.4)
Norway	0 (0.0)	18 (3.9)	82 (3.9)	0 (0.0)	30 (5.0)	70 (5.0)
Philippines	13 (3.1)	65 (4.9)	21 (4.4)	18 (3.8)	75 (4.3)	8 (2.8)
Russian Federation	18 (3.5)	69 (3.9)	13 (2.9)	33 (4.4)	63 (4.0)	4 (1.9)
Slovenia	0 (0.0)	43 (5.6)	57 (5.6)	0 (0.0)	32 (5.5)	68 (5.5)
Sweden	0 (0.0)	28 (4.5)	72 (4.5)	0 (0.0)	36 (5.6)	64 (5.6)

Data provided by teachers.

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

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

SOURCE: IEA TIMSS Advanced 2008 ©

each country whose teachers indicated that they assigned a particular activity *always or almost always, sometimes*, or *never or almost never.*

The most popular kind of homework assignment in every one of these countries was "doing problem/question sets." Virtually 100 percent of the students in every country were asked to complete such an assignment for homework at least sometimes and in many countries the majority of students were asked to do so always or almost always. Reading from the textbook and memorizing formulas and procedures were also assigned at least sometimes for a clear majority of students in a number of the countries. Except that these activities were used less frequently, in general, cross-national patterns varied with respect to the other two activities: data analysis and finding applications of recently covered content.

Students were asked about how much homework they did, and how frequently that homework involved three of the five activities that teachers had also been asked about: doing problem/question sets, reading the textbook, and memorizing formulas and procedures. Their responses are summarized in Exhibit 5.24. For each country, the exhibit indicates the average number of hours per week that the students spent on mathematics homework as well as the percentage of students who reported that they "always or almost always", "sometimes", or "never or almost never" had homework that involved each of those activities.

Students' reports tended to correspond with the reports of their teachers—that is, students appear to be doing the assigned homework. Students in the Netherlands, Norway, and Sweden recorded the lowest average number of hours per week spent on mathematics homework: less than two hours in total. Students in Lebanon and the Russian Federation reported spending about three times as much time on mathematics homework: about six hours

Exhibit 5.24 **Students' Reports on the Time Spent Doing Various Kinds of Mathematics Homework**

TIMSSAdvanced 2008 Advanced Mathematics

Country	Average Hours per Week Spent Doing Mathematics Homework	Percent of Students Doing Various Activities for Mathematics Homework								
		Problem/Question Sets			Read the Textbook			Memorize Formulas and Procedures		
		Always or Almost Always	Sometimes	Never or Almost Never	Always or Almost Always	Sometimes	Never or Almost Never	Always or Almost Always	Sometimes	Never or Almost Never
Armenia	r 4.3 (0.15)	r 54 (2.1)	42 (2.0)	4 (0.9)	r 31 (2.0)	57 (2.1)	11 (1.2)	r 51 (2.4)	43 (2.2)	6 (1.0)
Iran, Islamic Rep. of	r 5.3 (0.11)	49 (1.5)	49 (1.5)	2 (0.4)	45 (1.6)	46 (1.5)	9 (0.8)	45 (1.4)	51 (1.3)	5 (0.6)
Italy	2.8 (0.11)	44 (2.1)	42 (1.6)	14 (1.3)	15 (1.5)	53 (1.3)	32 (1.7)	29 (1.9)	54 (1.7)	17 (1.4)
Lebanon	5.9 (0.10)	62 (1.5)	36 (1.5)	2 (0.3)	25 (1.0)	62 (1.3)	13 (1.0)	38 (1.2)	48 (1.3)	13 (0.9)
Netherlands	1.7 (0.07)	75 (1.2)	21 (1.2)	4 (0.6)	21 (1.4)	58 (1.7)	21 (2.0)	3 (0.5)	36 (2.1)	61 (1.9)
Norway	1.7 (0.05)	87 (0.9)	12 (0.8)	1 (0.3)	32 (1.8)	56 (1.5)	12 (1.5)	4 (0.5)	38 (1.7)	58 (1.6)
Philippines	3.1 (0.08)	49 (1.0)	49 (1.0)	1 (0.2)	15 (1.3)	68 (1.1)	17 (1.6)	44 (2.0)	53 (1.9)	3 (0.4)
Russian Federation	6.0 (0.17)	80 (1.1)	19 (1.0)	1 (0.2)	15 (1.2)	65 (1.2)	20 (1.3)	54 (1.5)	42 (1.3)	3 (0.5)
Slovenia	r 2.0 (0.12)	72 (2.5)	25 (2.2)	3 (0.6)	r 3 (0.4)	30 (2.3)	67 (2.3)	8 (1.0)	56 (2.2)	37 (2.2)
Sweden	s 1.1 (0.06)	r 77 (1.3)	22 (1.2)	2 (0.4)	r 45 (1.6)	48 (1.5)	7 (0.8)	r 16 (1.1)	58 (1.7)	26 (1.9)

SOURCE: IEA TIMSS Advanced 2008 ©

Data provided by teachers.

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

An "r" indicates data are available for at least 70% but less than 85% of the students. An "s" indicates data are available for at least 50% but less than 70% of the students.

a week. Students in Iran also reported relatively heavy homework schedules of about five hours per week. According to over 85 percent of students in each of the participating countries, their mathematics homework at least sometimes included doing problem/question sets. The lowest levels of homework activity were reported for reading the textbook in Slovenia and for memorizing formulas and procedures in the Netherlands and Norway. Apart from these three exceptions, a majority of students in every country reported that their mathematics homework included one or more of these three activities at least sometimes.

Types of Assessments Used in Advanced Mathematics Classes

This section concerns the assessment practices used by teachers of advanced mathematics in the participating countries to monitor their students' progress. Teachers were asked about the degree of emphasis they assigned to each of three possible data sources: classroom tests (e.g., teacher-made or textbook tests), informal assessment, and other tests. For each source, teachers indicated whether it was given major emphasis, some emphasis, or little or no emphasis. Results are presented in Exhibit 5.25 in terms of the percentage of students who were taught by teachers who reported that a given data source was accorded major, some, or little emphasis in their evaluation procedures.

Teachers in all the participating countries said that they placed much more emphasis on classroom tests (e.g., teacher-made or textbook tests) as sources of data on student progress than on either of the two other alternatives. Ninety-six percent or more of students in every one of these 10 countries were taught by teachers who indicated that they placed either major or some emphasis on such tests. The two other forms of assessment—informal assessment and other tests—were used by many teachers, but less emphasis was given to them.

Exhibit 5.25 **Teachers' Emphasis on Sources to Monitor Students' Progress in Mathematics**

TIMSSAdvanced2008 Advanced Mathematics

Country	Percent of Students by Their Teachers' Emphasis on Various Sources to Monitor Students' Progress								
	Classroom Tests (e.g., Teacher-made or Textbook Tests)			Informal Assessment			Other Tests		
	Major Emphasis	Some Emphasis	Little or No Emphasis	Major Emphasis	Some Emphasis	Little or No Emphasis	Major Emphasis	Some Emphasis	Little or No Emphasis
Armenia	67 (4.2)	29 (4.2)	4 (0.2)	6 (3.1)	42 (4.7)	52 (5.8)	44 (5.0)	35 (4.6)	21 (2.1)
Iran, Islamic Rep. of	62 (4.5)	35 (4.3)	3 (1.2)	20 (3.4)	49 (4.1)	31 (3.7)	17 (3.4)	44 (4.3)	38 (3.9)
Italy	71 (5.0)	29 (5.0)	0 (0.0)	18 (4.0)	60 (5.4)	23 (4.6)	17 (3.5)	51 (5.1)	33 (5.5)
Lebanon	72 (2.4)	23 (2.3)	4 (1.1)	r 39 (2.6)	37 (2.3)	24 (2.2)	r 24 (2.5)	43 (2.8)	33 (2.9)
Netherlands	96 (1.8)	2 (1.4)	1 (1.1)	5 (1.8)	16 (3.9)	78 (4.3)	– –	– –	– –
Norway	96 (1.7)	4 (1.7)	0 (0.0)	6 (1.8)	65 (4.4)	29 (4.7)	– –	– –	– –
Philippines	87 (3.4)	12 (3.3)	1 (0.0)	45 (5.5)	50 (6.0)	6 (2.4)	r 15 (3.7)	54 (5.6)	31 (4.5)
Russian Federation	95 (2.0)	4 (1.8)	1 (0.9)	20 (3.8)	55 (5.0)	25 (3.7)	12 (3.2)	51 (4.6)	37 (3.6)
Slovenia	75 (5.2)	23 (4.9)	2 (1.7)	51 (6.0)	43 (6.0)	6 (2.5)	18 (4.8)	55 (5.1)	27 (4.9)
Sweden	76 (3.8)	23 (3.8)	1 (0.5)	28 (4.0)	59 (5.0)	12 (3.7)	74 (4.1)	25 (3.9)	1 (0.0)

SOURCE: IEA TIMSS Advanced 2008 ©

Data provided by teachers.

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

A dash (–) indicates comparable data are not available.

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

In most participating countries, significant proportions of students were taught by teachers who gave little or no emphasis to either of these alternatives.

Exhibit 5.26 provides information about how often teachers administered tests or examinations to their TIMSS Advanced 2008 mathematics classes. Teachers were asked to select one of four alternatives: at least once a month, about every other month, about 2 or 3 times a year, and never. For each of these four groups, the results in Exhibit 5.26 show the percentage of students taught by teachers in that category and the average mathematics achievement for those students.

All students of advanced mathematics in these countries were taught by teachers who gave tests or examinations at least several times during the year. In every country except the Netherlands, at least three fourths of students (much more than three fourths in most cases) were administered a test or examination at least every other month. In Italy, the Philippines, and the Russian Federation, three fourths or more of the students were tested at least monthly. With the possible exception of Armenia, the direction of the achievement differences in a given country across the four groups of students did not favor one group over the others in a consistent fashion.

Exhibit 5.27 provides information about the item formats advanced mathematics students in these countries were most likely to see on tests and examinations. Teachers were asked to report whether the tests and examinations they administered to their students consisted of constructed-response items only, mostly constructed-response items, about half constructed-response and half objective items, mostly objective items, or only objective items. For each of these five groups, the results in Exhibit 5.27 show the percentages of students whose teachers used the various formats and the average achievement of those students.

Exhibit 5.26 Frequency of Advanced Mathematics Tests

TIMSSAdvanced 2008 Advanced Mathematics

Country	Percent of Students Whose Teachers Give a Mathematics Test or Examination							
	At Least Once a Month		About Every Other Month		About 2 or 3 Times a Year		Never	
	Percent of Students	Average Achievement	Percent of Students	Average Achievement	Percent of Students	Average Achievement	Percent of Students	Average Achievement
Armenia	r 42 (3.5)	453 (10.0)	r 34 (1.9)	432 (5.1)	r 24 (2.9)	396 (14.9)	r 0 (0.1)	~ ~
Iran, Islamic Rep. of	43 (4.1)	505 (10.3)	34 (4.0)	485 (8.9)	23 (2.9)	500 (12.6)	0 (0.0)	~ ~
Italy	85 (3.5)	452 (7.8)	11 (3.1)	423 (31.4)	5 (1.9)	434 (15.1)	0 (0.0)	~ ~
Lebanon	71 (2.1)	544 (3.0)	25 (2.0)	545 (3.9)	5 (0.6)	545 (6.0)	0 (0.0)	~ ~
Netherlands	5 (2.2)	543 (8.5)	59 (5.2)	553 (3.3)	36 (5.3)	553 (3.9)	0 (0.0)	~ ~
Norway	33 (5.6)	434 (7.8)	67 (5.6)	442 (6.0)	0 (0.0)	~ ~	0 (0.0)	~ ~
Philippines	75 (4.3)	363 (7.4)	21 (4.2)	331 (13.1)	4 (1.5)	360 (39.3)	0 (0.0)	~ ~
Russian Federation	93 (2.0)	560 (8.1)	7 (2.0)	578 (18.1)	0 (0.0)	~ ~	0 (0.0)	~ ~
Slovenia	29 (5.1)	456 (11.2)	70 (5.2)	460 (4.7)	1 (0.9)	~ ~	0 (0.0)	~ ~
Sweden	15 (4.4)	424 (10.2)	68 (5.4)	406 (7.0)	17 (3.9)	431 (12.4)	0 (0.0)	~ ~

SOURCE: IEA TIMSS Advanced 2008 ©

Data provided by teachers.

( ) 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.

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

Exhibit 5.27 Formats of Questions Used by Teachers in Advanced Mathematics Tests or Examinations

TIMSSAdvanced 2008 Advanced Mathematics

Country	Only Constructed-response		Mostly Constructed-response		About Half Constructed-response and Half Objective (e.g., Multiple-choice)		Mostly Objective		Only Objective	
	Percent of Students	Average Achievement	Percent of Students	Average Achievement	Percent of Students	Average Achievement	Percent of Students	Average Achievement	Percent of Students	Average Achievement
Armenia	8 (1.9)	422 (15.0)	4 (0.1)	443 (33.4)	59 (4.7)	435 (8.5)	26 (4.6)	452 (16.2)	3 (0.1)	396 (20.3)
Iran, Islamic Rep. of	10 (2.4)	464 (10.9)	33 (4.2)	488 (9.4)	48 (4.5)	506 (10.4)	8 (2.3)	507 (25.9)	0 (0.0)	~ ~
Italy	31 (4.6)	474 (10.3)	48 (6.2)	456 (10.7)	14 (3.7)	398 (20.7)	6 (2.3)	374 (12.5)	1 (0.8)	~ ~
Lebanon	5 (1.0)	556 (9.1)	35 (2.3)	551 (4.6)	25 (2.0)	546 (4.2)	31 (1.8)	533 (3.5)	4 (0.8)	547 (5.0)
Netherlands	94 (2.4)	553 (2.7)	2 (1.3)	~ ~	2 (1.2)	~ ~	2 (1.6)	~ ~	0 (0.0)	~ ~
Norway	19 (4.4)	438 (9.7)	47 (5.3)	438 (6.9)	20 (3.8)	444 (12.5)	10 (3.4)	429 (12.4)	3 (1.8)	435 (25.6)
Philippines	0 (0.0)	~ ~	27 (5.6)	354 (13.5)	66 (5.0)	356 (7.9)	5 (1.5)	381 (33.3)	1 (1.5)	~ ~
Russian Federation	23 (3.7)	568 (10.4)	43 (4.0)	571 (8.5)	34 (4.5)	543 (14.3)	0 (0.0)	~ ~	0 (0.0)	~ ~
Slovenia	58 (6.2)	475 (6.2)	38 (6.3)	436 (9.5)	4 (2.1)	396 (25.8)	0 (0.0)	~ ~	1 (0.8)	~ ~
Sweden	56 (4.7)	417 (7.5)	43 (4.7)	407 (7.4)	1 (0.7)	~ ~	0 (0.0)	~ ~	0 (0.0)	~ ~

SOURCE: IEA TIMSS Advanced 2008 ©

Data provided by teachers.

( ) 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.

There was substantial variation across countries in testing approaches. In the Netherlands, almost 95 percent of students were taught by teachers whose tests consisted exclusively of constructed-response items, the only country where that was the case. Slovenia and Sweden also reported extensive use of constructed-response items, exclusively for the majority of students and mostly for nearly all the rest of the students. Mostly constructed-response tests or tests that included both constructed-response and objective items were used for two thirds or more of students in Iran, Lebanon, Norway, the Philippines, and the Russian Federation. The most use of objective items (e.g., multiple-choice items) was reported in Armenia and Lebanon where over a quarter of students were taught by teachers whose tests were mostly objective. In the other countries, less than 10 percent of students were in that category. Once again, between-group, within-country differences in achievement did not favor one group over the others in a consistent fashion.

The focus of Exhibit 5.28 is the level of cognitive demand teachers emphasized in the mathematics tests they administered to their TIMSS Advanced 2008 students. Teachers were asked to indicate the frequency (always or almost always, sometimes, never or almost never) with which they included items requiring each of four levels of cognitive demand (recall of facts and procedures, application of mathematical procedures, searching for patterns and relationships, and explanations or justifications) on their tests. For each of these four cognitive-demand categories, the results in Exhibit 5.28 show the percentage of students who were taught by teachers in that category.

At least 97 percent of students in every country were taught by teachers who said that the tests they administered to their advanced mathematics students at least sometimes included items that required students to apply mathematical procedures. At least 94 percent of

Exhibit 5.28 Types of Questions in Advanced Mathematics Tests

TIMSSAdvanced 2008 Advanced Mathematics

Country	Percent of Students by Types of Questions Teachers Include in Their Mathematics Tests								
	Questions Based Primarily on Recall of Facts and Procedures			Questions Involving Application of Mathematical Procedures			Questions Involving Searching for Patterns and Relationships		
	Always or Almost Always	Sometimes	Never or Almost Never	Always or Almost Always	Sometimes	Never or Almost Never	Always or Almost Always	Sometimes	Never or Almost Never
Armenia	53 (2.9)	47 (2.9)	0 (0.0)	82 (3.3)	15 (3.3)	3 (0.2)	24 (4.0)	73 (4.0)	3 (0.1)
Iran, Islamic Rep. of	60 (4.0)	39 (3.9)	1 (0.9)	57 (3.7)	42 (3.6)	1 (0.7)	34 (4.0)	63 (4.2)	3 (1.1)
Italy	23 (5.0)	57 (4.8)	19 (4.1)	85 (4.0)	15 (4.0)	0 (0.0)	21 (5.3)	62 (5.2)	17 (3.5)
Lebanon	26 (2.2)	58 (2.5)	15 (1.7)	67 (2.6)	32 (2.6)	1 (0.5)	45 (2.6)	54 (2.6)	1 (0.5)
Netherlands	26 (4.8)	21 (4.7)	53 (5.6)	86 (4.3)	13 (4.2)	1 (0.7)	39 (5.3)	52 (5.7)	9 (3.3)
Norway	50 (5.0)	42 (5.3)	8 (2.8)	77 (4.1)	23 (4.1)	0 (0.0)	25 (3.7)	62 (4.1)	12 (2.2)
Philippines	28 (4.9)	67 (5.0)	5 (1.9)	91 (2.9)	8 (2.7)	1 (0.0)	38 (4.3)	58 (4.3)	4 (1.9)
Russian Federation	42 (3.9)	51 (4.6)	8 (2.4)	86 (2.9)	14 (2.9)	0 (0.0)	39 (3.9)	58 (4.2)	4 (1.9)
Slovenia	85 (4.3)	15 (4.3)	0 (0.0)	92 (3.2)	8 (3.2)	0 (0.0)	40 (6.0)	56 (6.2)	3 (1.9)
Sweden	17 (4.2)	32 (4.4)	52 (5.0)	83 (4.0)	17 (4.0)	0 (0.0)	14 (3.4)	73 (4.2)	12 (3.0)

SOURCE: IEA TIMSS Advanced 2008 ©

Country	Percent of Students by Types of Questions Teachers Include in Their Mathematics Tests (Continued)		
	Questions Requiring Explanations or Justifications		
	Always or Almost Always	Sometimes	Never or Almost Never
Armenia	74 (4.8)	23 (4.8)	3 (0.2)
Iran, Islamic Rep. of	33 (4.0)	61 (4.0)	5 (1.5)
Italy	58 (4.7)	42 (4.7)	0 (0.0)
Lebanon	75 (2.2)	24 (2.2)	1 (0.4)
Netherlands	44 (4.7)	55 (4.7)	0 (0.0)
Norway	48 (4.8)	45 (4.3)	6 (3.0)
Philippines	30 (4.9)	66 (5.1)	4 (1.8)
Russian Federation	87 (3.2)	11 (3.0)	2 (1.6)
Slovenia	8 (2.8)	68 (5.5)	25 (4.6)
Sweden	85 (3.6)	15 (3.6)	0 (0.0)

Data provided by teachers.

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

students in every country except Slovenia were taught by teachers who at least sometimes included items requiring explanations or justifications on their tests. Eighty-three percent or more of students were taught by teachers whose tests at least sometimes included items calling for students to investigate mathematical patterns and relationships. The largest differences occurred in asking students to recall facts or procedures. In the Netherlands and Sweden, half the students (51–53%) were never asked these types of questions on tests, and in Italy and Lebanon 15 to 19 percent were never asked such questions. In the rest of the countries, nearly all students were taught by teachers whose tests at least sometimes, if not always or almost always, included items based on recall of facts and procedures. Taken as a whole, the results indicate that the tests and examinations advanced mathematics students are administered in these countries typically contain items requiring all four levels of cognitive demand.

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Chapter 6

School Contexts for Advanced Mathematics Learning and Instruction

Chapter 6 presents information about the school contexts for teaching and learning advanced mathematics among the countries that participated in TIMSS Advanced 2008. Considerable research indicates that a school environment conducive to learning is important for students to have high achievement. This chapter describes the school environments in the participating countries and how supportive they may be in helping to bring students to high levels of learning. In particular, information is provided about the principals' roles in their schools and the availability of mathematics teachers, as well as principals' and teachers' perceptions of their schools' climates and of school safety. Information also is provided about the adequacy of resources for teaching advanced mathematics, including the availability of various types of technology.

Much of the data in this chapter was collected through questionnaires administered to schools, and completed by the principals or school heads assisted by school personnel. Results are generally shown as the percentages of students whose schools reported various characteristics. That is, the student is the unit of analysis so that TIMSS Advanced 2008 can describe students' school contexts.

The exhibits have special notations if relatively large percentages of students did not have school questionnaire information. That is, in several cases an “r” is included next to the data because data was available for less than 85 percent of the students, but available for at least 70 percent.

Role of the School Principal and Availability of Mathematics Teachers

Even if a country has established a rigorous and coherent curriculum in advanced mathematics, there are various ways that the school environment can help or hinder classroom instruction in that curriculum. This section presents information about two school staffing issues that can impact students’ opportunity to learn the intended curriculum. First, because research shows that achievement improves in schools where principals are effective instructional leaders, data is presented about how principals spend their time. Second, since qualified teachers are important for effective instruction, data is provided about the degree of difficulty schools are having in recruiting mathematics teachers to fill final year vacancies.

Principals that are effective instructional leaders may actively advocate, nurture, and sustain a positive school culture and an education program conducive to students’ learning and teachers’ professional growth. Because the primary roles that the principal fulfills provide a useful indication of the administrative and educational structures and priorities of the school, the principals of the schools offering advanced mathematics courses were asked how they distributed their time across the competing demands of administrative, instructional, supervisory, disciplinary, teaching, and public relations tasks.

Exhibit 6.1 presents, for each country, the percentage of time that principals reported they would have spent on the different types of

Exhibit 6.1 **Principals' Percent of Time Spent on Various School-related Activities**

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Advanced Mathematics

Country	Administrative Duties (e.g., Hiring, Budgeting, Scheduling, Meetings)	Instructional Leadership (e.g., Developing Curriculum and Pedagogy)	Supervising and Evaluating Teachers and Other Staff	Issues Related to Student Discipline	Teaching	Public Relations and Fundraising	Other
Armenia	26 (0.2)	21 (0.2)	23 (0.1)	14 (0.2)	7 (0.1)	12 (0.1)	7 (0.1)
Iran, Islamic Rep. of	19 (0.9)	26 (1.1)	20 (0.8)	13 (0.8)	4 (0.5)	10 (0.7)	8 (0.4)
Italy	31 (1.5)	24 (0.9)	17 (0.9)	11 (1.1)	3 (0.6)	12 (0.7)	3 (0.7)
Lebanon	24 (0.6)	18 (0.4)	19 (0.4)	17 (0.4)	6 (0.3)	11 (0.3)	6 (0.3)
Netherlands	r 24 (1.8)	r 23 (1.1)	r 19 (1.1)	r 8 (0.7)	r 7 (1.4)	r 5 (0.6)	r 14 (1.2)
Norway	51 (2.0)	21 (1.2)	9 (0.6)	4 (0.3)	3 (1.0)	6 (0.9)	6 (0.7)
Philippines	25 (1.1)	24 (1.1)	23 (1.0)	10 (0.5)	6 (0.6)	8 (0.6)	4 (0.5)
Russian Federation	27 (1.2)	20 (0.8)	20 (1.0)	6 (0.4)	8 (0.8)	12 (0.7)	8 (0.6)
Slovenia	36 (1.9)	24 (1.6)	12 (0.7)	6 (0.4)	6 (0.6)	9 (0.6)	7 (0.6)
Sweden	43 (1.6)	18 (1.1)	18 (1.1)	8 (0.9)	2 (0.5)	5 (0.5)	8 (1.1)

SOURCE: IEA TIMSS Advanced 2008 ©

Data provided by schools.

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

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

school-related tasks by the end of the school year. According to their reports, the vast majority of principals' time is distributed across three broad categories of tasks: administrative duties, providing instructional leadership in the areas of curriculum and pedagogy, and supervising teachers and other staff. Although there was some variation, in Armenia, Iran, Lebanon, the Netherlands, the Philippines, and the Russian Federation, the distribution of time was similar across these three categories (about one fifth to one fourth of the principals' time spent on each of the three areas). In comparison, in Italy and Slovenia principals reported devoting relatively more of their time (about one third) to administrative duties, about one fourth to instructional leadership, and a relatively less time to supervising and evaluating teachers. The distribution of time across these three areas was least balanced in Norway and Sweden, with principals' time considerably skewed toward the administrative side (51% and 43%, respectively). Although the percentages were not large, across the countries principals typically reported as much if not more time devoted to disciplining students (4 to 17%) than to teaching them the schools' curriculum (2 to 8%). Public relations took from 10 to 12 percent of the principals' time in Armenia, Iran, Italy, Lebanon, and the Russian Federation, but smaller percentages of time in the other countries.

Exhibit 6.2 presents schools' reports about the degree of difficulty they are having recruiting mathematics teachers to fill vacancies in the final year of secondary school. As discussed in Chapter 5, substantial percentages of the teachers of advanced mathematics have been teaching for 25 years or so in several of the TIMSS Advanced 2008 countries, and thus could be expected to be considering retirement. Also, as evidenced by the TIMSS Advanced data, there are not large pools of students currently being trained in advanced mathematics and few of them plan to continue their study of mathematics (Exhibits 4.14

Exhibit 6.2 **School's Reports on Mathematics Teacher Recruitment**

TIMSSAdvanced 2008 Advanced Mathematics

Country		Filling Mathematics Teaching Vacancies for the School Year							
		No Vacancies		Easy to Fill Vacancies		Somewhat Difficult to Fill Vacancies		Very Difficult to Fill Vacancies	
		Percent of Students	Average Achievement	Percent of Students	Average Achievement	Percent of Students	Average Achievement	Percent of Students	Average Achievement
Armenia		89 (0.8)	422 (3.6)	2 (0.1)	~ ~	5 (0.1)	586 (17.8)	4 (0.9)	515 (17.8)
Iran, Islamic Rep. of		23 (3.5)	506 (13.9)	25 (4.4)	469 (11.2)	39 (5.0)	502 (11.3)	13 (3.4)	515 (15.4)
Italy		51 (5.4)	438 (10.5)	27 (5.2)	452 (12.6)	18 (5.4)	465 (15.9)	3 (2.4)	490 (10.0)
Lebanon		48 (2.2)	545 (3.3)	16 (1.8)	563 (7.2)	23 (2.1)	538 (3.8)	13 (1.7)	529 (4.1)
Netherlands	r	55 (5.8)	551 (3.3)	9 (2.4)	559 (9.8)	26 (5.3)	552 (5.1)	10 (2.8)	557 (9.7)
Norway		27 (5.6)	450 (6.9)	33 (4.5)	451 (6.8)	31 (5.5)	429 (8.9)	9 (2.8)	406 (18.4)
Philippines		26 (5.2)	353 (12.4)	32 (4.8)	348 (11.3)	33 (5.6)	353 (11.0)	9 (3.2)	399 (20.1)
Russian Federation		80 (4.3)	559 (8.4)	13 (2.9)	574 (12.9)	4 (1.9)	566 (18.7)	3 (2.0)	539 (66.1)
Slovenia		77 (4.9)	460 (4.6)	22 (4.9)	451 (9.7)	1 (0.0)	~ ~	0 (0.0)	~ ~
Sweden		39 (5.0)	406 (8.9)	51 (5.5)	414 (8.6)	10 (2.9)	431 (14.0)	0 (0.0)	~ ~

Country		Incentives to Recruit or Retain Mathematics Teachers			
		School Uses Incentives		School Does Not Use Incentives	
		Percent of Students	Average Achievement	Percent of Students	Average Achievement
Armenia		18 (0.8)	442 (3.7)	82 (0.8)	431 (4.3)
Iran, Islamic Rep. of		39 (4.2)	515 (12.4)	61 (4.2)	484 (7.0)
Italy		– –	– –	– –	– –
Lebanon		34 (2.2)	553 (4.7)	66 (2.2)	540 (2.4)
Netherlands	r	9 (3.1)	551 (8.2)	91 (3.1)	553 (2.9)
Norway		5 (2.0)	436 (16.6)	95 (2.0)	439 (5.2)
Philippines		33 (5.8)	369 (11.8)	67 (5.8)	348 (7.8)
Russian Federation		74 (4.4)	561 (7.4)	26 (4.4)	562 (15.6)
Slovenia		1 (0.9)	~ ~	99 (0.9)	459 (4.3)
Sweden		1 (0.7)	~ ~	99 (0.7)	413 (5.5)

Data provided by schools.

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

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

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

SOURCE: IEA TIMSS Advanced 2008 ©

and 4.15), which would indicate even smaller percentages planning to become teachers. Since there does not seem to be a regular pipeline into the career of teaching advanced mathematics in a number of the TIMSS Advanced 2008 countries, it is not surprising that advanced mathematics students in some participating countries are attended schools that are having some difficulty recruiting mathematics teachers for the final year of secondary school.

In several countries, most advanced mathematics students were in schools with hardly any vacancies for mathematics teachers in the final year of secondary school, including Armenia (89%), the Russian Federation (80%), and Slovenia (77%). In contrast, however, half the Iranian advanced mathematics students in their final year of secondary school were attending schools with vacancies for mathematics teachers that were at least somewhat difficult to fill as were about 40 percent or so of the Norwegian and Philippine students, and a little over one third of the Lebanese and Dutch students.

As shown in the lower portion of Exhibit 6.2, schools were asked if they used any incentives (e.g., pay, housing, signing bonuses, smaller classes) to recruit or maintain mathematics teachers for students in the final year of secondary school. The results indicate that incentives were used most widely in the Russian Federation, and apparently with some success since nearly all vacancies were filled as discussed above. Iran, Lebanon, and the Philippines also reported some use of incentives. Neither the percentage of difficult-to-fill vacancies nor the use of incentives was systematically related to average achievement in advanced mathematics.

Orderly and Safe Schools

Although an orderly and safe school environment does not, in and of itself, guarantee high levels of student achievement, safe schools can be considered a necessary condition for providing a good learning environment for students. TIMSS 2007 showed that mathematics achievement was related to teachers' and students' perceptions about how safe they felt at school at both the fourth and eighth grades, and it might be anticipated that school discipline and behavior problems in secondary schools might be of even greater concern. However, the TIMSS Advanced 2008 results indicate that school safety generally is not a problem for the select populations of final year students studying advanced mathematics. According to their principals and teachers, these students generally are in orderly and safe school environments.

To provide an initial context for considering the degree of order and safety in the schools attended by students studying advanced mathematics, TIMSS Advanced 2008 asked principals to rate the seriousness of the following behavior problems among final year students in their schools: vandalism, theft, intimidation or verbal abuse among students, students causing physical injury to other students, students intimidating or verbally abusing teachers, and students physically injuring teachers or staff. TIMSS Advanced used the principals' responses about each behavior (i.e., not a problem, minor problem, or serious problem) to create an Index of Good Behavior at School for Students in the Final Year of Secondary School. Students in the high category attended schools where principals reported that *none* of these six behaviors were a problem. In contrast, students in the low category attended schools where principals reported widespread minor and/or serious behavior problems. The medium category included students attending schools where these behaviors were minor problems.

Exhibit 6.3 presents the results for the Index of Good Behavior at School for Students in the Final Year of Secondary School. The countries are presented in order from the largest to smallest percentage of students in the high category. In six countries, the majority of students (from 51 to 78%) were in the high category; that is, attended schools where *none* of these student behaviors were even minor problems according to principals. From 29 to 40 percent of the students attended such "problem-free" schools in Lebanon, Italy, the Philippines, and Sweden. Most notably, no more than 8 percent of the students in any country were in the low category; that is, attending schools where principals considered these student behaviors—including physical conflicts—to be widespread or serious problems. In Iran and Slovenia, students in the schools with no behavior problems had higher achievement than their counterparts in schools with minor or major behavior problems.

Exhibit 6.4 presents the results of the Index of Mathematics Teachers' Perceptions of Safety in Their Schools. The index is based on mathematics teachers' responses to three statements pertaining directly to being safe in their schools:

- This school is located in a safe neighborhood
- I feel safe at this school
- The school's security policies and practices are sufficient.

Students were assigned to the high level when their teachers agreed with all three statements and to the low category when their teachers disagreed with all three. Students whose teachers provided other response combinations were assigned to the medium category. The results are presented according the percentage of students in the high category from largest to smallest.

Exhibit 6.3 **Index of Good Behavior at School for Students in the Final Year of Secondary School (GBS)**

TIMSSAdvanced 2008 Advanced Mathematics

Country		High GBS		Medium GBS		Low GBS	
		Percent of Students	Average Achievement	Percent of Students	Average Achievement	Percent of Students	Average Achievement
Armenia		78 (0.5)	430 (4.7)	20 (0.5)	450 (3.8)	3 (0.1)	396 (16.9)
Russian Federation		73 (4.3)	561 (8.0)	27 (4.3)	561 (12.1)	0 (0.0)	~ ~
Iran, Islamic Rep. of		71 (4.1)	503 (7.3)	29 (4.1)	478 (10.6)	0 (0.0)	~ ~
Netherlands	r	63 (4.6)	553 (3.7)	37 (4.6)	552 (3.3)	0 (0.0)	~ ~
Norway		54 (5.4)	434 (6.0)	46 (5.4)	447 (8.1)	0 (0.0)	~ ~
Slovenia		51 (6.0)	470 (7.7)	47 (6.0)	446 (6.8)	2 (0.9)	~ ~
Lebanon		40 (2.5)	541 (4.0)	52 (2.5)	550 (3.2)	8 (0.4)	537 (7.0)
Italy		37 (5.7)	447 (11.2)	57 (5.8)	457 (9.6)	6 (2.5)	384 (30.7)
Philippines		31 (4.3)	357 (12.2)	68 (4.3)	354 (7.0)	1 (1.0)	~ ~
Sweden		29 (5.0)	420 (7.0)	66 (5.5)	407 (7.7)	5 (2.7)	427 (20.8)

SOURCE: IEA TIMSS Advanced 2008 ©

Based on principals' responses about the seriousness of following behaviors in their school: vandalism, theft, intimidation or verbal abuse of other students, physical injury to other students, students intimidating or verbally abusing teachers or staff, and students causing physical injury to teachers or staff. Principals' responses were averaged across the six statements based on a 3-point scale: 1=Not a Problem, 2=Minor Problem, 3=Serious Problem. Students in the high category attended schools where principals reported none of these problems with students behavior (average of 1). Students in the low category attended schools where principals reported widespread minor and/or serious student behavior problems (average greater than 2). Students in the medium category attended schools where principals reported minor student behavior problems (average greater than 1 and less than or equal to 2).

( ) 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.

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

Exhibit 6.4 **Index of Advanced Mathematics Teachers' Perceptions of Safety in Their Schools (TPSS)**

TIMSSAdvanced 2008 Advanced Mathematics

Country	High TPSS		Medium TPSS		Low TPSS	
	Percent of Students	Average Achievement	Percent of Students	Average Achievement	Percent of Students	Average Achievement
Iran, Islamic Rep. of	99 (0.7)	497 (6.2)	1 (0.0)	~ ~	0 (0.0)	~ ~
Netherlands	96 (2.1)	553 (2.7)	4 (2.1)	539 (8.1)	0 (0.0)	~ ~
Sweden	94 (2.5)	416 (5.8)	6 (2.5)	409 (16.1)	0 (0.0)	~ ~
Norway	94 (4.0)	440 (5.1)	6 (4.0)	422 (48.2)	0 (0.0)	~ ~
Philippines	92 (2.3)	350 (5.7)	8 (2.3)	410 (24.0)	0 (0.0)	~ ~
Armenia	91 (2.0)	435 (3.8)	8 (2.0)	396 (15.4)	1 (0.0)	~ ~
Lebanon	88 (1.6)	546 (2.5)	11 (1.5)	541 (7.4)	1 (0.5)	~ ~
Italy	86 (3.2)	453 (8.2)	12 (2.9)	433 (13.4)	2 (1.4)	~ ~
Slovenia	85 (3.7)	463 (4.9)	14 (3.6)	435 (14.1)	1 (0.0)	~ ~
Russian Federation	80 (4.1)	566 (8.0)	20 (4.0)	544 (11.5)	1 (0.1)	~ ~

SOURCE: IEA TIMSS Advanced 2008 ©

Based on teachers' responses to three statements about their schools: 1)This school is located in a safe neighborhood; 2) I feel safe at this school; 3) This school's security policies and practices are sufficient. Teachers' responses were averaged across the three statements based on a 4-point Likert scale: 1=Agree a lot; 2=Agree; 3=Disagree; 4=Disagree a lot. Students were assigned to the high level when their teachers agreed or agreed a lot with all three statements and to the low category when their teachers disagreed or disagreed a lot with all three. Students whose teachers provided other response combinations were assigned to the medium category.

( ) 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.

Nearly all teachers of advanced mathematics students agreed that the schools offering courses in advanced mathematics were safe. In six countries, more than 90 percent of the advanced mathematics students were attending schools judged to be safe by their teachers, and in the other four countries, 80 to 88 percent of the students were attending such schools. The pattern was for advanced mathematics students in schools where teachers perceived "medium" safety concerns to have lower average achievement than their counterparts attending schools in the high category (except in the Philippines).

Principals' and Teachers' Perceptions of School Climate

Beyond an orderly and safe environment, a positive school climate supportive of teaching and learning helps to build better morale among teachers and students, encourages students to concentrate on their studies, and creates an expectation for high levels of academic success, all of which lead to higher student achievement. TIMSS Advanced 2008 asked both school principals and teachers to characterize the climate of their school according to important indicators of an environment conducive to learning. The principals and the teachers were asked to rate each of the following school characteristics on a 4-point scale from *very high* to *very low*.

- Teachers' job satisfaction
- Teachers' understanding of the school's curricular goals
- Teachers' degree of success in implementing the school's curriculum
- Teachers' expectations for student achievement
- Parental support for student achievement
- Parental involvement in school activities

- Students' regard for school property
- Students' desire to do well in school.

Based on the responses provided by the principals and teachers, respectively, TIMSS Advanced created two comparable scales: the Index of Principals' Perception of School Climate and the Index of Advanced Mathematics Teachers' Perception of School Climate. In each case, advanced mathematics students were assigned to the high level if their principals or teachers, respectively, averaged a *high* or *very high* rating on these aspects of school climate, and to the low level if their principals or teachers, respectively, averaged *low* or *very low*. Students in the medium category had principals or teachers with other response combinations.

Exhibit 6.5 presents the results for the Index of Principals' Perception of School Climate, including the percentage of students at each level of the index in each country, together with their average achievement in advanced mathematics. The countries are ordered according to the percentage of students in the high category. In every country, except the Philippines, there was a positive association between a climate more supportive of student learning and higher average achievement in advanced mathematics. In most of the other countries, average mathematics achievement was highest among students at the high level of the principals' perception of school climate index, next highest at the medium level, and lowest at the low level.

In five countries, 90 percent or more of the advanced mathematics students were in schools whose principals reported learning climates categorized as high or medium, including the Philippines, Slovenia, Sweden, the Russian Federation, and Norway. The largest percentage of students in the high category was in the Philippines with more than half (53%). About one fourth of the students were in schools with learning

Exhibit 6.5 Index of Principals' Perceptions of School Climate (PPSC)

TIMSSAdvanced 2008 Advanced Mathematics

Country	High PPSC		Medium PPSC		Low PPSC	
	Percent of Students	Average Achievement	Percent of Students	Average Achievement	Percent of Students	Average Achievement
Philippines	53 (5.3)	354 (7.8)	43 (4.5)	365 (9.8)	4 (2.2)	303 (28.8)
Slovenia	25 (3.6)	506 (6.1)	68 (4.4)	447 (6.0)	6 (2.6)	405 (8.3)
Iran, Islamic Rep. of	25 (4.0)	528 (14.0)	59 (5.2)	496 (9.1)	16 (3.7)	449 (6.4)
Lebanon	25 (2.0)	558 (4.6)	59 (2.1)	543 (3.1)	16 (1.3)	525 (3.7)
Sweden	18 (4.9)	438 (11.0)	73 (4.8)	411 (6.2)	10 (3.3)	381 (9.0)
Russian Federation	13 (3.4)	605 (18.6)	81 (3.8)	559 (6.7)	6 (2.0)	494 (24.7)
Norway	7 (2.7)	441 (11.2)	90 (3.3)	440 (5.1)	4 (1.9)	403 (58.4)
Italy	3 (1.8)	481 (45.6)	60 (5.1)	458 (8.7)	37 (5.0)	431 (12.4)
Armenia	2 (0.1)	~ ~	83 (0.4)	436 (4.1)	15 (0.4)	420 (5.3)
Netherlands r	1 (0.7)	~ ~	68 (5.5)	555 (3.7)	31 (5.5)	547 (3.7)

SOURCE: IEA TIMSS Advanced 2008 ©

Based on principals' responses to the following aspects of school climate in their schools: teachers' job satisfaction, teachers' opportunities for professional development, teachers' understanding of the school's curricular goals, teachers' degree of success in implementing the school's curriculum, teachers' expectations for student achievement, parental support for student achievement, parental involvement in school activities, students' regard for school property, and students' desire to do well in school. Average is computed across the nine statements based on a 5-point scale: 1 = Very High, 2 = High, 3 = Medium, 4 = Low, 5 = Very Low. High level indicates students whose principals' perception of their school climate was very positive (average is less than or equal to 2). Medium level indicates students whose principals' perception of their school climate was moderately positive (average is greater than 2 and less than 3). Low level indicates students whose principals' perception of their school climate was not so positive (average is greater than or equal to 3).

( ) 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.

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

Exhibit 6.6 Index of Advanced Mathematics Teachers' Perceptions of School Climate (TPSC)

TIMSSAdvanced 2008 Advanced Mathematics

Country	High TPSC		Medium TPSC		Low TPSC	
	Percent of Students	Average Achievement	Percent of Students	Average Achievement	Percent of Students	Average Achievement
Philippines	37 (5.1)	372 (10.8)	52 (5.4)	344 (9.3)	11 (2.7)	355 (22.2)
Lebanon	31 (2.1)	557 (4.3)	47 (1.8)	546 (2.9)	22 (1.9)	526 (4.7)
Iran, Islamic Rep. of	21 (3.2)	529 (13.5)	49 (4.4)	497 (8.6)	29 (3.8)	474 (7.1)
Sweden	16 (3.8)	428 (12.2)	68 (4.8)	421 (6.1)	17 (3.6)	383 (13.5)
Norway	11 (3.7)	450 (18.4)	62 (5.1)	433 (6.2)	27 (4.7)	450 (7.2)
Slovenia	9 (3.5)	491 (16.9)	60 (5.6)	471 (5.9)	31 (4.8)	418 (7.4)
Russian Federation	8 (2.6)	616 (13.4)	73 (3.3)	564 (8.2)	20 (3.4)	527 (10.2)
Armenia	6 (1.3)	434 (18.7)	61 (3.9)	451 (6.7)	33 (3.7)	402 (8.6)
Italy	4 (1.7)	502 (25.3)	37 (5.2)	456 (11.5)	59 (5.2)	440 (9.1)
Netherlands	2 (1.2)	~ ~	59 (5.3)	555 (3.1)	40 (5.2)	551 (4.0)

SOURCE: IEA TIMSS Advanced 2008 ©

Based on teachers' responses to the following aspects of school climate in their schools: teachers' job satisfaction, teachers' understanding of the school's curricular goals, teachers' degree of success in implementing the school's curriculum, teachers' expectations for student achievement, support for teachers' professional development, parental support for student achievement, parental involvement in school activities, students' regard for school property, and students' desire to do well in school. Average is computed across the nine statements based on a 5-point scale: 1 = Very High, 2 = High, 3 = Medium, 4 = Low, 5 = Very Low. High level indicates students whose teachers' perception of their school climate was very positive (average is less than or equal to 2). Medium level indicates students whose teachers' perception of their school climate was moderately positive (average is greater than 2 and less than 3). Low level indicates students whose teachers' perception of their school climate was not so positive (average is greater than or equal to 3).

( ) 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.

climates categorized as high in Slovenia, Lebanon, and Iran. Across countries, Italian and Dutch principals had the lowest perceptions of the climates in their schools. According to principals, few (1–3%) of the advanced mathematics students in Italy and the Netherlands were in schools with learning climates categorized as high and about one third (31–37%) were in schools with climates categorized as low.

Exhibit 6.6 presents the results for the Index of Advanced Mathematics Teachers' Perceptions of School Climate and, in general, they correspond to the results for the Index of Principals' Perceptions of School Climate described above. Similar to the findings for the principals' index of school climate, average achievement in advanced mathematics was positively related to teachers' perceptions of school climate in a number of the participating countries, with the exception of the Philippines, Norway, and Armenia, where the patterns were not consistent.

Three of the countries with the highest percentages of advanced mathematics students in the high category according to their teachers are the same as they were according to principals—the Philippines, Lebanon, and Iran. Interestingly, however, Slovenian teachers (9 percent of advanced mathematics students in the high category) were quite a bit less positive about their school climates than were the Slovenian principals (25 percent in the high category). Although the cross-country differences between teachers' and principals' perceptions typically were not as large as in Slovenia, teachers tended to be less positive about their school climates than principals. According to teachers, from 20 to 40 percent of students were in schools categorized as low in 7 out of 10 countries. Agreeing with their principals, the Italian teachers were the least positive across countries about their school climates and, consistent with the cross-country pattern, were even somewhat less positive than their principals. According to their teachers, only 4 percent of the advanced mathematics students in Italy were in schools with climates categorized as high (in agreement with principals' reports of 3%) and 59 percent were in schools with climates categorized as low (compared to principals' estimates of 37%).

As an additional indication of whether the school had an environment supportive of high academic learning, principals were asked whether these schools that were offering courses in advanced mathematics had policies for encouraging students to choose advanced mathematics courses. Exhibit 6.7 presents the results for each country for the percentage of students in schools with advanced mathematics courses that specifically encouraged students to study advanced mathematics. Average achievement in advanced mathematics is shown for schools with such policies and for schools that did not have such policies.

The extremes are represented by the Philippines and the Russian Federation at one end of the continuum, with 96 to 100 percent of advanced mathematics students in schools expressly encouraging students to study advanced mathematics, and Sweden, at the other end of the continuum, where none of the schools had such a policy, presumably because, as explained in Exhibit 1.1, choices about studying advanced mathematics are left to the students. Across the seven countries where some of the schools with students enrolled in advanced mathematics had "encouraging" policies and others did not, all three possible relationships with average achievement were represented. In Armenia and Norway, students in schools with such policies had lower average achievement—perhaps the underlying reason for the policy of encouragement. In contrast, Iranian students in schools with specific policies had higher average achievement than their counterparts in schools without such policies. In the remaining countries, there was little difference in average achievement between the two types of schools.

Exhibit 6.7 **Schools' Policies for Encouraging Students to Study Advanced Mathematics**

TIMSSAdvanced2008 Advanced Mathematics

Country	School Has Policy		School Does Not Have Policy	
	Percent of Students	Average Achievement	Percent of Students	Average Achievement
Armenia	57 (0.8)	410 (5.2)	43 (0.8)	469 (5.2)
Iran, Islamic Rep. of	73 (4.5)	504 (7.8)	27 (4.5)	476 (10.8)
Italy	44 (6.2)	449 (10.0)	56 (6.2)	448 (9.8)
Lebanon	64 (2.2)	545 (2.9)	36 (2.2)	540 (4.1)
Netherlands	23 (5.7)	548 (7.3)	77 (5.7)	554 (2.8)
Norway	27 (6.0)	422 (12.6)	73 (6.0)	445 (4.9)
Philippines	100 (0.0)	355 (5.5)	0 (0.0)	~ ~
Russian Federation	96 (1.9)	560 (7.3)	4 (1.9)	594 (56.4)
Slovenia	36 (5.3)	467 (8.9)	64 (5.3)	454 (5.0)
Sweden	0 (0.0)	~ ~	100 (0.0)	412 (5.5)

SOURCE: IEA TIMSS Advanced 2008 ©

Data provided by schools.

( ) 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.

School Resources and Technology

The last section of this chapter presents information about the range of resources available in schools providing instruction in advanced mathematics. Curriculum implementation can be made easier by ready access to the facilities, materials, and equipment necessary to achieve the specified learning goals. Results from successive TIMSS assessments indicate that fourth and eighth grade students attending schools that are well resourced generally have higher achievement than those in schools where shortages of resources affect teachers' capacity to implement the curriculum. In addition to schools' reports about the adequacy of general resources and resources particularly targeted to mathematics instruction, this section includes data about school availability of computers and Internet access for final year students.

To gather information about whether the lack of availability of school resources had an adverse impact on instruction in advanced mathematics, TIMSS Advanced 2008 queried principals about the degree to which shortages or inadequacies in six general areas affected their school's capacity to provide instruction: instructional materials (textbooks, for example); budget for supplies (paper, pencils, etc.); school buildings and grounds; heating/cooling and lighting systems; instructional space (classrooms, for example); and special equipment for students with disabilities. Principals also responded to questions about whether shortages or inadequacies in five resource areas specifically pertaining to mathematics instruction affected their school's capacity to provide instruction: computers for mathematics instruction; computer software for mathematics instruction; calculators for mathematics instruction; library materials relevant to mathematics instruction; and audio-visual resources for mathematics instruction. Responses to both types of questions were provided on a 4-point scale:

no, *a little*, *some*, and *a lot*. TIMSS Advanced created two indices based on principals' responses to the two groups of questions about school resource shortages—one concerning shortages in general areas and the other concerning shortages in resources specifically related to mathematics instruction.

To create the Index of Adequacy of General School Resources, principals' responses were averaged across the six questions about shortages in general resources, and to create the Index of Adequacy of Resources Specifically for Mathematics Instruction, principals' responses were averaged across the five questions about shortages in resources pertaining specifically to mathematics instruction. For each of the two indices, students were placed in the high category if principals responded that shortages in resources affected the capacity to provide instruction only a little, if at all (average less than 2). In contrast, students were placed in the low category if principals responded that resource shortages had considerable impact on the schools' capacity to provide instruction (i.e., across all resource areas to some degree and/or shortages in several areas adversely affected instruction a lot (average 3 or higher)). Students in the medium category were in schools where the capacity to provide instruction was somewhat adversely affected by the lack of some resources.

Exhibit 6.8 displays the results for the Index of Adequacy of General School Resources for each country ordered by the percentage of students in the high category. As would be anticipated based on the range in the economic indicators for the participating countries, there was considerable variability in principals' responses across countries. Approximately three fourths (73 to 79%) of the students studying advanced mathematics attended schools in the high category in Sweden, Armenia, and the Netherlands; just under two thirds (65%) in the Russian Federation and Italy; approximately three fifths (59 to 62%)

Exhibit 6.8 **Index of Adequacy of General School Resources (Shortages Do Not Affect Capacity to Provide Instruction) (AGSR)**

TIMSSAdvanced 2008 Advanced Mathematics

Country		High AGSR		Medium AGSR		Low AGSR	
		Percent of Students	Average Achievement	Percent of Students	Average Achievement	Percent of Students	Average Achievement
Sweden		79 (5.4)	411 (6.3)	19 (5.4)	425 (9.7)	2 (1.1)	~ ~
Armenia		75 (0.5)	436 (3.8)	17 (0.4)	412 (9.1)	9 (0.3)	447 (13.7)
Netherlands	r	73 (5.2)	550 (3.0)	27 (5.2)	560 (5.3)	0 (0.0)	~ ~
Russian Federation		65 (5.1)	560 (8.6)	29 (4.8)	563 (10.7)	5 (2.4)	576 (17.8)
Italy		65 (6.0)	447 (8.8)	28 (5.6)	451 (14.4)	7 (3.0)	453 (43.8)
Lebanon		62 (2.4)	547 (2.9)	27 (2.2)	535 (4.8)	10 (1.4)	547 (4.1)
Slovenia		60 (6.6)	457 (6.9)	26 (4.7)	455 (9.5)	14 (4.9)	468 (15.2)
Iran, Islamic Rep. of		59 (5.0)	508 (9.3)	29 (4.6)	489 (11.7)	12 (3.2)	458 (12.0)
Norway		50 (5.6)	434 (7.1)	43 (5.5)	445 (7.5)	7 (3.3)	442 (23.2)
Philippines		45 (4.6)	376 (9.6)	35 (4.3)	338 (11.6)	20 (4.0)	339 (11.5)

SOURCE: IEA TIMSS Advanced 2008 ©

Based on principals' responses to how much the school's capacity to provide instruction is affected by shortages or inadequacies of the following: instructional materials (e.g., textbooks), budget for supplies (e.g., paper, pencils), school buildings and grounds, heating/cooling and lighting systems, instructional space (e.g., classrooms), and special equipment for students with disabilities. Principals' responses were averaged across the six statements based on a 4-point scale: 1 = No, 2 = A little, 3 = Some, 4 = A lot. Students were placed in the high category if principals responded that shortages in general resources affected only a little, if at all (average is less than 2). Students were placed in the low category if principals responded that shortages in all the general resource areas had some adverse affect on capacity to provide instruction and/or shortages in several general resource areas adversely affected instruction a lot (average is greater than or equal to 3). Students in the medium category were in schools where the capacity to provide instruction was adversely affected somewhat by the lack of general resources (average is greater than or equal to 2 and less than 3).

( ) 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.

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

Exhibit 6.9 **Index of Adequacy of Resources Specifically for Mathematics Instruction (Shortages Do Not Affect Capacity to Provide Instruction) (ARMI)**

TIMSSAdvanced 2008 Advanced Mathematics

Country		High ARMI		Medium ARMI		Low ARMI	
		Percent of Students	Average Achievement	Percent of Students	Average Achievement	Percent of Students	Average Achievement
Sweden		75 (3.3)	412 (7.0)	25 (3.3)	416 (8.4)	0 (0.0)	~ ~
Netherlands	r	72 (5.4)	552 (2.8)	28 (5.3)	554 (5.8)	1 (0.7)	~ ~
Norway		68 (5.7)	439 (5.8)	32 (5.7)	441 (8.5)	0 (0.0)	~ ~
Italy		57 (6.1)	450 (7.7)	41 (6.1)	450 (13.0)	2 (1.5)	~ ~
Russian Federation		49 (4.7)	565 (9.3)	41 (4.1)	564 (12.2)	10 (3.0)	538 (15.1)
Slovenia		48 (5.6)	471 (7.8)	44 (5.0)	449 (6.6)	8 (2.8)	444 (29.8)
Armenia		45 (0.7)	431 (5.9)	45 (0.7)	444 (4.7)	10 (0.3)	390 (9.1)
Lebanon		44 (2.5)	546 (3.8)	35 (2.2)	545 (3.6)	21 (2.2)	536 (4.7)
Iran, Islamic Rep. of		36 (4.2)	518 (13.9)	41 (4.4)	487 (7.3)	23 (3.9)	479 (10.2)
Philippines		31 (5.4)	362 (11.7)	27 (4.5)	379 (14.8)	43 (5.5)	336 (10.5)

SOURCE: IEA TIMSS Advanced 2008 ©

Based on principals' responses to how much the school's capacity to provide mathematics instruction is affected by shortages or inadequacies of the following: computers for mathematics instruction, computer software for mathematics instruction, calculators for mathematics instruction, library materials relevant to mathematics instruction, audio-visual resources for mathematics instruction. Principals' responses were averaged across the five areas based on a 4-point scale: 1 = No, 2 = A little, 3 = Some, 4 = A lot. Students were placed in the high category if principals responded that shortages in resources specifically related to mathematics instruction affected the capacity to provide instruction only a little, if at all (average is less than 2). Students were placed in the low category if principals responded that shortages in all the mathematics related areas had some adverse affect on capacity to provide instruction and/or shortages in several mathematics related areas adversely affected instruction a lot (average is greater than or equal to 3). Students in the medium category were in schools where the capacity to provide instruction was adversely affected somewhat by the lack of mathematics related resources (average 2 or higher but less than 3).

( ) 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.

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

in Lebanon, Slovenia, and Iran; half in Norway; and under half (45%) in the Philippines. From 10 to 14 percent of the advanced mathematics students in Lebanon, Slovenia, and Iran as well as 20 percent in the Philippines were in the low category. Iran had the strongest relationship between a higher level of adequacy of general resources and higher average achievement in advanced mathematics.

Exhibit 6.9 shows the results for the Index of Adequacy of Resources Specifically for Mathematics Instruction. In a number of the countries principals reported more adverse affects on instruction from shortages in resources specifically for mathematics instruction than from shortages in general resources, although there was a similar variability in the results. Because the mathematics related resource areas primarily were technology related (i.e., computer hardware and software, calculators, and audio-visual resources), it makes sense that schools might have more difficulty keeping up-to-date in these areas. Norway was the only country where principals reported a higher percentage (68%) of advanced mathematics students in the high category for adequacy of mathematics specific instructional resources (little, if any adverse impact on their instruction due to shortages) than in the high category for adequacy of general resources (50%).

Sweden and the Netherlands appear to be well-resourced in mathematics related instructional materials and equipment as well as in general areas. Similar to the results for general resources described above, about three fourths (72 to 75%) of the Swedish and Dutch students studying advanced mathematics were in the high category for adequacy of mathematics related resources. Also, similar to the Philippine results for general resources, the principals reported considerable adverse impact on instruction as a result of shortages in mathematics related resources, and an even greater percentage of students (43%) in the low category. From 21 to 23 percent of the advanced mathematics students in Iran and Lebanon were in the low category for adequacy of mathematics instructional resources as were 10 percent in Armenia and the Russian Federation.

Exhibit 6.10 presents information about the degree to which schools offering advanced mathematics courses had computers and access to the Internet. The first data column for each country provides the average number of computers in the schools available for use by final year students. Care should be taken in interpreting these results because these computers most likely are not for the exclusive use of final year students and could also be used by other students attending the schools, and the total number of students having access to the computers in each school most likely varies depending on such factors as the type of school and size of school enrollment.

Taking the above caveats into consideration, there still was a considerable range in the results. For schools with advanced mathematics courses, Sweden reported an average of 209 computers per school available for use by final year students, and the Netherlands and Norway, respectively, reported 112 and 121 computers per school on average. In the other participating countries, however, principals of schools with advanced mathematics courses reported less computer availability for final year students: Italy reported an average of 60 computers per school, the Philippines and Slovenia reported averages of 46 and 42, respectively, the Russian Federation reported an average of 35 computers per school, Lebanon reported 27, and Armenia reported 15. Computers were even rarer in Iran, with only 8 per school on average.

The remaining data columns in Exhibit 6.10 provide information about Internet access in schools. It shows the percentages of advanced mathematics students in each country attending schools where “all”, “most”, “some”, or “none” of the school computers available for their use had Internet access, together with the average achievement for students

Exhibit 6.10: **Computer Availability and Internet Access in School**

TIMSSAdvanced 2008 Advanced Mathematics

Country		Average Number of Computers Available for Use by Final Year Students	Internet Access for Educational Purposes								
			All Computers		Most Computers		Some Computers		No Computers		
				Percent of Students	Average Achievement	Percent of Students	Average Achievement	Percent of Students	Average Achievement	Percent of Students	Average Achievement
Armenia		15 (0.2)		40 (0.7)	454 (5.3)	19 (0.8)	438 (4.6)	16 (0.4)	402 (11.6)	25 (0.6)	416 (5.8)
Iran, Islamic Rep. of		8 (0.7)		33 (4.6)	508 (11.8)	8 (2.7)	557 (26.0)	29 (4.7)	496 (11.8)	29 (4.3)	467 (10.5)
Italy		60 (6.0)		83 (4.1)	453 (7.6)	12 (3.5)	413 (17.0)	3 (1.7)	487 (48.5)	1 (0.1)	~ ~
Lebanon		27 (0.7)		33 (2.2)	558 (3.6)	15 (1.4)	555 (4.6)	22 (2.5)	540 (6.2)	30 (2.4)	530 (4.2)
Netherlands	r	112 (8.8)	r	85 (4.3)	554 (3.0)	15 (4.3)	548 (7.0)	0 (0.0)	~ ~	0 (0.0)	~ ~
Norway		121 (10.2)		91 (4.6)	441 (5.5)	9 (4.6)	424 (23.6)	0 (0.0)	~ ~	0 (0.0)	~ ~
Philippines		46 (4.3)		45 (6.1)	380 (11.3)	17 (4.5)	323 (15.0)	30 (4.6)	351 (11.6)	8 (2.2)	309 (15.3)
Russian Federation		35 (2.0)		50 (5.6)	559 (10.3)	33 (4.3)	563 (9.0)	17 (4.3)	563 (12.1)	0 (0.0)	~ ~
Slovenia		42 (4.6)		88 (4.2)	458 (4.5)	12 (4.2)	465 (14.6)	0 (0.0)	~ ~	0 (0.0)	~ ~
Sweden		209 (19.4)		89 (3.3)	414 (6.0)	11 (3.3)	409 (10.5)	0 (0.0)	~ ~	0 (0.0)	~ ~

SOURCE: IEA TIMSS Advanced 2008 ©

Data provided by schools.

( ) 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.

An "r" indicates data are available for at least 70% but less than 85% of the students in each category. In Italy, the Netherlands, Norway, Slovenia, and Sweden, from 83 to 91 percent of the advanced mathematics students were attending schools where all of the computers had Internet access, and (except for 3% in Italy) the rest of the students were in schools where most computers had Internet access.

In Iran and Lebanon, the two participating countries reporting the least Internet access in schools, one third of the advanced mathematics students were in schools where all the computers had Internet access, and a few more (8% and 15%, respectively) were in schools where most computers had Internet access. However, according to the last column in Exhibit 6.10, approximately 30 percent of the advanced mathematics students in Iran and Lebanon as well as 25 percent in Armenia attended schools where no computers had Internet access, and these students had lower average achievement than their counterparts in schools where all or most of the computers had Internet access.

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Chapter 7

The Physics Curriculum in the Participating Countries

The physics assessment for TIMSS Advanced 2008 was developed according to a framework designed to reflect the physics studied around the world in science programs during the final year of schooling. More specifically, the TIMSS Advanced 2008 physics framework[1] was organized around content domains and cognitive domains. The content domains or subject matter to be assessed included mechanics, electricity and magnetism, heat and temperature, and atomic and nuclear physics, while the cognitive domains or thinking behaviors expected of students as they engaged with the physics content included knowing, applying, and reasoning. The TIMSS Advanced 2008 countries participated in the iterative review process used to develop the framework and worked collaboratively with the TIMSS & PIRLS International Study Center to develop the test questions (items) covering the framework. Although all countries agreed that the physics described in the framework and addressed by the items in the assessment represented a reasonable fit to their curricular goals, it must be emphasized that each of the participating countries had its own approach to teaching and learning physics. To better understand the results, therefore, it is important first to understand the differences in the education systems in the

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

participating countries and the characteristics of the students assessed for TIMSS Advanced.

Because the participating countries took substantively different approaches to educating students in physics, the first section of Chapter 7 contains information about the structure of the educational systems in the countries that participated in TIMSS Advanced 2008, with a particular focus on the number of years of schooling involved and the selectivity of the program or track assessed by TIMSS Advanced. Data are presented about the characteristics of the physics curriculum in each country, and about the students who participated. Later sections deal with the amount of instructional time allocated to physics in these advanced programs or tracks, the degree to which certain topics from the TIMSS Advanced physics framework were taught, and the extent to which teachers indicated that they felt well-qualified to teach physics.

In comparing achievement across countries, it is important to consider differences in students' curricular experiences, how these differences may affect the physics they have studied, and their subsequent achievement. Students' opportunities to learn the physics covered by the TIMSS Advanced 2008 content and cognitive domains depend initially to some degree on that physics being part of each country's guidelines and policies for science education. Thus, participants provided information about various educational policies and the curriculum topics covered in their respective curriculum guidelines (intended curriculum). Inclusion in the country's curriculum, however, does not guarantee students' opportunity to learn. Just as important is what their teachers choose to teach them. The content of the lessons provided by the teachers ultimately determines the physics that students are taught (implemented curriculum).

The goal of Chapter 7 is to provide information about the teaching and learning of physics in each of the nine countries that participated in the TIMSS Advanced assessment of physics in 2008. It is hoped that this information will enable readers to compare and contrast the different approaches taken by different countries in this area, in order to establish a basis for making cross-country comparisons of outcome data in subsequent chapters.

Among the topics to be covered in Chapter 7 are an overview of the educational systems in the participating countries, descriptions of the populations of students tested, the characteristics of the physics curriculum, the amount of time devoted to physics in the curriculum at this level, and students' opportunity to learn the topics covered in the TIMSS Advanced physics assessment, including teachers' reports about whether those topics were taught and their feelings about how well prepared they were to teach physics at this level.

Overview of the Educational Systems

Science curricula and instructional practices vary considerably around the world. For example, at the elementary and junior secondary school levels, many countries take a general science approach where various branches of science are integrated into a single course. In other countries, science curricula are organized into separate courses focusing on the major science disciplines: chemistry, biology, physics, earth science, etc. At the secondary school level, and especially in the final year or two of secondary school, significant differences can be found across countries in the topics that are included in their science curricula, in the rates of participation of students in the science courses available at that level, and in the proportions of students still in school and studying physics.

Such considerations add to the complexity of making achievement comparisons across countries at this level, but they also heighten the degree of interest in those comparisons. When all children are in school learning the basic concepts of science, cross-country comparisons, while complicated by socioeconomic and cultural factors among others, are somewhat less problematic. But when there are substantial variations among countries with respect to these kinds of factors, as there are at the senior secondary level, straightforward comparisons are more difficult to draw. Thus, readers of this report are cautioned to be judicious in drawing conclusions about the relative strengths of national systems of education on the basis of the results presented in this volume. The results can be used to examine the range of educational outcomes produced in different countries, and to illustrate the wide range of educational choices that are in effect in those countries.

Exhibit 7.1 presents information about how the overall curriculum for upper secondary school and the physics program are structured in each of the nine countries that participated in TIMSS Advanced 2008. In eight of the nine countries, the last year of secondary school is either the 11th or the 12th year of schooling. The exception is Italy, where the last year of secondary school in some programs is the 13th year. Normally, students in the Russian Federation would complete secondary school after 11 years of schooling; however, about half of the students in their final year at the time of the TIMSS Advanced data collection were in their 10th year, having skipped Year 4 as part of the implementation process for the current program.

In five of these nine countries—Armenia, Iran, Lebanon, the Netherlands, and Sweden—upper secondary schooling consists of a 3-year program. However, in Norway and the Russian Federation, it is 2 years, in Slovenia it is 4 years, and in Italy it can be 5 years. The

Netherlands may also be considered to have a 5-year program since it includes 2 years of basic education where students follow the same curriculum. The number of hours of physics studied per year was in the range of 100 to 140 hours for most countries, with Slovenia and Sweden reporting a somewhat lower time allocation of 75 to 79 hours and Lebanon reporting a somewhat higher time allocation of 166 hours per year.

In some of the countries, including Armenia, Iran, Italy, and the Russian Federation, students had to meet entrance requirements (e.g., previous grades, exams, recommendations) to be permitted to enroll in the physics program. In the rest of the countries, students appeared to have considerable latitude in making decisions about which program to follow after completing basic education or general courses required of all students.

In several countries, the students who were identified for participation in TIMSS Advanced 2008 were enrolled in rather highly specialized programs, notably Armenia where the TIMSS physics students were enrolled in the "physmat" program and, similarly in Iran, where the track assessed was specifically for university bound students studying both mathematics and physics. In the Netherlands, most of the TIMSS physics students were taking a specialized physics program as part of the science and technology program, and in the Russian Federation they studied physics for 3 hours or more per week in any of several types of schools. In other countries, a somewhat broader cross-section of the final year population was represented.

Exhibit 7.1 **Structural Characteristics of the Physics Programs (Tracks) Assessed by TIMSS Advanced 2008**

TIMSSAdvanced2008 Physics

Country	Description of How the Programs (Tracks) Fit into Overall Curriculum	Number of Years Students Spent in These Programs (Tracks)	Number of Hours of Physics Instruction in Total	Criteria for Admission to These Programs (Tracks)
Armenia	Secondary schooling is a 3-year program up to the 11th grade. All students follow the same curriculum through the 3-year program, although students in a small number of special “physmat” schools cover additional topics in mathematics and science. Students at the 11th grade in these “physmat” schools constitute the target population for TIMSS Advanced 2008. As a result of recent reforms to increase the number of years of school, Armenian students were assessed in what is now called the 11th grade. However, since the assessed students skipped a grade as part of implementing the reform, they have had 10 years of formal schooling.	Three years	108	Completion of elementary school and success on the centralized state examination after the 9th grade.
Iran, Islamic Rep. of	After lower secondary school (grade 9), students can choose the track they wish to attend in upper secondary school. Students who complete the 11th grade in the mathematics track are allowed to participate in the advanced mathematics and physics track in the pre-university stage. This advanced mathematics and physics track is the target population assessed by TIMSS Advanced 2008.	Three years	110	For enrollment in the advanced mathematics and physics track, students’ cumulative grade point average at the 9th grade, their grades in mathematics and science, and the opinion of the school counselor are taken into consideration.
Italy	Secondary education can last 3, 4, or 5 years and is given in four types of schools: classical schools, scientific schools, technical schools, and vocational schools. The students assessed by TIMSS Advanced 2008 are in grade 13 and have taken an advanced mathematics and physics course. Most of these students are found in the Liceo Scientifico (general schools with scientific focus), Liceo Scientifico Tecnologico (general school with a focus on technology), or Instituti Technici (vocational full time training).	Five years	100	Completion of lower secondary education and success on the national examination after the 8th grade.
Lebanon	Secondary schooling is a 3-year program up to the 12th grade. All students follow the same curriculum in their first year. In the second year, students can choose between humanities and sciences and in the third year, students from the sciences can choose from one of three programs: sociology and economics, life science, or general science. Students from the general science program at the 12th grade constitute the TIMSS Advanced 2008 target population.	Three years	166	Diploma from basic education (brevet).
Netherlands	Secondary education begins with 2 years (grades 7 and 8) of basic education where all students follow the same curriculum. Students can then choose one of three tracks. In the pre-university track (VWO) which is a 4-year program, in the first year (grade 9) all students follow the same curriculum. The next year (grade 10) they can choose one of four programs. Students who select the Physics 2 course—most of whom come from the science and technology program—constitute the target population for TIMSS Advanced 2008.	Three years	112*	Students are free to enroll in the different tracks based on their ability and interest.
Norway	The Norwegian students assessed for TIMSS Advanced 2008 had 9 years of compulsory education followed by 3 years of secondary education. The first year of secondary education consists of general courses for all students in the academic track. In the last 2 years, students choose which subjects they want to take. Physics courses in the last 2 years consists of 2FY and 3FY. The students assessed by TIMSS Advanced 2008 were in the final year of secondary education and had taken the 3FY physics course. After implementing a curriculum reform, the Norwegian school system consists of 13 years of schooling.	Two years	140	Completion of all general courses in the first year of upper secondary schooling.

SOURCE: IEA TIMSS Advanced 2008 ©

Data provided by National Research Coordinators.

* Instructional time is not prescribed for physics. According to the curriculum, a total of 560 hours over three years should be spent by the students on physics (including homework and instruction). About 60% on average should be spent as class time.

Exhibit 7.1 **Structural Characteristics of the Physics Programs (Tracks) Assessed by TIMSS Advanced 2008 (Continued)**

TIMSSAdvanced2008 Physics

Country	Description of How the Programs (Tracks) Fit into Overall Curriculum	Number of Years Students Spent in These Programs (Tracks)	Number of Hours of Physics Instruction in Total	Criteria for Admission to These Programs (Tracks)
Russian Federation	All students study mathematics and physics every year in basic and upper secondary education. In basic education, all students follow the same curriculum, but in upper secondary (grades 10 and 11), the programs differ. The students assessed by TIMSS Advanced 2008 are the 11th grade students who had 3 hours or more per week of instruction in physics. These students can be found in lyceums, gymnasiums, special schools for mathematics and physics, and general secondary schools with different profiles in the upper secondary level. As a result of an ongoing reform to increase the number of years of school, Russian students were assessed in what is now called the 11th grade and about half the students have had 11 years of formal schooling. However, the other half skipped grade 4 as part of implementing the reform and only have had 10 years of formal schooling.	Two years	102	Admission to the physics course involves a written test, interview and students' performance in physics for the previous years of schooling.
Slovenia	The Slovenian students assessed for TIMSS Advanced 2008 had 8 years of elementary education and 4 years of secondary education. Secondary education in Slovenia consists of two types of programs: general gymnasia and vocational or technically oriented programs. Only the general gymnasia program offers students the possibility of admission to university studies. Students in the fourth year of general gymnasia programs who chose to take an additional physics course in their final year were the target population assessed in physics by TIMSS Advanced 2008. Currently, Slovenia is in the process of increasing elementary school to 9 years, so that students will have 13 years of schooling.	Four years	79	Completion of elementary schooling. There are no other special admission criteria for the general gymnasia program.
Sweden	Upper secondary education starts from grade 10 and is divided into 17 national 3-year programs. Of these programs, the natural science program has two mandatory physics courses (Physics A and B) while the technology program has one mandatory physics course (Physics A) and one optional course (Physics B). The students assessed by TIMSS Advanced 2008 were the 12th grade students who had taken the Physics B course.	Three years	75	Completion of compulsory education. Students are then free to choose any upper secondary program.

SOURCE: IEA TIMSS Advanced 2008 ©

Data provided by National Research Coordinators.

Description of the Students Assessed for TIMSS Advanced 2008

More information about the makeup of the TIMSS Advanced 2008 target populations in the participating countries can be found in Exhibit 7.2. As noted in the first column of data, the number of students in the program or track assessed for TIMSS Advanced 2008 varied from about 1600 students in Slovenia to over 100,000 in the Islamic Republic of Iran. Students in their final year of schooling were older in some countries than they were in others, ranging from a low of 17 years in the Russian Federation, to highs of 19 in Italy, Norway, Slovenia, and Sweden (with 12 or 13 years of schooling).

Because the number of students taking physics in a country is affected not only by the size of the country but also by the selectivity of the program or track, Exhibit 7.2 provides information about the relative situation in each of the nine countries. In particular, the TIMSS Advanced Physics Coverage Index shown in the fourth data column of Exhibit 7.2 provides a means of comparing the relative sizes of the populations included in the study in these countries. The coverage index for a given country is an estimate of the percentage of the entire national age cohort covered by the TIMSS Advanced target population. It may be helpful to consider the TIMSS Advanced Coverage Index as a fraction, expressed as a percentage. For most countries, the denominator of the fraction (found in the third data column) is the estimate of the size of the entire national population for the same age cohort as the students tested for TIMSS Advanced. For example, the students assessed in Iran for TIMSS Advanced were, on average, 18 years old (the second data column), so the population estimate for Iran in the third data column is for all 18-year olds in Iran. For Armenia, Lebanon, and Slovenia, data for the age cohorts were not available year-by-year but only for the group of students aged 15 to 19

Exhibit 7.2 **Size of the TIMSS Advanced 2008 Target Population for Physics, the Age Cohort, and the TIMSS Advanced Physics Coverage Index**

TIMSSAdvanced 2008 Physics

Country	Estimated Size of the Population of Students in the Final Year of Secondary School Taking the Physics Track or Program Targeted by TIMSS Advanced (Derived from TIMSS Advanced Student Sample)	Age Cohort Corresponding to the Final Year of Secondary School	Size of the Age Cohort Corresponding to the TIMSS Advanced Population Based on National Census Figures[a]	TIMSS Advanced Physics Coverage Index – the Ratio of the Estimated Size of the TIMSS Advanced Target Student Population (Column 2) to the Size of the Corresponding Age Cohort (Column 4)	Years of Formal Schooling*
Armenia	2,684	18	62,758	4.3%	10
Iran, Islamic Rep. of	111,908	18	1,705,000	6.6%	12
Italy	23,176	19	605,507	3.8%	13
Lebanon	4,724	18	79,784	5.9%	12
Netherlands	6,889	18	205,200	3.4%	12
Norway	4,181	19	61,093	6.8%	12
Russian Federation	52,934	17	2,073,041	2.6%	10/11
Slovenia	1,635	19	21,815	7.5%	12
Sweden	13,873	19	125,923	11.0%	12

SOURCE: IEA TIMSS Advanced 2008 ©

a Armenia: Estimate derived by dividing the population of 15–19-year olds by 5 for the single year estimate for the year 2008. Data taken from the U.S. Census Bureau's International Database (www.census.gov/). Islamic Rep. of Iran: Total population of 18-year olds in Iran in 2008. Data taken from the Statistical Center of Iran (SCI) (http://www.sci.org.ir/portal/faces/public/sci_en). Italy: Total population of 19-year olds in Italy for the year 2008. Data taken from the Italian Bureau of Statistics (ISTAT) (http://demo.istat.it/pop2008/index.html). Lebanon: Estimate derived by dividing the population of 18–20-year olds by 3 for the single year estimate. Data taken from the Central Bureau for Statistics in the Ministry of Interior. Netherlands: Estimate based on data taken from the Central Bureau of Statistics in the Netherlands (www.cbs.nl). Norway: Total population of 19-year olds in Norway on 1 January 2008. Data taken from the Norwegian National Bureau of Statistics (SSB) (http://www.ssb.no/english/). Philippines: Population of 16-year olds for 2008 projected from the 2000 census. Data taken from the National Statistics Office, Philippines (NSO) (http://www.census.gov.ph/). Russian Federation: Total population of 17-year olds in 2008. Data taken from the Federal State Statistics Service (http://www.gks.ru/wps/portal/english). Slovenia: Estimate was derived by dividing the population of 15–19-year olds by 5 for the single year estimate for the year 2008. Data taken from the Statistical Office of the Republic of Slovenia (www.stat.si). Sweden: Total population of 19-year olds in Sweden for the year 2008. Data taken from Statistics Sweden (SCB) (http://www.scb.se/default____2154.aspx). Data provided by National Research Coordinators.

* Represents years of formal schooling counting from the first year of primary or basic education (first year of ISCED Level1). Because of ongoing reforms in some countries to increase the number of years of schooling, the number of years of formal schooling is not always the same as the grade assessed (see Exhibit 7.1).

(18 to 20 for Lebanon), so the population estimates for those countries are averages. The numerator of the fraction is the estimated size of the target population assessed by TIMSS Advanced derived from the TIMSS Advanced student sample (first data column).

The TIMSS Advanced Physics Coverage Index expresses the number of students enrolled in the physics program or track assessed by TIMSS Advanced as a percentage of all of the students of the same age who could potentially have been in the advanced program or track (if they had all continued their schooling to the final year, wanted to be in the program, and had all been accepted). That is, this is the percentage of students in the age cohort in each country receiving the most elite physics education. The exhibit shows that the range of the coverage index for physics is considerably smaller than was the case for advanced mathematics. The lowest coverage index for physics was 2.6 percent in the Russian Federation, and the highest was 11 percent in Sweden.

The countries that participated in TIMSS Advanced 2008 were very different both in terms of the overall size of their age cohorts (which depend on the size of their national populations), and the numbers of students enrolled in their physics programs (which depend both on the size of the population and the degree of selectivity and availability of the program or track assessed). In Iran and the Russian Federation, the estimated size of the age group from which the TIMSS Advanced 2008 population was selected was greater than 1.5 million. At the opposite extreme, the size of the comparable age cohort in Slovenia was less than 25,000. Armenia, Lebanon, and Norway also had rather small age cohorts, with each being between 60 and 80 thousand.

Characteristics of the Physics Curriculum

Exhibit 7.3 summarizes how recently the physics curriculum has been updated in each of the participating countries. It shows that, in all countries, the physics curriculum either had been revised within the 10 years preceding the TIMSS Advanced 2008 assessment, or was in the process of revision.

Exhibit 7.4 contains summary information for each country about whether the TIMSS Advanced 2008 physics topics were covered in their national curriculum guidelines. The information about topics included in the participants' curricula is discussed in greater depth in Exhibits 7.12 through 7.16, which also include information about the implemented curriculum and provide the results topic-by-topic within each content domain. In general, the countries reported a high degree of correspondence between the topics covered by the TIMSS Advanced 2008 physics assessment and the topics included in their national curricula for the programs, tracks, or courses identified to be assessed in TIMSS Advanced. As previously described, the framework and the test items for the TIMSS Advanced 2008 physics assessment covered four content domains: mechanics, electricity and magnetism, heat and temperature, and atomic and nuclear physics. As is shown in Exhibit 7.4, the test items dealt with 17 physics topics chosen from the four content domains: 7 in mechanics, 4 in electricity and magnetism, 3 in heat and temperature, and 3 in atomic and nuclear physics.

The vast majority of topics included in the TIMSS Advanced 2008 physics framework were included in the physics curricula of all the participating countries. In all countries, almost all (15 or more out of 17) of the topics from the TIMSS Advanced 2008 physics framework were included in their intended curriculum. All four content domains had very high inclusion rates in all countries.

Exhibit 7.3 Structural Characteristics of the Physics Curriculum in Participating Countries

TIMSSAdvanced 2008 Physics

Country	Year Curriculum Taken by Students Assessed in TIMSS Advanced Was Introduced	Curriculum Changes
Armenia	2006	
Iran, Islamic Rep. of	1998	
Italy	1923; last revised: Technical Schools 1994, Lyceum 2000	The curriculum is being revised to increase the number of hours of teaching the English language, mathematics and science. The new curriculum will be introduced in 2010.
Lebanon	2001	
Netherlands	1998	Various areas of physics content have been combined and the number of instructional hours have been reduced. Consequently, there are fewer topics in the curriculum and on the final examination. The new curriculum started in August 2007 in grade 10 and therefore has not affected the students participating in TIMSS Advanced 2008.
Norway	1998	A new curriculum was implemented in 2006 with more emphasis on competencies and basic skills, and less on instructional methods. The TIMSS Advanced population belonged to the last cohort not affected by this curriculum reform.
Russian Federation	2004	
Slovenia	1998	In 1998, the curriculum for the general gymnasia program was changed to align with the compulsory Matura examination in terms of contents, standards, number of hours per subject, and content of compulsory parts of optional courses. The previous curriculum for all 4 years of secondary schools was divided into one curriculum for the general gymnasia program and a curriculum for vocational or technically oriented programs with the former being more advanced in all subjects.
Sweden	2000	The curriculum is under revision and is intended to be implemented in 2011.

SOURCE: IEA TIMSS Advanced 2008 ©

Data provided by National Research Coordinators.

Exhibit 7.4 Number of TIMSS Physics Topics in the Intended Curriculum

TIMSSAdvanced 2008 Physics

Country	Overall (17 topics)	Mechanics (7 Topics)	Electricity and Magnetism (4 topics)	Heat and Temperature (3 Topics)	Atomic and Nuclear Physics (3 Topics)
Armenia	17	7	4	3	3
Iran, Islamic Rep. of	15	5	4	3	3
Italy	17	7	4	3	3
Lebanon	15	7	4	1	3
Netherlands	15	6	3	3	3
Norway	17	7	4	3	3
Russian Federation	17	7	4	3	3
Slovenia	16	6	4	3	3
Sweden	16	6	4	3	3

SOURCE: IEA TIMSS Advanced 2008 ©

Data provided by National Research Coordinators.

Because the TIMSS Advanced assessment attempted to align with instructional practices as much as possible, the assessment was designed so that students could use calculators in ways that mirrored their classroom experiences without unduly advantaging or disadvantaging students either way. Exhibit 7.5 summarizes information concerning the policies in effect in the countries with respect to the use of calculators and computers in physics classrooms and during examinations. All participating countries reported permitting students to use calculators of various kinds on national examinations. Two countries, Iran and the Russian Federation, indicated that there was little, if any, mention of calculator and computer use in official documents related to the curriculum. In some countries, curriculum documents encourage teachers to explore applications of technology with their students, but do not provide a lot of specific suggestions or recommendations. Some countries allow students to use graphing calculators during examinations; others forbid their use. In the Netherlands, the examination board each year produces a list of the specific brands of calculators that may be used by students during examinations. On the whole, it seems that mathematics and science educators in many countries are still unsure about how best to incorporate technology into mathematics and science teaching, given the constraints they face in terms of the content of the curriculum and the availability of software of sufficiently high quality and low enough cost to make its adoption possible.

Because public examinations are used in some countries to make decisions about the students enrolled in physics programs, tracks, or courses, participating countries were asked to provide information about their examination systems. Exhibit 7.6 indicates that some type of “high-stakes” examinations (i.e., an examination or system of examinations with academic consequences) were a feature of nearly

Exhibit 7.5 **Curriculum Studied by TIMSS Advanced Students Includes Policies Regarding Use of Computers and Calculators**

TIMSSAdvanced 2008 Physics

Country	Computers	Calculators	Types of Calculators	Calculators in National Examinations	Description of Policies
Armenia	○	○	○	●	Simple calculators are allowed in national examinations.
Iran, Islamic Rep. of	○	○	○	●	Since calculators and computers are not accessible for all students, use of them is not discussed in the national curriculum. Simple calculators only for calculation are permitted in national examination.
Italy	●	○	○	●	There are no policies about the use of calculators. Students use their own calculator during the examinations, but they are not provided. Students use computers while studying some subjects in the lyceum or in specific subjects of technical schools.
Lebanon	○	●	●	●	Non-programmable calculators are permitted. There are no curricular policies about the use of computers. Computer use is optional.
Netherlands	●	●	○	●	Only graphing calculators are allowed in national examinations. The examination board yearly prescribes which brands are allowed.
Norway	●	●	●	●	Graphing calculators are allowed during examinations and frequently used in class. The curriculum, however, only has a vague and general statement about using technological tools in investigations, modeling, and problem solving.
Russian Federation	●	○	○	●	There are no statements about calculator use in the physics curriculum but students are allowed to use nonprogrammable calculators in national examinations. The regional authorities provide free calculators at the examination centers or allow students to bring their own calculators. Concerning computer requirements in the physics curriculum, students should be able to use ICT for searching, processing and presenting the physics information in the computer and web database as the result of studying physics at the advanced level.
Slovenia	●	●	●	●	The national curriculum requires that calculators used in the national examination should be scientific calculators without the capability of symbolic or graphic calculations. During lessons students are allowed to use their own calculators. The use of computers is recommended.
Sweden	●	○	○	●	There are no national examinations in Physics. There is a national test bank, with tasks and tests, and any calculator is allowed to be used on the tests found in the test bank. There are statements in the curriculum that students should develop their ability to use modern technical tools for the collection and analysis of data and for simulation of physics phenomena. This implies use of computers.

● Yes
○ No

SOURCE: IEA TIMSS Advanced 2008 ©

every one of these nine educational systems, with the exception of Sweden. In the other participating countries, students write national examinations in physics and other subjects during their final year of secondary school and, in some cases, at other grade levels as well. In most cases the important examinations at the end of secondary school are administered by the Ministry of Education or a national examination board. In Sweden, on the other hand, evaluation is the responsibility of the teacher. There are national examinations, but they are intended to supplement the evaluation information that teachers develop on their own.

The National Research Coordinators responsible for implementing TIMSS Advanced in each of the participating countries were asked to indicate which of six possible methods for evaluating the degree of implementation of the physics curriculum were used in their countries, and their responses are summarized in Exhibit 7.7. The results show that countries tend to use several sources to collect data about curriculum implementation, including results from international comparative studies such as TIMSS Advanced 2008. The most commonly used sources were national examinations, assessments, or tests, while the least frequently used methods were research and evaluation programs and school self-evaluation.

All of the participating countries publish either an official curriculum document or a set of notes and directives detailing the physics curriculum for teachers, as shown in Exhibit 7.8. Most of them also reported either recommending or mandating particular textbooks to be used by teachers and students for the advanced course. Other kinds of support materials were made available for teachers in some, but not all, countries. These materials included some form of a teacher's guide with suggestions for teaching various topics, suggested instructional activities, and a description of the structure and content

Exhibit 7.6 **Examination System in Participating Countries**

TIMSSAdvanced 2008 Physics

Country	Examinations with Consequences for Individuals	Grades at Which Examinations Are Given	Nature and Format of Examination	Purpose of Examination and Consequences	Comments
Armenia	●	Compulsory examinations at grades 9 and 11.		The 9th grade examination is used to determine which students can continue their secondary schooling. The 11th grade examination is necessary for graduation and entry to university.	Both of these are centralized state examinations.
Iran, Islamic Rep. of	●	Examination is given at the pre-university year.	Assessment at pre-university includes mid-semester and final examination.	Passing all subjects in both semesters is a requirement for entering university.	National examinations for grade promotion are given each semester, in two subjects chosen randomly. Examinations in the rest of the subjects are given by the schools. Another national examination is given for entry to the university.
Italy	●	Compulsory examination at the end of grade 8 and at the end of grade 13.	The assessment at grade 13 includes two written tests developed by the Ministry of Education and a third developed by the teacher.	The national examination at grade 8 determines entry to secondary school. The national examination at grade 13 determines entry to university.	Final examination for technical and professional schools also gives students an opportunity to find a job.
Lebanon	●	Examination at the end of the 12th grade.	Written examination.	The examination is used to determine which students have completed secondary schooling and is also used for university admission.	Some university faculties, especially science, engineering and medicine, administer entrance examinations in subjects such as mathematics and physics.
Netherlands	●	There is a national examination at the end of lower-secondary (grade 8) and at the end of upper-secondary education. Depending on the track in upper-secondary the examinations are in grade 10 (pre-vocational), grade 11 (senior general), grade 12 (pre-university).	Diploma for the upper secondary level is given based on three school-based examinations, number of practical assignments, and final national examinations in different subjects.	The pre-university diploma is needed in order to enter into university.	The national examinations are conducted by the National Examination Board.
Norway	●	Students may be selected for examination in the last 2 years of upper secondary school.	Written national examination or oral local examination.	The examination results influence entrance to tertiary education.	National examinations are administered by the Ministry of Education.
Russian Federation	●	There is a national examination in physics at grade 9 and 11 for those who select physics as a basis for graduating and entering the next level.	The grade 9 examination in physics consists of a written as well as an experimental part. The grade 11 examination is conducted in written form.	The 9th grade examination is used to determine which students can continue their secondary schooling. The 11th grade examination is necessary for graduation and entry to university.	The Federal Service of Supervision in Education and Science administers the examination in physics.

● Yes
○ No

Data provided by National Research Coordinators.

SOURCE: IEA TIMSS Advanced 2008 ©

Exhibit 7.6 **Examination System in Participating Countries (Continued)**

TIMSSAdvanced 2008 Physics

Country	Examinations with Consequences for Individuals	Grades at Which Examinations Are Given	Nature and Format of Examination	Purpose of Examination and Consequences	Comments
Slovenia	●	There is a national examination at the end of elementary school (grade 8) and at the end of secondary school (grade 12). The national examination at the end of secondary school is called the Matura (General Matura for gymnasia program and Vocational Matura for vocational/ technical programs).	The Matura consists of written and oral examinations from the compulsory subjects of mathematics, mother tongue and foreign language and two subjects of the student's choice. Physics is one of the choices.	Matura is a school-leaving examination required for the completion of secondary education and for university entrance.	A pass in the Matura is a general admission requirement for any academic university study program and a minimal admission requirement for those academic courses having no limit on the number of students. Achievement in the Matura and achievement in the last 2 years of schooling are used to select students where there is a limit to the number of candidates for an university program. The Matura is prepared and administered by the National Examination Center.
Sweden	○				Sweden does not have an examination system with direct consequences for individual students. However, national assessment materials are used as an important tool to support teachers in grading their students.

● Yes
○ No

Data provided by National Research Coordinators.

SOURCE: IEA TIMSS Advanced 2008 ©

Exhibit 7.7 Methods Used to Evaluate the Implementation of the Curriculum for Physics

TIMSSAdvanced 2008 Physics

Country	Visits by Inspectors	Evaluation or Research Programs	School Self-Evaluation	National Examinations, Assessments, or Tests	TIMSS Advanced	Others
Armenia	●	●	●	●	●	● Subject monitored by National Institute of Education
Iran, Islamic Rep. of	●	●	○	●	●	○
Italy	●	○	●	●	●	○
Lebanon	●	●	○	●	●	○
Netherlands	●	○	○	●	○	● Subject monitored and textbooks reviewed by the Netherlands Institute for Curriculum Development (SLO)
Norway	○	●	○	●	●	○
Russian Federation	●	●	●	●	●	● Regional monitoring of students' achievement
Slovenia	○	○	●	●	●	○
Sweden	●	○	●	○	●	○

● Yes ○ No

Data provided by National Research Coordinators.

SOURCE: IEA TIMSS Advanced 2008 ©

Exhibit 7.8 Formats in Which the Curriculum for Physics Is Made Available

TIMSSAdvanced 2008 Physics

Country	Official Publication Containing the Curriculum	Ministry Notes and Directives	Mandated or Recommended Textbooks	Instructional or Pedagogical Guide	Specifically Developed or Recommended Instructional Activities	Description of Content of Public Examination	Other
Armenia	●	●	●	●	●	●	○
Iran, Islamic Rep. of	○	●	●	○	○	●	○
Italy	●	●	○	○	●	○	● Professional development for teachers
Lebanon	●	●	●	●	●	●	○
Netherlands	●	●	○	●	●	●	○
Norway	●	●	○	○	○	●	○
Russian Federation	●	●	●	●	●	●	● Professional development for teachers
Slovenia	●	●	●	○	●	●	● Most information (curriculum, etc.) can be found on websites of the Ministry of Education
Sweden	●	○	○	○	○	○	○

SOURCE: IEA TIMSS Advanced 2008 ©

of the formal examination to be administered at the end of the year. In some countries, copies of examinations from previous years are made available to teachers and students to familiarize them with the kind of examination they should expect. Armenia, Lebanon, and the Russian Federation indicated that they provide all of these kinds of curriculum support, while Sweden provides only an official curriculum guide for its teachers.

Exhibit 7.9 describes how teachers are kept abreast of changes to the official curriculum in physics in their school system. All of the TIMSS Advanced 2008 countries reported documenting such changes on the Ministry of Education's website and making various forms of in-service education and professional development opportunities available to teachers. Other activities carried out in five or more countries included conducting special conferences or seminars for teachers, distributing copies of revised curricula to schools, issuing notices to schools about recent changes to the curriculum, and publishing announcements of changes in professional association newsletters and in journals for teachers.

Exhibit 7.8 shows that, in Sweden, copies of the official curriculum were made available in printed form to teachers and others, but that none of the other alternatives listed were supported. Exhibit 7.9, on the other hand, shows that Sweden makes use of six of the eight listed alternatives for helping teachers to stay up-to-date with curricular changes. All but one of the countries indicated that they used five or more of the ways listed. Slovenia mentioned only three.

Exhibit 7.9 **Ways in Which Changes in the Curriculum Are Communicated to Teachers**

TIMSSAdvanced 2008 Physics

Country	Special Conferences/ Seminars	Ministry Website	Printed Copies of the Curriculum Distributed to Schools	Teachers Receive Own Printed Copy	Professional Development/ Inservice Education	Ministry Notes	Professional Association Newsletter	Education Journals
Armenia	●	●	●	○	●	●	○	●
Iran, Islamic Rep. of	○	●	○	○	●	●	●	●
Italy	●	●	●	○	●	●	●	●
Lebanon	●	●	●	○	●	●	○	○
Netherlands	○	●	●	○	●	●	●	●
Norway	●	●	●	●	●	●	●	○
Russian Federation	●	●	○	○	●	●	○	●
Slovenia	●	●	○	○	●	○	○	○
Sweden	●	●	●	○	●	○	●	●

● Yes
○ No

Data provided by National Research Coordinators.

SOURCE: IEA TIMSS Advanced 2008 ©

Implementation of the TIMSS Physics Curriculum

Exhibit 7.10 presents information about how many hours of classroom time are devoted each week to physics in the participating countries. The National Research Coordinators provided the estimates for the amount of time prescribed in the official curriculum, and the teachers of the students being assessed provided the information about the number of hours devoted to physics each week in their own classrooms. While the two estimates were equal only in Italy, there was a high degree of agreement in all countries except Slovenia and Sweden. That is, the estimate of class time in the intended curriculum is about the same as that in the implemented curriculum. In Slovenia, the National Research Coordinator reported that two hours of instructional time each week were to be allocated to physics according to the official curriculum, but teachers reported allocating almost three hours.

Teachers also were asked to report the percent of instructional time they devoted to the four TIMSS Advanced 2008 content domains—mechanics, electricity and magnetism, heat and temperature, and atomic and nuclear physics—as well as to other topics. As shown in Exhibit 7.11, the four TIMSS Advanced content domains together accounted for the vast majority of the instructional time available for physics in every country—in fact, 90 percent or more everywhere except in the Russian Federation and Slovenia.

The final year teachers reported that the largest proportion of class time in physics in every one of the participating countries was devoted to either mechanics or electricity and magnetism, with those two domains accounting for about half the class time or more everywhere. In Italy, almost two thirds of class time was reported to have been spent on electricity and magnetism, much more than anywhere else. The Netherlands had the most balanced time allocations

Exhibit 7.10 Weekly Hours of Intended and Implemented Instructional Time for Physics in the Final Year

TIMSSAdvanced 2008 Physics

Country	Intended Instructional Time as Prescribed in the Curriculum (in Hours per Week)	Number of Weeks Schools Are Open in a Year*	Weekly Hours of Implemented Instructional Time for Physics
Armenia	3.2	34	r 3.1 (0.00)
Iran, Islamic Rep. of	3.7	36	3.8 (0.11)
Italy	3.0	42	3.0 (0.05)
Lebanon	6.0	26	6.1 (0.09)
Netherlands	3.0**	40	2.9 (0.09)
Norway	3.7	38	3.9 (0.12)
Russian Federation	3.0–4.5	34	3.6 (0.09)
[a] Slovenia	1.7	35	2.9 (0.00)
Sweden	2.0***	38	3.2 (0.09)

SOURCE: IEA TIMSS Advanced 2008 ©

Intended instructional time provided by National Research Coordinators. Implemented instructional time provided by teachers.

* Number of weeks are estimated by dividing total number of school days in a year by five.

** Instructional time is not prescribed for physics. According to the curriculum, a total of 560 hours over three years should be spent by the students on physics (including homework and instruction). About 60% on average should be spent as class time.

*** Instructional time is not prescribed in the current curriculum. The range above is an estimate based on prescriptions of instructional time from the previous curriculum averaged over three years.

a Implemented time for Slovenia includes preparation time for Matura Examination.

( ) Standard errors appear in parentheses.

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

Exhibit 7.11 Percent of Time in Physics Class Devoted to TIMSS Content During the Final Year

TIMSSAdvanced 2008 Physics

Country	Mechanics	Electricity and Magnetism	Heat and Temperature	Atomic and Nuclear Physics	Other
Armenia	r 26 (0.2)	r 29 (0.2)	r 21 (0.2)	r 18 (0.1)	r 4 (0.2)
Iran, Islamic Rep. of	42 (1.4)	14 (0.9)	10 (0.7)	24 (0.8)	10 (1.2)
Italy	14 (1.3)	65 (2.7)	7 (1.0)	12 (1.3)	2 (0.7)
Lebanon	32 (0.4)	31 (0.4)	3 (0.4)	24 (0.3)	9 (0.6)
Netherlands	29 (1.3)	22 (0.8)	15 (0.8)	25 (1.5)	9 (1.1)
Norway	38 (0.8)	30 (0.5)	6 (0.7)	15 (0.6)	10 (0.8)
Russian Federation	16 (1.0)	33 (1.3)	12 (1.0)	18 (1.2)	22 (1.3)
Slovenia	21 (0.0)	26 (0.1)	16 (0.0)	24 (0.1)	13 (0.1)
Sweden	33 (1.1)	29 (0.7)	11 (0.7)	24 (0.7)	4 (0.8)

SOURCE: IEA TIMSS Advanced 2008 ©

Data provided by teachers.

( ) Standard errors appear in parentheses.

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

across the four domains. The Russian Federation gave over 20 percent of instructional time to topics other than the four TIMSS Advanced content domains, much more than in the other countries.

TIMSS Advanced asked teachers about the physics topics they taught to their students. Teachers of the assessed students were asked to indicate whether each of the TIMSS Advanced topics was *mostly taught before this year, mostly taught this year,* or *not yet taught or just introduced*. Exhibit 7.12 presents teachers' reports on the percentages of students who were taught the TIMSS Advanced physics topics prior to or during the year of the assessment. The exhibit shows, for each country, averaged across the content domains, the percentage of students whose teachers reported that the students had been taught each topic. Overall, in every country except Italy, teachers reported that at least 82 percent of their students had been taught all 17 topics. In Italy, the result was 77 percent. Results for the individual topics were correspondingly high, with the two lowest rates recorded in Italy for atomic and nuclear physics (40%) and in Lebanon for heat and temperature (43%).

As previewed in Exhibit 7.4, the participating countries were asked to indicate whether each of the TIMSS Advanced 2008 physics topics was included in their intended curriculum. As shown in Exhibit 7.12, the teachers of the TIMSS Advanced 2008 physics classes in every country were asked to indicate whether the physics students had been taught that topic. There were 17 topics in all: 7 in mechanics, 4 in electricity and magnetism, 3 in heat and temperature, and 3 in atomic and nuclear physics. The topic-by-topic responses are summarized in Exhibits 7.13 through 7.16.

Exhibit 7.13 shows that all of the partcipating countries included most of the topics (5 of 7) in the mechanics domain in their intended physics curriculum. The exceptions were that Iran did not include

Exhibit 7.12 **Average Percent of Students Taught the TIMSS Advanced 2008 Physics Topics Prior to or During the Final Year**

TIMSSAdvanced 2008 Physics

Country	Overall (17 topics)	Mechanics (7 Topics)	Electricity and Magnetism (4 topics)	Heat and Temperature (3 Topics)	Atomic and Nuclear Physics (3 Topics)
Armenia	r 87 (1.2)	r 97 (0.7)	r 98 (1.0)	r 91 (1.3)	r 77 (2.8)
Iran, Islamic Rep. of	90 (1.4)	79 (1.1)	95 (1.9)	95 (1.7)	90 (2.2)
Italy	77 (1.5)	90 (1.3)	89 (1.8)	90 (1.5)	40 (3.7)
Lebanon	82 (0.6)	96 (0.6)	96 (0.8)	43 (2.0)	91 (0.8)
Netherlands	91 (0.9)	88 (0.8)	93 (1.3)	91 (2.3)	93 (1.5)
Norway	93 (0.7)	94 (0.9)	99 (0.5)	92 (1.5)	87 (1.8)
Russian Federation	93 (0.9)	99 (0.4)	100 (0.3)	92 (1.3)	83 (2.7)
Slovenia	92 (0.1)	90 (0.0)	99 (0.1)	96 (0.1)	85 (0.2)
Sweden	87 (1.1)	94 (0.8)	96 (1.5)	84 (2.4)	72 (3.6)

SOURCE: IEA TIMSS Advanced 2008 ©

Data provided by teachers.

( ) Standard errors appear in parentheses.

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

Exhibit 7.13 Intended and Taught TIMSS Advanced 2008 Mechanics Topics

TIMSSAdvanced 2008 Physics

Mechanics (7 topics)	Conditions of Equilibrium		Energy (K.E., P.E., and Conservation of M.E.)		Mechanical Wave Phenomena in Sound and Refraction		Forces Including Frictional Force Acting on a Moving Body	
Country	Topic Is in the Intended Curriculum	Percent of Students Taught This Topic	Topic Is in the Intended Curriculum	Percent of Students Taught This Topic	Topic Is in the Intended Curriculum	Percent of Students Taught This Topic	Topic Is in the Intended Curriculum	Percent of Students Taught This Topic
Armenia	●	r 95 (0.1)	●	r 100 (0.0)	●	r 98 (1.6)	●	r 100 (0.0)
Iran, Islamic Rep. of	●	97 (1.2)	●	97 (1.5)	●	98 (1.4)	●	100 (0.0)
Italy	●	97 (1.3)	●	98 (1.1)	●	90 (3.1)	●	97 (1.3)
Lebanon	●	98 (0.8)	●	100 (0.0)	●	95 (1.4)	●	96 (1.1)
Netherlands	●	98 (1.5)	●	99 (0.8)	●	99 (0.8)	●	100 (0.0)
Norway	●	89 (4.6)	●	100 (0.0)	●	100 (0.5)	●	100 (0.0)
Russian Federation	●	99 (0.6)	●	99 (0.6)	●	99 (0.9)	●	99 (0.6)
Slovenia	●	100 (0.0)	●	99 (0.0)	●	98 (0.1)	●	100 (0.0)
Sweden	●	100 (0.0)	●	100 (0.0)	●	99 (0.7)	●	100 (0.0)

Mechanics (7 topics)	Forces Acting on a Moving Body in Circular Path		Elastic and Inelastic Collision		Relativity	
Country	Topic Is in the Intended Curriculum	Percent of Students Taught This Topic	Topic Is in the Intended Curriculum	Percent of Students Taught This Topic	Topic Is in the Intended Curriculum	Percent of Students Taught This Topic
Armenia	●	r 100 (0.0)	●	r 100 (0.0)	●	s 84 (3.3)
Iran, Islamic Rep. of	●	98 (1.4)	○	51 (4.7)	○	11 (2.1)
Italy	●	97 (1.3)	●	97 (1.4)	●	51 (6.1)
Lebanon	●	95 (1.3)	●	99 (0.7)	●	87 (2.1)
Netherlands	●	99 (0.8)	●	96 (2.5)	○	25 (4.9)
Norway	●	100 (0.0)	●	100 (0.0)	●	71 (4.2)
Russian Federation	●	100 (0.0)	●	100 (0.0)	●	95 (1.9)
Slovenia	●	100 (0.0)	●	99 (0.0)	○	35 (0.2)
Sweden	●	100 (0.2)	●	100 (0.0)	○	61 (5.3)

● Yes ○ No

Data on intended curriculum provided by National Research Coordinators, and on implemented curriculum by teachers at the time of testing.

( ) Standard errors appear in parentheses.

An "r" indicates data are available for at least 70% but less than 85% of the students. An "s" indicates data are available for at least 50% but less than 70% of the students.

SOURCE: IEA TIMSS Advanced 2008 ©

Exhibit 7.14 **Intended and Taught TIMSS Advanced 2008 Electricity and Magnetism Topics**

TIMSS Advanced 2008 Physics

Electricity and Magnetism (4 topics)	Coulomb's Law		Electric Circuits (Ohm's and Joule's Law)		Faraday's and Lenz's Laws of Induction		Electromagnetic Radiation	
Country	Topic Is in the Intended Curriculum	Percent of Students Taught This Topic	Topic Is in the Intended Curriculum	Percent of Students Taught This Topic	Topic Is in the Intended Curriculum	Percent of Students Taught This Topic	Topic Is in the Intended Curriculum	Percent of Students Taught This Topic
Armenia	●	r 100 (0.0)	●	r 100 (0.0)	●	r 98 (1.5)	●	r 93 (2.9)
Iran, Islamic Rep. of	●	95 (2.1)	●	93 (2.8)	●	94 (2.3)	●	97 (1.6)
Italy	●	97 (1.5)	●	97 (1.6)	●	95 (2.1)	●	68 (5.1)
Lebanon	●	96 (1.0)	●	97 (1.1)	●	95 (0.9)	●	96 (0.7)
Netherlands	○	78 (4.4)	●	100 (0.0)	●	99 (1.5)	●	96 (2.1)
Norway	●	100 (0.0)	●	100 (0.0)	●	100 (0.0)	●	97 (1.8)
Russian Federation	●	100 (0.0)	●	100 (0.0)	●	100 (0.2)	●	98 (1.0)
Slovenia	●	100 (0.0)	●	99 (0.1)	●	99 (0.1)	●	97 (0.2)
Sweden	●	100 (0.4)	●	96 (1.7)	●	92 (4.4)	●	96 (2.5)

● Yes ○ No

Data on intended curriculum provided by National Research Coordinators, and on implemented curriculum by teachers at the time of testing.

( ) Standard errors appear in parentheses.

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

SOURCE: IEA TIMSS Advanced 2008 ©

Exhibit 7.15 **Intended and Taught TIMSS Advanced 2008 Heat and Temperature Topics**

TIMSS Advanced 2008 Physics

Heat and Temperature (3 topics)	Difference Between Heat and Temperature, Heat Transfer and Specific Heat Capacities, Evaporation and Condensation		Expansion of Solids and Liquids in Relation to Temperature Change, Law of Ideal Gases, First Law of Thermodynamics		Black Body Radiation and Temperature	
Country	Topic Is in the Intended Curriculum	Percent of Students Taught This Topic	Topic Is in the Intended Curriculum	Percent of Students Taught This Topic	Topic Is in the Intended Curriculum	Percent of Students Taught This Topic
Armenia	●	r 100 (0.0)	●	r 90 (1.6)	●	r 82 (2.8)
Iran, Islamic Rep. of	●	94 (2.4)	●	95 (2.0)	●	95 (2.1)
Italy	●	97 (1.6)	●	97 (1.6)	●	75 (4.1)
Lebanon	●	57 (2.3)	○	44 (2.3)	○	27 (2.4)
Netherlands	●	93 (2.9)	●	94 (2.4)	●	87 (3.1)
Norway	●	100 (0.0)	●	98 (1.7)	●	79 (4.2)
Russian Federation	●	100 (0.0)	●	100 (0.4)	●	76 (3.9)
Slovenia	●	99 (0.0)	●	99 (0.0)	●	90 (0.2)
Sweden	●	96 (1.7)	●	76 (3.6)	●	81 (3.7)

● Yes ○ No

Data on intended curriculum provided by National Research Coordinators, and on implemented curriculum by teachers at the time of testing.

( ) Standard errors appear in parentheses.

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

SOURCE: IEA TIMSS Advanced 2008 ©

Exhibit 7.16 **Intended and Taught TIMSS Advanced 2008 Atomic and Nuclear Physics Topics**

TIMSS Advanced 2008 Physics

Atomic and Nuclear Physics (3 topics)	Structure of Atom			Light Emission and Absorption			Nuclear Reactions		
Country	Topic Is in the Intended Curriculum		Percent of Students Taught This Topic	Topic Is in the Intended Curriculum		Percent of Students Taught This Topic	Topic Is in the Intended Curriculum		Percent of Students Taught This Topic
Armenia	●	r	83 (3.6)	●	r	88 (3.0)	●	r	65 (2.7)
Iran, Islamic Rep. of	●		95 (2.2)	●		96 (2.0)	●		79 (3.7)
Italy	●		64 (4.9)	●		41 (5.5)	●		14 (4.3)
Lebanon	●		95 (0.6)	●		95 (1.1)	●		81 (1.6)
Netherlands	●		96 (1.8)	●		92 (3.0)	●		89 (1.8)
Norway	●		97 (1.7)	●		67 (4.9)	●		98 (1.3)
Russian Federation	●		88 (2.6)	●		89 (3.2)	●		72 (3.9)
Slovenia	●		92 (0.2)	●		86 (0.2)	●		77 (0.2)
Sweden	●		73 (4.3)	●		86 (3.3)	●		56 (5.7)

SOURCE: IEA TIMSS Advanced 2008 ©

● Yes ○ No

Data on intended curriculum provided by National Research Coordinators, and on implemented curriculum by teachers at the time of testing.

( ) Standard errors appear in parentheses.

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

elastic and inelastic collisions, and relativity was not included in Iran, the Netherlands, Slovenia, or Sweden. Generally speaking, the TIMSS Advanced topics in mechanics corresponded to those included in the intended curriculum and taught to a large proportion of the students.

Exhibit 7.14 shows that all four topics in the TIMSS Advanced 2008 electricity and magnetism domain were included in the intended curriculum of all these countries, with one exception. The Netherlands reported that Coulomb's Law was not in their intended curriculum, although, according to teachers' reports, almost 80 percent of students had been taught about it. In Italy, although electromagnetic radiation was reported to be in the intended curriculum, about one third of students were not taught about it.

Exhibit 7.15 focuses on the heat and temperature domain. All three topics were part of the intended curriculum in all countries except Lebanon where two of the three topics were not. Lebanon was also the only country where these three topics were not part of the implemented curriculum for many students. Otherwise, all three topics were taught to almost all students.

Exhibit 7.16 presents the intended and implemented results for the three topics in atomic and nuclear physics. All three were in the intended curriculum of every country, and in the implemented curriculum for the majority of students everywhere, with the exception of Italy, where only 41 percent were reported to have been taught about light emission and absorption and only 14 percent about nuclear reactions.

How Well Prepared Do Teachers Feel They Are to Teach Physics?

TIMSS Advanced 2008 asked the physics teachers how well prepared they felt they were to teach the topics included in the physics framework. For each topic, teachers were asked to indicate whether they felt very well prepared, somewhat prepared, or not well prepared. Teachers were asked about 17 topics in total, including 7 topics in mechanics, 4 topics in electricity and magnetism, 3 topics in heat and temperature, and 3 topics in atomic and nuclear physics. The percentages of students whose teachers reported feeling very well prepared to teach the various topics are presented in Exhibits 7.17 and 7.18. In Exhibit 7.17, the results are summarized by averaging the percentages of students whose teachers reported feeling very well prepared to teach each topic first across all of the 17 physics topics, and next across the topics in each of the four content domains. Exhibit 7.18 presents the results for each topic.

Exhibit 7.17 makes it clear that, in most of the participating countries, the vast majority of students were taught by teachers who considered themselves to be very well prepared to teach these physics topics at this level. This result is not particularly surprising, but there may be some cause for concern in those countries where 20 percent or more of the students were taught by teachers who considered themselves only somewhat prepared or not well prepared to teach these 17 topics. Over 80 percent of the students in Iran, Lebanon, the Netherlands, Norway, and Sweden were taught by teachers who considered themselves well prepared, on average, to teach the TIMSS Advanced topics. On the other hand, more than 20 percent of students in Armenia, Italy, and Slovenia were taught by teachers who were not as confident about their degree of preparedness.

Exhibit 7.18 shows the percent of students whose teachers considered themselves to be very well prepared to teach the topics in

Exhibit 7.17 **Percent of Students Whose Teachers Feel "Very Well" Prepared to Teach the TIMSS Advanced 2008 Physics Topics**

TIMSSAdvanced 2008 Physics

Country	Percent of Students				
	Overall (17 topics)	Mechanics (7 topics)	Electricity and Magnetism (4 topics)	Heat and Temperature (3 topics)	Atomic and Nuclear Physics (3 topics)
Armenia	78 (0.6)	80 (0.4)	82 (1.1)	81 (1.2)	68 (1.7)
Iran, Islamic Rep. of	86 (1.3)	81 (1.4)	92 (1.5)	91 (1.9)	78 (2.0)
Italy	42 (4.2)	50 (4.8)	49 (4.7)	47 (5.1)	22 (3.9)
Lebanon	86 (1.0)	92 (0.9)	92 (1.1)	66 (1.9)	93 (1.1)
Netherlands	84 (2.8)	80 (2.8)	83 (3.1)	85 (3.0)	87 (3.1)
Norway	93 (1.4)	94 (1.3)	96 (1.4)	90 (2.5)	92 (2.1)
Russian Federation	– –	– –	– –	– –	– –
Slovenia	76 (0.2)	77 (0.1)	80 (0.2)	78 (0.2)	70 (0.2)
Sweden	86 (1.7)	90 (1.5)	90 (2.1)	77 (2.7)	88 (2.4)

SOURCE: IEA TIMSS Advanced 2008 ©

Data provided by teachers.

A dash (-) indicates comparable data are not available. The Russian Federation did not collect this information.

( ) Standard errors appear in parentheses.

the four TIMSS Advanced 2008 physics content domains on a topic-by-topic basis. One might expect that almost all physics teachers at this level would consider themselves well qualified, insofar as the subject matter of the course is concerned, and that such teachers would feel themselves to be very well prepared to teach the course. This turns out, surprisingly enough, not to be the case for every topic in every country, and this is reflected in the content of the four tables that make up the exhibit: one table for each of the four content domains.

If 80 percent or more is used as a criterion for countries where a large majority of students were taught by teachers who considered themselves to be very well prepared to teach a topic, all of the mechanics topics except relativity would be included except in Italy. In Italy, large proportions of the teachers reported that they did not feel very well prepared to teach any of the mechanics topics.

The second table in Exhibit 7.18 concerns the four electricity and magnetism topics, and it raises similar issues. All four are areas in which a large majority of students of physics were taught by teachers who felt they were well prepared to do so. This, however, was not true in Italy, where significant proportions of physics teachers said they did not consider themselves very well prepared to teach the electricity and magnetism topics.

The third table in the exhibit deals with the three topics grouped under heat and temperature. Here again, large proportions of students in Italy were taught by teachers who considered themselves less than very well prepared to teach these topics. Moreover, many teachers in most countries expressed a relative lack of confidence in their preparedness to teach the topic of black body radiation and temperature, even though the topic was included in the intended curriculum in every country and most students were taught it.

Exhibit 7.18 **Percent of Students Whose Teachers Feel "Very Well" Prepared to Teach the TIMSS Advanced 2008 Physics Topics in Mechanics, Electricity and Magnetism, Heat and Temperature, and Atomic and Nuclear Physics**

TIMSSAdvanced 2008 Physics

SOURCE: IEA TIMSS Advanced 2008 ©

Country	Percent of Students Whose Teachers Report Feeling Very Well Prepared to Teach the Topics in Mechanics (7 topics)						
	Conditions of Equilibrium	Energy (K.E., P.E., and Conservation of M.E.)	Mechanical Wave Phenomena in Sound and Refraction	Forces Including Frictional Force Acting on a Moving Body	Forces Acting on a Moving Body in Circular Path	Elastic and Inelastic Collision	Relativity
Armenia	83 (2.1)	97 (0.1)	81 (1.8)	91 (0.3)	84 (0.4)	74 (0.5)	48 (0.7)
Iran, Islamic Rep. of	92 (2.7)	99 (0.6)	92 (2.7)	97 (1.3)	88 (2.8)	73 (3.7)	24 (3.7)
Italy	55 (5.6)	61 (5.7)	43 (5.9)	61 (5.5)	55 (5.8)	56 (5.3)	19 (4.2)
Lebanon	96 (0.8)	97 (0.8)	91 (1.3)	94 (1.2)	93 (1.4)	95 (1.2)	77 (2.5)
Netherlands	90 (3.3)	91 (3.0)	87 (3.8)	92 (2.8)	87 (3.7)	82 (3.7)	31 (4.8)
Norway	92 (2.3)	99 (1.0)	96 (1.8)	99 (1.0)	99 (1.0)	95 (2.2)	78 (3.9)
Russian Federation	– –	– –	– –	– –	– –	– –	– –
Slovenia	90 (0.2)	84 (0.2)	82 (0.2)	90 (0.2)	76 (0.2)	78 (0.2)	42 (0.2)
Sweden	96 (1.9)	97 (1.7)	89 (2.7)	95 (2.1)	96 (1.6)	97 (1.5)	59 (4.7)

Country	Percent of Students Whose Teachers Report Feeling Very Well Prepared to Teach the Topics in Electricity and Magnetism (4 topics)			
	Coulomb's Law	Electric Circuits (Ohm's and Joule's Law)	Faraday's and Lenz's Laws of Induction	Electromagnetic Radiation
Armenia	91 (0.4)	89 (2.5)	80 (3.2)	69 (1.9)
Iran, Islamic Rep. of	98 (1.3)	83 (3.7)	96 (1.8)	91 (2.4)
Italy	62 (5.5)	51 (5.7)	58 (5.9)	26 (5.2)
Lebanon	94 (1.3)	92 (1.4)	92 (1.5)	90 (1.3)
Netherlands	81 (3.8)	87 (3.4)	81 (3.4)	83 (3.9)
Norway	99 (1.1)	93 (2.7)	97 (1.7)	96 (2.1)
Russian Federation	– –	– –	– –	– –
Slovenia	88 (0.2)	82 (0.2)	81 (0.2)	69 (0.2)
Sweden	94 (2.2)	82 (4.8)	91 (2.1)	93 (2.1)

Data provided by teachers.

A dash (–) indicates comparable data are not available. The Russian Federation did not collect this information.

( ) Standard errors appear in parentheses.

Exhibit 7.18 **Percent of Students Whose Teachers Feel "Very Well" Prepared to Teach the TIMSS Advanced 2008 Physics Topics in Mechanics, Electricity and Magnetism, Heat and Temperature, and Atomic and Nuclear Physics (Continued)**

TIMSSAdvanced 2008 Physics

Country	Percent of Students Whose Teachers Report Feeling Very Well Prepared to Teach the Topics in Heat and Temperature (3 topics)		
	Difference Between Heat and Temperature, Heat Transfer and Specific Heat Capacities, Evaporation and Condensation	Expansion of Solids and Liquids in Relation to Temperature Change, Law of Ideal Gases, First Law of Thermodynamics	Black Body Radiation and Temperature
Armenia	87 (2.0)	92 (2.8)	64 (2.4)
Iran, Islamic Rep. of	97 (1.8)	94 (2.3)	83 (3.4)
Italy	59 (6.0)	56 (6.1)	27 (5.1)
Lebanon	81 (1.8)	72 (2.4)	45 (2.6)
Netherlands	90 (3.2)	86 (3.4)	80 (3.6)
Norway	94 (2.4)	88 (3.0)	89 (3.2)
Russian Federation	– –	– –	– –
Slovenia	80 (0.2)	84 (0.2)	68 (0.2)
Sweden	92 (2.2)	61 (4.3)	78 (4.2)

Country	Percent of Students Whose Teachers Report Feeling Very Well Prepared to Teach the Topics in Atomic and Nuclear Physics (3 topics)		
	Structure of Atom	Light Emission and Absorption	Nuclear Reactions
Armenia	78 (2.3)	78 (2.1)	51 (4.1)
Iran, Islamic Rep. of	96 (1.8)	93 (1.9)	46 (4.1)
Italy	29 (5.5)	25 (4.5)	12 (3.3)
Lebanon	94 (1.0)	93 (1.2)	92 (1.2)
Netherlands	89 (3.1)	88 (3.1)	83 (3.6)
Norway	96 (1.8)	95 (1.9)	84 (3.9)
Russian Federation	– –	– –	– –
Slovenia	79 (0.2)	66 (0.3)	64 (0.2)
Sweden	91 (2.9)	91 (3.2)	81 (2.9)

SOURCE: IEA TIMSS Advanced 2008 ©

Data provided by teachers.

A dash (–) indicates comparable data are not available. The Russian Federation did not collect this information.

( ) Standard errors appear in parentheses.

The final table in Exhibit 7.18 deals with atomic and nuclear physics. In this content domain, Italy reported significant percentages of students taught by teachers who did not consider themselves very well prepared to teach this material, even though these topics were included in their intended curriculum.

In summary, Chapter 7 presents a considerable amount of important information that should be taken into account when considering the achievement results presented in Chapter 8. Many country characteristics, such as socioeconomic factors and population size, can affect the challenges associated with educating students in physics. Beyond that, in some countries, students have had more years of schooling, or the physics program entails many more hours of study across the years of the program. In some cases, countries were more selective than others in identifying the students to be assessed in TIMSS Advanced. Also, the curriculum differed somewhat across the physics programs assessed in TIMSS Advanced, as did teachers' confidence in their preparation to teach the topics assessed. The considerable variation across the nine participating countries in these system-wide contexts for educating students in physics provides a complex and multifaceted backdrop for considering the variation in physics achievement.

OCCASVS
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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.

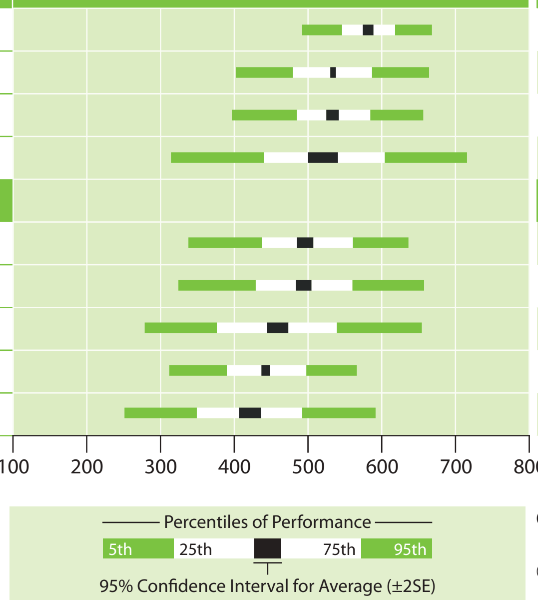
4 Taking into account the standard error provided in parentheses with each average scale score (mean achievement for the country), it can be said with 95 percent confidence that the corresponding value in the population falls between the sample estimate plus or minus two standard errors. Confidence intervals 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: 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

Physics Achievement Distribution



▲ Country average significantly higher than TIMSS Advanced scale average

▼ Country average significantly lower than TIMSS Advanced scale average

SOURCE: IEA TIMSS Advanced 2008 ©

* 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.

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.

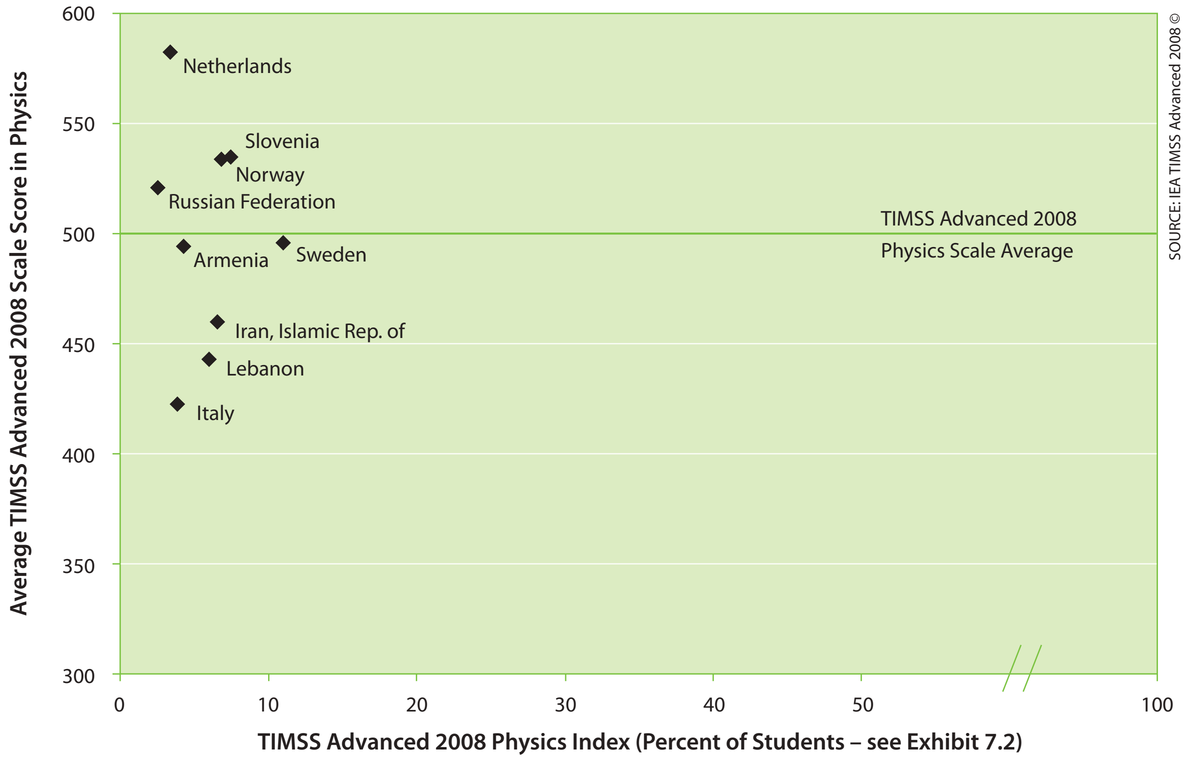
Because of differences among the years of schooling for these students in their final year as well as differences in age of entry to school and in promotion/retention policies, students' ages also varied across countries. The average age of the TIMSS Advanced 2008 students in Slovenia, Norway, Sweden, 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**

TIMSSAdvanced 2008 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)	▼

▲ 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.

SOURCE: IEA TIMSS Advanced 2008 ©

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.

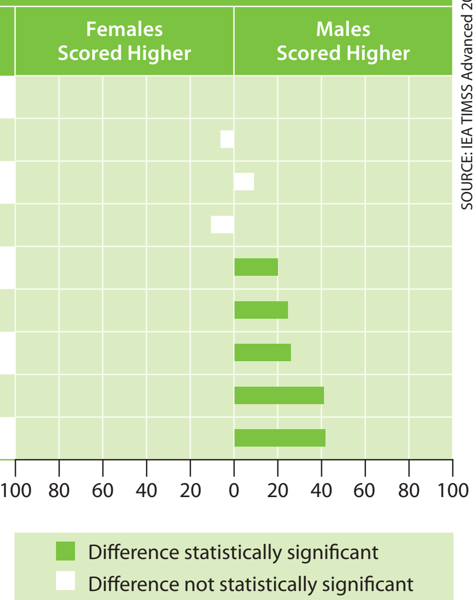
Enrollment in physics courses was predominately male in the TIMSS Advanced countries. In almost all of the countries, higher percentages of males than females were studying physics, and in some cases the physics courses were comprised primarily of male students; for example, 81 percent male students 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**

TIMSSAdvanced 2008 Physics

Country	Percent of Students		Average Achievement		
	Females	Males	Females	Males	Absolute Difference
‡ 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.

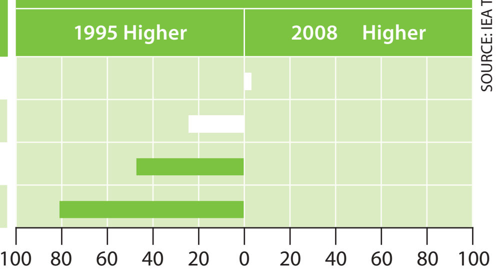
The participants are shown in the exhibit according to the difference between their 1995 and 2008 scores. In two of the four countries—Norway and Sweden—average achievement in physics declined between the two assessments. Sweden showed the greatest average decline—81 points, although the decrease in 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 2008	TIMSS Physics Coverage Index 1995	TIMSS Advanced 2008 Physics Average Scale Score	TIMSS Advanced 1995 Physics Average Scale Score*	Difference Between 1995 and 2008 Scores
‡ 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)



Difference statistically significant
Difference not statistically significant

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: 2008 Average Scale Score	Females: 1995 to 2008 Difference	Males: 2008 Average Scale Score	Males: 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**

TIMSSAdvanced 2008 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) ▼

SOURCE: IEA TIMSS Advanced 2008 ©

▲ 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.

Chapter 9

Physics Performance at the TIMSS Advanced 2008 International Benchmarks

As was described more fully in the Introduction, the TIMSS Advanced 2008 physics achievement scale summarizes students' performance on test items designed to measure breadth of content in mechanics, electricity and magnetism, heat and temperature, and atomic and nuclear physics, as well as a range of cognitive processes within the knowing, applying, and reasoning domains. To interpret the achievement results in meaningful ways, it is important to understand the relationship between scores on the scale and students' success on the content of the assessment. As a way of interpreting the scaled results, three points on the scale were identified as international benchmarks and descriptions of student achievement at those benchmarks in relation to students' performance on the test items were developed. The TIMSS Advanced benchmarks represent the range of performance shown by students internationally. The Advanced International Benchmark is 625, the High International Benchmark is 550, and the Intermediate International Benchmark is 475. In TIMSS at the fourth and eighth grade levels, four benchmarks were used: viz., advanced, high, intermediate, and low. The Low International Benchmark was not included in the TIMSS Advanced benchmarking analysis since, in all the participating countries, this is a highly select population of students.

The TIMSS & PIRLS International Study Center worked with a committee of experts[1] from several countries to conduct a detailed scale anchoring analysis to describe physics achievement at these benchmarks. Scale anchoring is a way of describing TIMSS Advanced 2008 performance at different points on the TIMSS Advanced physics scale in terms of the types of items students answered correctly. In addition to a data analysis component to identify items that discriminated between successive points on the scale,[2] the analysis also involved a judgmental component in which committee members examined the physics content and cognitive processing dimensions assessed by each item and generalized to describe students' knowledge and understandings.

This chapter presents the TIMSS Advanced 2008 physics achievement results at the international benchmarks for the participating countries. Then, benchmark by benchmark, there is a description of the understanding of physics content and types of cognitive processing skills and strategies demonstrated by students at each of the international benchmarks, together with illustrative items. For each example item, the percent correct for each of the TIMSS Advanced 2008 participants is shown. For multiple-choice items, the correct answer is identified by a bullet, •, and the percent of students in each country who chose each response is also given. For constructed-response items, a copy of the scoring guide showing the percent of students choosing each correct or incorrect approach to the solution is provided, along with a student response that was given full credit.[3] The items published in this report were selected from the items released for public use.[4] Every effort was made to include examples which not only illustrated the particular benchmark under discussion, but also represented different item formats and content area domains.

1 In addition to Robert A. Garden, the TIMSS Advanced Mathematics Coordinator, and Svein Lie, the TIMSS Physics Coordinator, committee members included Carl Angell, Wolfgang Dietrich, Liv Sissel Gronmo, Torgeir Onstad, and David F. Robitaille.

2 For example, in brief, a multiple-choice item anchored at the Advanced International Benchmark if at least 65 percent of students scoring at 625 answered the item correctly and fewer than 50 percent of students scoring at the High International Benchmark (550) answered correctly, and so on, for each successively lower benchmark. Since constructed-response questions nearly eliminate guessing, the criterion for the constructed-response items was simply 50 percent at the particular benchmark. For more information, see the *TIMSS Advanced 2008 Technical Report*.

3 All of the constructed-response items were scored according to detailed scoring guides containing descriptions and examples of the types of responses that should receive credit. Although most constructed-response items were worth 1 point, some were worth 2 points (with 1 point awarded for partial credit). If the example item was worth 2 points, the data are for responses receiving 2 points (full credit).

4 After each TIMSS assessment, a certain proportion of the items are released into the public domain and the rest of the items are kept secure for use in measuring trends over time in subsequent assessments. In the case of TIMSS Advanced, more than one-half of the items are being released.

How Do Countries Compare on the TIMSS Advanced 2008 International Benchmarks of Physics Achievement?

Exhibit 9.1 summarizes what students of physics in the participating countries who score at the TIMSS international benchmarks typically know and can do in physics. The data show that there were substantial differences in students' performance across the three benchmarks. Students at the Advanced International Benchmark demonstrated their ability to combine and apply concepts and laws of physics in solving complex problems in a variety of situations. Students at the High International Benchmark were able to apply basic laws of physics in solving problems in a variety of situations. Those at the Intermediate International Benchmark demonstrated knowledge of the physics underlying a range of phenomena pertinent to everyday life.

Exhibit 9.2 displays the percent of physics students in each country who reached each of the three international benchmarks. The percents displayed in each row corresponding to the three international benchmarks are cumulative. Every student who scored at the Advanced Benchmark is also included in the High and Intermediate Benchmark categories.

For each country, Exhibit 9.2 shows the percent of physics students who reached each international benchmark as well as the TIMSS Advanced Physics Coverage Index for that country. In the table, the countries are listed in descending order of the percent of their students who reached the Advanced Benchmark. As might be expected, given that they had the highest physics achievement on average, the Netherlands and the Russian Federation had the highest percentages attaining the Advanced International Benchmark, 21 and 19 percent, respectively. A group including Slovenia, Norway, and Armenia followed in the 10 to 12 percent range. Much larger percentages of

Exhibit 9.1 **TIMSS Advanced 2008 International Benchmarks of Physics Achievement**

TIMSSAdvanced 2008 Physics

Advanced International Benchmark – 625

Summary

Students can combine and apply concepts and laws of physics in solving complex problems in a variety of situations.

Students can combine conceptual understanding, reasoning, and calculation to solve problems. They can also select relevant information and interpret and use data from graphs and diagrams. Students can combine and apply concepts and laws of mechanics, including momentum, in complex problem situations. They can apply Ohm's law and Joule's law to complex circuits, and identify the direction of the force on a conductor in a magnetic field. They can determine the direction and the magnitude of a resulting electric force and field from an arrangement of charged particles. Students can solve problems by applying their knowledge of heat conduction. They can compare lengths using coefficients of linear expansion. They can apply the gas laws to solve straightforward problems. Students can apply knowledge of notation for isotopes and principles of conservation of charge and number of nucleons in solving problems about radioactive decay and nuclear reactions.

High International Benchmark – 550

Summary

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

Students can apply laws of mechanics, conservation of energy, and energy transformation to solve problems involving vertical circular motion, compression of springs, collisions, and tension in strings. They can apply Ohm's law and Joule's law to solve simple problems, and can identify properties of charged particle motion in electric and magnetic fields. Students can apply knowledge of the relative size of an atom and its nucleus, and solve problems involving the half-life of a radioactive isotope. They also can apply basic knowledge of heat capacity and relate different types of electromagnetic radiation to the temperature of a heat-emitting body, and demonstrate understanding of sound wave phenomena.

Intermediate International Benchmark – 475

Summary

Students demonstrate knowledge of the physics underlying a range of phenomena pertinent to everyday life.

Students can apply basic laws of mechanics to situations involving free-falling objects, circular motion, and wave motion. Students can apply knowledge about heat and temperature in a variety of contexts including heat transfer, the greenhouse effect, and the role of pressure in the relationship between altitude and temperature. They can relate different types of electromagnetic radiation to their wavelengths and read a simple circuit diagram. Students demonstrate knowledge of the components of an atomic nucleus and its notation and apply knowledge of the photoelectric effect.

SOURCE: IEA TIMSS Advanced 2008 ©

Exhibit 9.2 **Percent of Students Reaching the TIMSS Advanced 2008 International Benchmarks of Physics Achievement**

TIMSSAdvanced2008 Physics

Country	Percent of Students Reaching the International Benchmarks			TIMSS Advanced Physics Coverage Index
	Advanced Benchmark (625)	High Benchmark (550)	Intermediate Benchmark (475)	
† Netherlands	21 (2.2)	73 (2.5)	98 (1.0)	3.4%
Russian Federation	19 (2.7)	42 (3.4)	66 (3.2)	2.6%
‡ Slovenia	12 (1.3)	44 (1.5)	77 (1.4)	7.5%
Norway	11 (1.4)	43 (2.2)	79 (1.7)	6.8%
Armenia	10 (1.5)	29 (2.4)	58 (2.7)	4.3%
Iran, Islamic Rep. of	9 (1.5)	23 (2.6)	43 (2.7)	6.6%
Sweden	7 (0.8)	30 (1.9)	62 (2.5)	11.0%
Italy	2 (0.7)	11 (1.7)	31 (3.0)	3.8%
Lebanon	0 (0.2)	8 (0.9)	36 (1.7)	5.9%

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.

Exhibit 9.3 **Trends in Percent of Students Reaching the TIMSS Advanced 2008 International Benchmarks of Physics Achievement**

TIMSSAdvanced2008 Physics

Country	TIMSS Advanced Physics Coverage Index		Percent of Students Reaching the International Benchmarks								
			Advanced International Benchmark (625)			High International Benchmark (550)			Intermediate International Benchmark (475)		
	2008	1995	2008 Percent of Students		1995 Percent of Students	2008 Percent of Students		1995 Percent of Students	2008 Percent of Students		1995 Percent of Students
Russian Federation	2.6%	1.5%	19 (2.7)		21 (2.9)	42 (3.4)		53 (4.9)	66 (3.2)	▼	77 (3.6)
‡ Slovenia	7.5%	38.6%	12 (1.3)		15 (4.7)	44 (1.5)		45 (6.8)	77 (1.4)		73 (4.8)
Norway	6.8%	8.4%	11 (1.4)	▼	28 (2.7)	43 (2.2)	▼	68 (3.7)	79 (1.7)	▼	93 (1.4)
Sweden	11.0%	16.3%	7 (0.8)	▼	25 (2.4)	30 (1.9)	▼	66 (2.8)	62 (2.5)	▼	92 (1.4)

SOURCE: IEA TIMSS Advanced 2008 ©

▲ 2008 percent significantly higher than 1995

▼ 2008 percent significantly lower than 1995

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

( ) Standard errors appear in parentheses.

physics students in the Netherlands reached the High and Intermediate Benchmarks than in any other country: 73 and 98 percent, respectively. Norway was next with 43 and 79 percent, respectively. Fewer than half the physics students in Iran, Italy, and Lebanon reached the Intermediate Benchmark.

On the one hand, these students—the very best physics students in their respective countries—found the TIMSS Advanced physics test to be challenging. Only four countries had more than 10 percent of their students reaching the Advanced Benchmark, and no country exceeded 25 percent. On the other hand, in five of the nine countries, more than 50 percent reached at least the Intermediate Benchmark which, as shown in Exhibit 9.1, means that those students demonstrated knowledge of the physics underlying a range of phenomena pertinent to everyday life assessed by TIMSS Advanced 2008.

Exhibit 9.3 presents changes in the percent of students reaching the benchmarks between 1995 and 2008 for the four countries that participated in both studies. Countries are ranked in descending order of the percent of students who reached the Advanced International Benchmark in 2008. The display also shows the TIMSS Advanced Physics Coverage Index for each country in the 1995 and 2008 assessments. Slovenia had the most dramatic drop in its Coverage Index: from about 40 percent coverage in 1995 to about 8 percent in 2008. Norway and Sweden also reported decreases in coverage, and the Russian Federation was the only one to record an increase.

In Norway and Sweden, the percentages of students reaching each of the three benchmarks declined between 1995 and 2008. There was also a decline in the Russian Federation at the Intermediate Benchmark. Only Slovenia had no changes over this period in the percentages reaching international benchmarks.

Physics: Achievement at the Advanced International Benchmark

The TIMSS Advanced 2008 Assessment Frameworks called for the items to be included in the physics assessment to be divided across the four content domains as follows: 30 percent for mechanics, 30 percent for electricity and magnetism, 20 percent for heat and temperature, and 20 percent for atomic and nuclear physics.

Mechanics can be regarded as the foundation of physics, since ideas of forces and motion are fundamental also to other areas of physics. In the assessment framework, Newton's three laws of motion together with the law of gravitation provide the elements of the mechanics domain. Some basic features of relativity also are included since Einstein's theory is a significant extension of the classical Newtonian version of mechanics.

The content of the electricity and magnetism domain deals with topics that are integral to everyday life. In particular, electricity is crucial for industry, business, and the home, providing energy in the form of heating, lighting, and power for a range of electric and electronic devices. Magnetic phenomena are crucial for energy transformation and transfer and our everyday electronic surroundings. The close relationship between electricity and magnetism is apparent in electromagnetic radiation, with visible light an example of a particular interval of wave frequencies.

Although heat and temperature are distinct concepts, they are grouped into a single domain in the assessment framework. Heat is energy and, as such, can be transferred by many mechanisms, where temperature may be regarded as a measure of kinetic energy for molecules. Heat transfer from the Sun and between bodies of water, land masses, and the atmosphere is the underlying cause of weather and climate on Earth. At varied temperatures, substances appear in the form (or phase) of solid, liquid, or gas. The strength and wavelength of heat radiation is strongly dependent on the temperature of the radiating body.

The domain of atomic and nuclear physics covers much of what is sometimes referred to as modern physics, since the relevant theories and experiments have been published within the past 100 years or so. The exploration of the atom and its nucleus opened a microscopic world of physics where many of the classical laws and concepts are no longer relevant.

In the mechanics domain, the framework specifies that students should be able to interpret a graph and apply the definition of momentum to solve a problem. Exhibit 9.4 shows a mechanics item in multiple-choice format that was likely to be solved correctly by students performing at the Advanced Benchmark. In the table accompanying this item, and in the corresponding table for the other example items, the countries are listed in descending order of their percent correct.

In this example (Example Item 1), students had to read information from a graph as well as from the stem of the item, and then use that information to find the momentum of a cyclist crossing the finish line in a race. The correct response, 800 kg•m/s, is bulleted in the exhibit. According to the information provided in Chapter 7 on the topics included in the intended curriculum and taught to the students (Exhibit 7.13), all countries included this topic in their curricula and virtually all students were taught it. Performance on this item in the Netherlands, Norway, and Slovenia was much higher than in the other countries, ranging from 74 to 78 percent correct. Students in Iran and Armenia found this item very difficult, with 33 and 26 percent responding correctly, respectively.

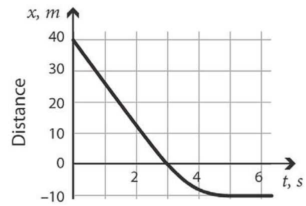
To obtain the correct answer, students had to calculate the speed of the cyclist as she crossed the finish line (40m/3s), and multiply that

Exhibit 9.4 **TIMSS Advanced 2008 Advanced International Benchmark (625) of Physics Achievement – Example Item 1**

TIMSSAdvanced 2008 Physics

Content Domain: Mechanics

Description: Interprets a graph and applies the definition of momentum to solve a problem



The graph shown above represents a cyclist approaching and passing the finishing line in a race. If the cyclist weighs 60 kg, what is her momentum as she crosses the finishing line?

Ⓐ 2400 kg·m/s
● 800 kg·m/s
Ⓒ 600 kg·m/s
Ⓓ 0 kg·m/s

Country	Percent Correct
† Netherlands	78 (2.4)
Norway	75 (2.1)
‡ Slovenia	74 (3.0)
Sweden	62 (2.5)
Russian Federation	52 (3.2)
Italy	46 (3.6)
Lebanon	43 (2.7)
Iran, Islamic Rep. of	33 (2.3)
Armenia	26 (3.4)

SOURCE: IEA TIMSS Advanced 2008 ©

Country	Percent of Students				
	A	B Correct Response	C	D	NR*
† Netherlands	4 (1.0)	78 (2.4)	9 (1.5)	8 (1.5)	2 (0.9)
Norway	6 (1.0)	75 (2.1)	11 (1.5)	6 (1.4)	2 (0.8)
‡ Slovenia	7 (1.9)	74 (3.0)	11 (1.8)	7 (1.6)	2 (0.8)
Sweden	9 (1.4)	62 (2.5)	22 (2.2)	6 (1.0)	2 (0.7)
Russian Federation	9 (1.4)	52 (3.2)	21 (2.4)	15 (2.0)	3 (0.6)
Italy	12 (2.5)	46 (3.6)	12 (1.7)	10 (2.2)	20 (2.8)
Lebanon	9 (1.6)	43 (2.7)	19 (1.9)	24 (2.4)	4 (1.3)
Iran, Islamic Rep. of	9 (1.5)	33 (2.3)	19 (1.8)	20 (2.0)	18 (1.7)
Armenia	16 (2.9)	26 (3.4)	38 (4.2)	12 (2.4)	7 (1.9)

* No Response

† 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 results are rounded to the nearest whole number, some totals may appear inconsistent.

number by the mass of the cyclist. Alternative C (600 kg•m/s) attracted more students than either of the others. Non-response rates were quite low except in the Islamic Republic of Iran (18%) and Italy (20%).

Exhibit 9.5 shows an example of a multiple-choice item from the electricity and magnetism domain that anchored at the Advanced Benchmark (Example Item 2). The item was designed to test students' ability to recognize the mutual electric forces acting on two charged particles. As in the case of Example Item 1, this material was included in both the intended and the implemented physics curriculum in every country. The item was very difficult, with 36 percent correct in Armenia being the best performance. The percent correct in the majority of countries was less than chance level (25%).

Non-response rates for this item were very low, which could mean that students everywhere seemed to think they knew what had to be done to obtain the correct response. In several countries, more students chose A as their answer choice than the correct answer, which may indicate that they recognized that the 2 charges would repel one another, but mistakenly thought that the magnitude of the forces on each charge were different. The second most popular incorrect answer choice was C.

The third example of an item that anchored at the Advanced Benchmark comes from the heat and temperature domain and is shown in Exhibit 9.6. Example Item 3 required students to apply their knowledge of heat conduction in different materials in solving a multiple-choice item. Performance on this item had the least cross-country variability of any of the example items, ranging from 64 percent correct in the Netherlands to 40 percent in the Russian Federation, Lebanon, and Italy.

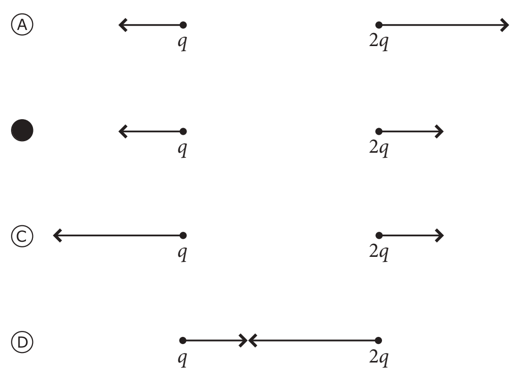
Exhibit 9.5 **TIMSS Advanced 2008 Advanced International Benchmark (625) of Physics Achievement – Example Item 2**

TIMSSAdvanced 2008 Physics

Content Domain: Electricity and Magnetism

Description: Identifies mutual electric forces acting on two charged particles

Two particles have charges q and $2q$, respectively. Which figure BEST describes the electric forces acting on the two particles?



Country	Percent Correct
Armenia	36 (4.1)
Sweden	30 (3.5)
Iran, Islamic Rep. of	29 (2.6)
Russian Federation	26 (2.8)
‡ Slovenia	20 (2.4)
Norway	17 (2.0)
† Netherlands	16 (1.9)
Italy	16 (2.8)
Lebanon	10 (1.8)

SOURCE: IEA TIMSS Advanced 2008 ©

Country	Percent of Students				
	A	B Correct Response	C	D	NR*
Armenia	36 (4.6)	36 (4.1)	9 (2.0)	18 (2.4)	1 (0.4)
Sweden	38 (2.7)	30 (3.5)	25 (2.5)	5 (1.0)	1 (0.7)
Iran, Islamic Rep. of	26 (2.4)	29 (2.6)	32 (2.1)	12 (1.4)	1 (0.4)
Russian Federation	39 (2.9)	26 (2.8)	23 (2.3)	11 (1.8)	0 (0.2)
‡ Slovenia	38 (3.4)	20 (2.4)	30 (2.7)	12 (2.1)	1 (0.6)
Norway	48 (2.8)	17 (2.0)	26 (2.1)	8 (1.4)	0 (0.3)
† Netherlands	47 (2.7)	16 (1.9)	32 (2.7)	4 (1.0)	1 (0.4)
Italy	51 (4.3)	16 (2.8)	24 (2.9)	6 (1.4)	3 (1.1)
Lebanon	45 (2.7)	10 (1.8)	28 (2.5)	16 (1.9)	1 (0.6)

* No Response

† 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 results are rounded to the nearest whole number, some totals may appear inconsistent.

Exhibit 9.6 **TIMSS Advanced 2008 Advanced International Benchmark (625) of Physics Achievement – Example Item 3**

TIMSSAdvanced 2008 Physics

Content Domain: Heat and Temperature

Description: Applies knowledge of heat conduction in different materials

A table with metal legs and a wooden top is inside a room with a temperature of about 20 °C. Which statement explains why the metal legs feel colder than the wooden top?

Ⓐ The heat capacity of the metal legs is lower than the wooden top.

Ⓑ The metal has a lower temperature than the wooden top.

● The metal conducts heat better than wood.

Ⓓ The molecules move faster in metal than in wood.

Country	Percent Correct
† Netherlands	64 (2.6)
Armenia	60 (3.6)
‡ Slovenia	54 (3.6)
Iran, Islamic Rep. of	52 (2.5)
Sweden	52 (2.3)
Norway	42 (2.0)
Russian Federation	40 (3.0)
Lebanon	40 (2.3)
Italy	40 (3.0)

SOURCE: IEA TIMSS Advanced 2008 ©

Country	Percent of Students				
	A	B	C Correct Response	D	NR*
† Netherlands	29 (2.7)	6 (1.4)	64 (2.6)	1 (0.4)	0 (0.0)
Armenia	13 (2.7)	17 (3.2)	60 (3.6)	9 (2.0)	1 (0.6)
‡ Slovenia	32 (3.3)	10 (1.9)	54 (3.6)	2 (0.9)	1 (0.7)
Iran, Islamic Rep. of	28 (2.0)	7 (1.3)	52 (2.5)	12 (1.6)	1 (0.4)
Sweden	37 (2.2)	5 (1.1)	52 (2.3)	6 (1.3)	0 (0.0)
Norway	45 (2.2)	6 (1.2)	42 (2.0)	7 (1.3)	1 (0.4)
Russian Federation	47 (2.8)	10 (1.6)	40 (3.0)	2 (0.7)	0 (0.1)
Lebanon	25 (2.2)	16 (1.8)	40 (2.3)	13 (2.1)	5 (0.9)
Italy	48 (3.7)	6 (1.5)	40 (3.0)	3 (0.9)	4 (1.9)

* No Response

† 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 results are rounded to the nearest whole number, some totals may appear inconsistent.

As with the previous example, non-response rates were very low. Option A, that the heat capacity of metal is lower than wood, was by far the most frequently selected incorrect response. Although the heat capacity of metal is generally lower than wood, this is not an appropriate explanation for why metals typically feel colder to the touch than wood. The two other alternatives are clearly not correct: the temperatures of both materials are the same, and, in such a situation, the metal molecules do not move faster than the wood molecules.

Physics: Achievement at the High International Benchmark

Exhibit 9.7 shows a constructed-response item from the mechanics domain that anchored at the High International Benchmark. Example Item 4 required students to apply the principle that, in a collision, total mechanical energy is conserved. In the Netherlands, 81 percent of physics students answered this item correctly, 12 points higher than in Lebanon, which had the second highest performance. Students in Armenia, Sweden, Italy, Iran, and Norway did not do well on this item, with fewer than half the students answering correctly. As was shown in Exhibit 7.13, the topic of elastic and inelastic collisions was part of the intended curriculum in every participating country except the Islamic Republic of Iran, and was taught to virtually all students in those eight countries. Non-response rates on this item varied widely across countries: from 2 percent and 4 percent in the Netherlands and Slovenia, respectively, to 43 percent in Armenia and 44 percent in Italy.

Example Item 5, shown in Exhibit 9.8, is from the heat and temperature domain and it also anchored at the High International Benchmark. This multiple-choice item was designed to assess students' knowledge of the fact that heat radiation is a kind of electromagnetic radiation emitted from the surface of an object in the form of infrared light. The options for the item refer to different kinds of electromagnetic

Exhibit 9.7 **TIMSS Advanced 2008 High International Benchmark (550) of Physics Achievement – Example Item 4**

TIMSSAdvanced 2008 Physics

Content Domain: Mechanics

Description: Applies the energy law to calculate the maximum compression of a spring

A block of mass 2.0 kg travels horizontally at a speed 2.5 m/s towards a massless spring with spring constant 800 N/m. After the block collides with the spring, its speed decreases and the spring compresses. What is the maximum distance that the spring will compress? (Ignore friction and air resistance.)

Show your work.

Total mechanical energy before and after the collision is conserved.

$$\frac{1}{2}mv^2 = \frac{1}{2}kx^2 +$$

$$\cancel{\frac{1}{2}} \times \cancel{2} \times (2.5)^2 = \cancel{\frac{1}{2}} \times \overset{4}{\cancel{8}}00 \times x^2$$

$$\frac{6.25}{400} = x^2$$

$$\frac{2.5}{20} = x =$$

$$x = \frac{250}{2000} = \frac{125}{1000}$$

$$\underline{\underline{0.125\ m}}$$

The answer shown is an example of a student response that was scored as correct

Country	Percent Correct
† Netherlands	81 (2.2)
Lebanon	69 (2.3)
‡ Slovenia	65 (3.0)
Russian Federation	52 (3.0)
Armenia	45 (3.4)
Sweden	31 (2.3)
Italy	30 (3.3)
Iran, Islamic Rep. of	29 (2.4)
Norway	19 (2.1)

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. Because results are rounded to the nearest whole number, some totals may appear inconsistent.

Exhibit 9.7 **TIMSS Advanced 2008 High International Benchmark (550) of Physics Achievement – Example Item 4 (Continued)**

TIMSSAdvanced 2008 Physics

Scoring Guide

Code	Response	Item: PA23072
	Correct Student Responses	
10	Uses conservation of mechanical energy, $\frac{1}{2}mv^2 = \frac{1}{2}kx^2 \rightarrow x = (0.12 - 0.14 \text{ m})$	
11	Correct reasoning but calculation error and/or missing or incorrect units.	
	Incorrect Student Responses	
70	0.025 m, based on $mg = kx$	
71	Correct answer, no work shown	
79	Other incorrect	
NR	No Response	

SOURCE: IEA TIMSS Advanced 2008 ©

Country	Percent of Students in Each Scoring Guide Category					
	Correct Student Responses		Incorrect Student Responses			
	10	11	70	71	79	NR
† Netherlands	71 (2.5)	10 (1.5)	0 (0.3)	0 (0.0)	17 (2.1)	2 (0.7)
Lebanon	53 (2.3)	15 (1.8)	1 (0.6)	0 (0.0)	19 (2.0)	10 (1.5)
‡ Slovenia	53 (3.1)	12 (2.2)	4 (1.1)	0 (0.0)	28 (2.4)	4 (0.9)
Russian Federation	42 (3.0)	10 (1.6)	0 (0.1)	0 (0.1)	23 (2.2)	25 (2.4)
Armenia	43 (3.4)	2 (1.2)	0 (0.0)	0 (0.0)	12 (2.7)	43 (3.0)
Sweden	26 (2.3)	6 (1.1)	1 (0.5)	0 (0.2)	50 (2.2)	18 (2.0)
Italy	23 (3.0)	7 (1.6)	0 (0.0)	0 (0.0)	26 (3.6)	44 (3.8)
Iran, Islamic Rep. of	19 (1.8)	11 (1.4)	3 (0.8)	0 (0.0)	57 (2.5)	11 (1.6)
Norway	16 (1.8)	3 (0.8)	1 (0.5)	0 (0.0)	52 (2.5)	27 (1.7)

† 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 results are rounded to the nearest whole number, some totals may appear inconsistent.

Exhibit 9.8 **TIMSS Advanced 2008 High International Benchmark (550) of Physics Achievement – Example Item 5**

TIMSSAdvanced 2008 Physics

Content Domain: Heat and Temperature

Description: Identifies the type of electromagnetic radiation related to the temperature of a heat-emitting body

A satellite observes the temperatures on Earth. What type of electromagnetic radiation should the sensors be able to detect?

- (A) radio waves
- ● infrared light
- (C) visible light
- (D) ultraviolet light

Country	Percent Correct
† Netherlands	84 (2.0)
Norway	60 (2.6)
Russian Federation	59 (2.9)
‡ Slovenia	57 (2.9)
Sweden	56 (2.7)
Italy	48 (3.5)
Iran, Islamic Rep. of	37 (2.3)
Armenia	36 (3.5)
Lebanon	23 (2.2)

SOURCE: IEA TIMSS Advanced 2008 ©

Country	Percent of Students				
	A	B Correct Response	C	D	NR*
† Netherlands	2 (0.7)	84 (2.0)	1 (0.6)	12 (1.7)	0 (0.0)
Norway	7 (1.1)	60 (2.6)	5 (1.0)	28 (2.0)	0 (0.0)
Russian Federation	18 (2.0)	59 (2.9)	2 (0.6)	21 (1.9)	0 (0.2)
‡ Slovenia	5 (1.3)	57 (2.9)	6 (1.3)	32 (2.5)	0 (0.0)
Sweden	10 (1.4)	56 (2.7)	5 (1.1)	30 (2.2)	0 (0.2)
Italy	16 (2.7)	48 (3.5)	8 (2.1)	25 (2.8)	3 (1.0)
Iran, Islamic Rep. of	20 (1.7)	37 (2.3)	14 (1.9)	24 (2.0)	6 (0.9)
Armenia	33 (3.5)	36 (3.5)	13 (2.7)	17 (2.9)	1 (0.6)
Lebanon	26 (2.2)	23 (2.2)	20 (2.4)	27 (2.2)	4 (1.0)

* No Response

† 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 results are rounded to the nearest whole number, some totals may appear inconsistent.

radiation. Non-response rates were very low for this item, perhaps indicating that students had some degree of familiarity with the topic. Students in the Netherlands did particularly well on this item, while those in the Islamic Republic of Iran, Armenia, and Lebanon were much less successful. Many students selected alternative A (radio waves) or alternative D (ultraviolet light) as their response.

The third example of an item that anchored at the High Benchmark, Example Item 6, is from the atomic and nuclear physics domain and is shown in Exhibit 9.9. To solve this multiple-choice item, students had to be familiar with the law of radioactive decay and use their understanding of the half-life of a radioactive material to calculate the half-life of thorium. In 72 days, thorium becomes $\frac{0.25}{2.0} = \frac{1}{8} = \left(\frac{1}{2}\right)^3$ of its original mass; thus, its half-life is $72 \div 3 = 24$ days . In six countries, more than half the physics students answered this item correctly. Non-response rates were low in most countries, and alternative C (48 days) was the most popular incorrect answer choice.

Exhibit 9.9 TIMSS Advanced 2008 High International Benchmark (550) of Physics Achievement – Example Item 6

TIMSSAdvanced 2008 Physics

Content Domain: Atomic and Nuclear Physics

Description: Uses the law of radioactive decay to calculate the half-life of a radioactive element

A 2.0 g mass of radioactive thorium decays over 72 days, leaving 0.25 g of thorium unchanged.

What is the half-life of thorium?

Ⓐ 12 days
● 24 days
Ⓒ 48 days
Ⓓ 72 days

Country	Percent Correct
† Netherlands	88 (1.6)
Sweden	77 (1.4)
Norway	76 (1.8)
Russian Federation	65 (2.5)
‡ Slovenia	64 (1.9)
Lebanon	54 (2.3)
Armenia	44 (3.3)
Iran, Islamic Rep. of	39 (2.0)
Italy	37 (3.1)

SOURCE: IEA TIMSS Advanced 2008 ©

Country	Percent of Students				
	A	B Correct Response	C	D	NR*
† Netherlands	2 (0.5)	88 (1.6)	8 (1.3)	1 (0.3)	1 (0.4)
Sweden	7 (0.8)	77 (1.4)	15 (1.3)	1 (0.4)	0 (0.3)
Norway	6 (1.0)	76 (1.8)	17 (1.2)	1 (0.4)	1 (0.3)
Russian Federation	6 (0.9)	65 (2.5)	22 (2.0)	5 (0.6)	2 (0.5)
‡ Slovenia	9 (1.2)	64 (1.9)	21 (1.5)	3 (0.8)	3 (0.7)
Lebanon	5 (0.8)	54 (2.3)	26 (1.8)	5 (0.8)	10 (1.5)
Armenia	12 (1.6)	44 (3.3)	29 (2.8)	8 (1.6)	7 (1.2)
Iran, Islamic Rep. of	8 (1.0)	39 (2.0)	22 (1.5)	4 (0.7)	27 (2.0)
Italy	8 (1.2)	37 (3.1)	35 (2.9)	5 (1.0)	15 (2.3)

* No Response

† 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 results are rounded to the nearest whole number, some totals may appear inconsistent.

Physics: Achievement at the Intermediate International Benchmark

Example Item 7, shown in Exhibit 9.10 is from the mechanics domain. This constructed-response item calls on students to apply their knowledge of the forces acting on a body that is thrown straight up into the air. The forces acting on the body include the Earth's gravitational force and air resistance. The Netherlands and Armenia recorded the highest performance on this item (67% correct), and four countries (Lebanon, the Russian Federation, Sweden, and Italy) had fewer than half of their physics students answering correctly. Non-response rates were below 10 percent in most countries; the 2 exceptions were Armenia (14%) and Italy (12%). Many students' responses made reference to gravitational force, but not to air resistance.

The electricity and magnetism item shown in Exhibit 9.11 is a multiple-choice item that was intended to assess students' knowledge of the various kinds of electromagnetic radiation and their wavelengths. Students from the Islamic Republic of Iran had the highest performance on this item, with 69 percent of physics students recognizing the wavelength order of four radiation types (γ-radiation, X-rays, visible light, radio waves). As with the previous item, 4 countries had fewer than half their students responding correctly: Sweden, Italy, Lebanon, and Armenia. Non-response rates on this item were very low (less than 10% in every country), and alternative D (γ-radiation, X-rays, radio waves, visible light) was the most popular incorrect answer choice almost everywhere.

Example Item 9, a multiple-choice item shown in Exhibit 9.12, is taken from the atomic and nuclear physics domain. The item assessed students' knowledge of the atomic nucleus by asking them to identify the best description of a nucleus among four given alternatives.

Exhibit 9.10 **TIMSS Advanced 2008 Intermediate International Benchmark (475) of Physics Achievement – Example Item 7**

TIMSSAdvanced 2008 Physics

Content Domain: Mechanics

Description: Identifies forces acting on a body thrown up into the air

Lisa threw a small stone straight up into the air.

What forces act on the stone after it was thrown?

Earth's gravitational pull ~~o~~
and the air resistance

The answer shown is an example of a student response that was scored as correct

Country	Percent Correct
† Netherlands	67 (2.7)
Armenia	67 (3.2)
‡ Slovenia	63 (3.0)
Iran, Islamic Rep. of	57 (2.5)
Norway	53 (2.4)
Lebanon	47 (2.7)
Russian Federation	42 (2.7)
Sweden	36 (2.6)
Italy	31 (3.5)

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. Because results are rounded to the nearest whole number, some totals may appear inconsistent.

Exhibit 9.10 **TIMSS Advanced 2008 Intermediate International Benchmark (475) of Physics Achievement – Example Item 7 (Continued)**

TIMSSAdvanced 2008 Physics

Scoring Guide

Code	Response	Item: PA23014
	Correct Student Response	
10	Gravity/weight and air resistance	
	Incorrect Student Responses	
70	Gravity/weight mentioned, but not air resistance	
71	Air resistance mentioned, but not gravity/weight	
79	Other incorrect	
NR	No Response	

SOURCE: IEA TIMSS Advanced 2008 ©

Country	Percent of Students in Each Scoring Guide Category				
	Correct Student Response	Incorrect Student Responses			
	10	70	71	79	NR
† Netherlands	67 (2.7)	6 (1.1)	0 (0.0)	25 (2.7)	2 (1.0)
Armenia	67 (3.2)	3 (1.5)	1 (0.7)	15 (2.6)	14 (2.2)
‡ Slovenia	63 (3.0)	34 (3.1)	0 (0.0)	2 (0.8)	0 (0.0)
Iran, Islamic Rep. of	57 (2.5)	31 (2.2)	2 (0.8)	3 (0.8)	7 (1.2)
Norway	53 (2.4)	25 (2.6)	0 (0.2)	21 (2.4)	1 (0.6)
Lebanon	47 (2.7)	21 (2.0)	1 (0.6)	26 (2.3)	4 (1.0)
Russian Federation	42 (2.7)	16 (2.3)	1 (0.3)	34 (2.3)	7 (1.2)
Sweden	36 (2.6)	26 (2.4)	0 (0.0)	36 (2.2)	2 (0.6)
Italy	31 (3.5)	36 (3.5)	0 (0.2)	20 (2.7)	12 (2.1)

† 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 results are rounded to the nearest whole number, some totals may appear inconsistent.

Exhibit 9.11 TIMSS Advanced 2008 Intermediate International Benchmark (475) of Physics Achievement – Example Item 8

TIMSSAdvanced 2008 Physics

Content Domain: Electricity and Magnetism

Description: Orders types of electromagnetic radiation by wavelength

In the electromagnetic spectrum there are different types of radiation.

Which one of the following lists gives the radiation types in order of increasing wavelength?

● γ-radiation, X-rays, visible light, radio waves

Ⓑ X-rays, radio waves, visible light, γ-radiation

Ⓒ radio waves, γ-radiation, visible light, X-rays

Ⓓ γ-radiation, X-rays, radio waves, visible light

Country	Percent Correct
Iran, Islamic Rep. of	69 (2.0)
Russian Federation	58 (2.9)
Norway	56 (2.4)
† Netherlands	51 (2.4)
‡ Slovenia	50 (2.1)
Sweden	47 (2.0)
Italy	43 (2.8)
Lebanon	40 (1.9)
Armenia	38 (2.3)

SOURCE: IEA TIMSS Advanced 2008 ©

Country	Percent of Students				
	A Correct Response	B	C	D	NR*
Iran, Islamic Rep. of	69 (2.0)	5 (0.7)	11 (1.3)	11 (1.2)	5 (0.8)
Russian Federation	58 (2.9)	11 (1.2)	13 (1.3)	17 (1.6)	2 (0.4)
Norway	56 (2.4)	9 (1.0)	13 (1.3)	21 (1.5)	1 (0.3)
† Netherlands	51 (2.4)	11 (1.2)	10 (1.2)	26 (1.7)	1 (0.3)
‡ Slovenia	50 (2.1)	12 (1.3)	14 (1.4)	24 (1.7)	1 (0.3)
Sweden	47 (2.0)	11 (0.9)	15 (1.7)	25 (1.9)	2 (0.4)
Italy	43 (2.8)	10 (1.3)	19 (2.0)	20 (2.4)	8 (1.2)
Lebanon	40 (1.9)	19 (1.4)	19 (1.4)	19 (1.6)	4 (0.7)
Armenia	38 (2.3)	17 (2.0)	21 (2.0)	17 (2.6)	6 (1.2)

* No Response

† 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 results are rounded to the nearest whole number, some totals may appear inconsistent.

Exhibit 9.12 **TIMSS Advanced 2008 Intermediate International Benchmark (475) of Physics Achievement – Example Item 9**

TIMSSAdvanced 2008 Physics

Content Domain: Atomic and Nuclear Physics

Description: Selects the best description of an atomic nucleus

Which is the BEST description of an atomic nucleus?

Ⓐ a tight group of electrons, protons, and neutrons
Ⓑ electrons and protons moving around a core of neutrons
● a tight group of protons and neutrons
Ⓓ protons moving around a core of neutrons

Country	Percent Correct
† Netherlands	93 (1.6)
Sweden	82 (2.0)
Norway	80 (2.2)
‡ Slovenia	78 (2.6)
Italy	77 (3.6)
Iran, Islamic Rep. of	76 (2.1)
Russian Federation	62 (2.4)
Armenia	50 (3.9)
Lebanon	39 (2.6)

SOURCE: IEA TIMSS Advanced 2008 ©

Country	Percent of Students				
	A	B	C Correct Response	D	NR*
† Netherlands	2 (0.7)	2 (0.8)	93 (1.6)	1 (0.5)	2 (1.0)
Sweden	8 (1.4)	7 (1.3)	82 (2.0)	1 (0.6)	1 (0.5)
Norway	8 (1.6)	10 (1.4)	80 (2.2)	1 (0.6)	1 (0.6)
‡ Slovenia	11 (1.8)	7 (1.5)	78 (2.6)	4 (1.3)	0 (0.0)
Italy	7 (2.0)	12 (2.5)	77 (3.6)	2 (1.0)	2 (0.6)
Iran, Islamic Rep. of	10 (1.4)	8 (1.2)	76 (2.1)	2 (0.5)	4 (0.7)
Russian Federation	18 (1.6)	15 (1.7)	62 (2.4)	3 (0.9)	2 (0.8)
Armenia	22 (3.2)	18 (2.8)	50 (3.9)	8 (2.1)	2 (1.2)
Lebanon	17 (2.1)	14 (1.8)	39 (2.6)	25 (2.2)	5 (1.1)

* No Response

† 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 results are rounded to the nearest whole number, some totals may appear inconsistent.

Performance on this item was better than on the other example items with a high of 93 percent correct in the Netherlands and with five other countries (Sweden, Norway, Slovenia, Italy, and Iran) having more than 75 percent of students recognizing that the nucleus is a tight group of protons and neutrons. Lebanon, at 39 percent correct, was the only country where the percent correct was less than 50. As with several previous items, non-response rates on this item were very low. Students were more attracted to the descriptions in alternatives A (a tight group of electrons, protons, and neutrons) and B (electrons and protons moving around a core of neutrons) than to alternative D (protons moving around a core of neutrons).

OCCASVS
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Chapter 10

Physics Students' Backgrounds and Attitudes

The students studying the physics assessed by TIMSS Advanced in the final year of secondary school are a very select group, comprising just a small fraction of the age cohort in every participating country (see Chapter 7). In order to gain entry to the physics tracks or courses targeted by TIMSS, students will have had to have demonstrated sustained achievement in physical science throughout their school careers, and to have had sufficient ability to enable them to come to terms with challenging physics content. Although a solid record of achievement and a facility for studying physics are probably the main determinants of success, there are many other factors that may be related to physics achievement, including a supportive home environment and a positive attitude to studying physics. To provide information on factors that can be important in interpreting the achievement results, this chapter summarizes students' reports on aspects of their home environments, how they spend their out of school time, computer use, preparation for examinations, attitudes toward physics, and expectations for further study.

Home Environments Supportive of Physics Achievement

Successive cycles of TIMSS and PIRLS have shown that students from homes well-endowed with literacy resources have higher achievement in mathematics, science, and reading than students from less advantaged homes. Exhibit 10.1, which presents students' reports about the number of books in their homes, shows that this is true of students taking physics in their final year of secondary school also. The exhibit shows, for each TIMSS Advanced 2008 participant, the percentage of students in five categories of book ownership, *more than 200 books*, *101–200 books*, *26–100 books*, *11–25 books*, and *0–10 books*, together with average physics achievement in each category and changes in percentages since 1995.

As shown in the exhibit, and in line with differences in the Human Development Index presented in Chapter 7, there was a range of book ownership across countries, from Norway and Sweden where more than 50 percent of students reported having more than 200 books at home to Lebanon with 10 percent. Compared with 1995, there was a pronounced downward trend in book ownership in 2008, with three of the four trend countries—Norway, the Russian Federation, and Slovenia—showing decreases in the percentages of students from homes with many books (more than 200). All four trend countries (the three already mentioned and Sweden) had increased percentages of students from homes with fewer books (25 or less). This downward trend may reflect the growth of Internet availability since 1995 and the greatly increased availability of literacy materials on the web.

Although the relationship is not identical in every country, in general there was a positive association between the number of books in the home and average achievement on the TIMSS Advanced physics assessment. The relationship was most pronounced in Sweden, where

Exhibit 10.1 Books in the Home with Trends

TIMSSAdvanced 2008 Physics

Country	More than 200 Books			101–200 Books			26–100 Books		
	2008 Percent of Students	Average Achievement	Difference in Percent from 1995	2008 Percent of Students	Average Achievement	Difference in Percent from 1995	2008 Percent of Students	Average Achievement	Difference in Percent from 1995
Armenia	29 (1.5)	491 (7.8)	◊ ◊	21 (1.3)	500 (7.7)	◊ ◊	27 (1.5)	492 (8.6)	◊ ◊
Iran, Islamic Rep. of	20 (1.3)	502 (12.3)	◊ ◊	13 (0.8)	469 (9.5)	◊ ◊	27 (1.0)	462 (8.7)	◊ ◊
Italy	40 (1.7)	434 (9.0)	◊ ◊	18 (1.2)	429 (8.9)	◊ ◊	24 (1.2)	415 (10.1)	◊ ◊
Lebanon	10 (0.8)	463 (8.2)	◊ ◊	11 (0.8)	465 (7.0)	◊ ◊	31 (1.3)	448 (5.3)	◊ ◊
Netherlands	37 (1.8)	588 (4.6)	◊ ◊	24 (1.1)	583 (5.3)	◊ ◊	26 (1.3)	579 (4.5)	◊ ◊
Norway	53 (1.7)	551 (4.7)	–8 (2.8) ▼	20 (1.0)	532 (6.1)	–1 (1.9)	16 (1.0)	524 (6.2)	1 (1.8)
Russian Federation	30 (1.5)	550 (11.5)	–13 (2.5) ▼	32 (0.9)	532 (9.5)	–2 (1.7)	28 (1.2)	498 (12.0)	8 (2.4) ▲
Slovenia	23 (1.1)	554 (4.8)	–10 (3.1) ▼	26 (1.0)	547 (4.9)	–4 (2.9)	37 (1.3)	528 (3.7)	4 (3.1)
Sweden	51 (1.4)	520 (4.9)	–3 (2.3)	19 (1.1)	496 (8.9)	–5 (2.1) ▼	20 (0.9)	468 (7.3)	3 (1.6)

Country	11–25 Books			0–10 Books		
	2008 Percent of Students	Average Achievement	Difference in Percent from 1995	2008 Percent of Students	Average Achievement	Difference in Percent from 1995
Armenia	15 (1.7)	485 (10.5)	◊ ◊	7 (0.7)	476 (11.4)	◊ ◊
Iran, Islamic Rep. of	26 (1.1)	438 (6.6)	◊ ◊	15 (0.9)	429 (9.5)	◊ ◊
Italy	13 (1.2)	402 (11.9)	◊ ◊	5 (0.7)	392 (22.3)	◊ ◊
Lebanon	29 (1.1)	443 (4.8)	◊ ◊	19 (1.0)	420 (5.0)	◊ ◊
Netherlands	9 (0.9)	576 (6.1)	◊ ◊	4 (0.6)	574 (8.1)	◊ ◊
Norway	7 (0.7)	471 (8.2)	5 (0.8) ▲	3 (0.5)	469 (14.6)	2 (0.5) ▲
Russian Federation	9 (0.7)	467 (12.7)	7 (0.9) ▲	1 (0.2)	~ ~	0 (0.4)
Slovenia	12 (1.0)	510 (7.3)	8 (1.8) ▲	3 (0.5)	486 (14.1)	2 (0.6) ▲
Sweden	6 (0.6)	435 (10.1)	3 (0.9) ▲	3 (0.6)	424 (15.7)	2 (0.7) ▲

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

Data provided by students.

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

A diamond (◊) indicates the country did not participate in the 1995 assessment.

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

SOURCE: IEA TIMSS Advanced 2008 ©

the difference in average achievement between students from homes in the highest category of book ownership (*more than 200 books*) and students from the lowest category (*0–10 books*) was almost 100 scale-score points. In contrast, the average achievement difference between students from the highest and lowest categories of book ownership in the Netherlands was just 14 score points.

Exhibit 10.2 presents the physics students' reports about how often they spoke the language they were tested in at home. In six of the nine participating countries—Armenia, Italy, the Netherlands, Norway, the Russian Federation, and Slovenia—almost all of the students assessed by TIMSS Advanced (95% or more) reported that they always or almost always spoke the language of the physics test at home, and in Sweden the percentage was almost as large (93%). Among countries with large majorities of students routinely speaking the language of the test at home and with enough data to support a comparison—these include Italy, the Netherlands, Norway, the Russian Federation, and Sweden—average physics achievement was usually lower among students speaking the language of the test sometimes at home than among those speaking it more frequently.

In Iran, 80 percent of physics students reported always or almost always speaking Farsi, the language of the test, with 12 percent sometimes speaking Farsi and 9 percent never speaking it.[1] Average physics achievement was about the same for those almost or almost always speaking Farsi and those never speaking it, but lower for intermittent Farsi speakers. In Lebanon, where the TIMSS Advanced assessment was administered in French while Arabic is the language of everyday life for most people, only 9 percent of students reported speaking French frequently at home. There was a positive relationship between physics achievement and frequency of speaking French at

1 After rounding, the percentages add to more than 100.

Exhibit 10.2 Students Speak Language of the Test at Home with Trends

TIMSSAdvanced 2008 Physics

Country	Always or Almost Always			Sometimes			Never		
	2008 Percent of Students	Average Achievement	Difference in Percent from 1995	2008 Percent of Students	Average Achievement	Difference in Percent from 1995	2008 Percent of Students	Average Achievement	Difference in Percent from 1995
Armenia	98 (0.6)	491 (5.4)	◊ ◊	2 (0.6)	~ ~	◊ ◊	0 (0.2)	~ ~	◊ ◊
Iran, Islamic Rep. of	80 (2.4)	465 (7.8)	◊ ◊	12 (1.4)	419 (10.7)	◊ ◊	9 (1.4)	468 (17.3)	◊ ◊
Italy	96 (0.7)	423 (7.7)	◊ ◊	3 (0.6)	384 (20.1)	◊ ◊	1 (0.3)	~ ~	◊ ◊
Lebanon	9 (0.7)	479 (7.4)	◊ ◊	65 (1.4)	444 (3.8)	◊ ◊	26 (1.2)	434 (4.9)	◊ ◊
Netherlands	96 (0.6)	583 (3.5)	◊ ◊	3 (0.5)	569 (10.8)	◊ ◊	1 (0.3)	~ ~	◊ ◊
Norway	95 (0.5)	537 (4.2)	–1 (1.0)	4 (0.4)	486 (11.2)	1 (0.9)	1 (0.3)	~ ~	0 (0.5)
Russian Federation	96 (1.1)	522 (10.4)	–3 (1.1) ▼	3 (0.9)	508 (17.8)	3 (0.9) ▲	1 (0.4)	~ ~	0 (0.4)
Slovenia	97 (0.6)	536 (2.1)	1 (1.1)	2 (0.4)	~ ~	0 (0.8)	1 (0.3)	~ ~	–1 (0.9)
Sweden	93 (1.1)	502 (6.0)	–2 (1.4)	5 (0.8)	433 (14.4)	2 (1.1)	2 (0.4)	~ ~	0 (0.8)

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

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

A diamond (◊) indicates the country did not participate in the 1995 assessment.
A tilde (~) indicates insufficient data to report achievement.

SOURCE: IEA TIMSS Advanced 2008 ©

Exhibit 10.3 Students and Parents Born in the Country with Trends

TIMSSAdvanced 2008 Physics

Country	Both Parents and the Student Born in the Country			At Least One of the Parents or the Student Born in the Country			Neither the Parents Nor the Student Born in the Country		
	2008 Percent of Students	Average Achievement	Difference in Percent from 1995	2008 Percent of Students	Average Achievement	Difference in Percent from 1995	2008 Percent of Students	Average Achievement	Difference in Percent from 1995
Armenia	88 (1.2)	490 (6.1)	◊ ◊	11 (1.3)	506 (10.9)	◊ ◊	1 (0.4)	~ ~	◊ ◊
Iran, Islamic Rep. of	98 (0.5)	460 (7.3)	◊ ◊	2 (0.5)	~ ~	◊ ◊	0 (0.1)	~ ~	◊ ◊
Italy	92 (0.7)	423 (7.5)	◊ ◊	7 (0.7)	414 (14.2)	◊ ◊	1 (0.3)	~ ~	◊ ◊
Lebanon	85 (0.9)	443 (3.4)	◊ ◊	15 (0.9)	452 (7.1)	◊ ◊	0 (0.1)	~ ~	◊ ◊
Netherlands	85 (1.3)	584 (3.6)	◊ ◊	12 (1.2)	578 (6.6)	◊ ◊	3 (0.5)	567 (12.8)	◊ ◊
Norway	83 (1.1)	540 (4.1)	–7 (1.7) ▼	13 (1.0)	517 (8.0)	5 (1.4) ▲	4 (0.6)	492 (15.1)	2 (0.9)
Russian Federation	83 (0.9)	520 (10.6)	3 (4.3)	14 (0.8)	533 (11.5)	–4 (4.2)	3 (0.3)	505 (16.2)	1 (0.5)
Slovenia	87 (0.9)	538 (2.2)	3 (2.2)	12 (0.9)	517 (7.6)	–1 (1.9)	1 (0.3)	~ ~	–2 (0.8) ▼
Sweden	77 (1.7)	508 (6.3)	–5 (3.4)	16 (1.1)	474 (11.1)	0 (2.7)	8 (1.1)	438 (9.8)	4 (1.3) ▲

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

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

A diamond (◊) indicates the country did not participate in the 1995 assessment.
A tilde (~) indicates insufficient data to report achievement.

SOURCE: IEA TIMSS Advanced 2008 ©

home, with highest average achievement among those always or almost always speaking French at home.

Related to the issue of the language spoken in the home in many countries is whether students and their parents were native to the country or were recent immigrants. As shown in Exhibit 10.3, more than 90 percent of the physics students in Iran and Italy reported that they and both their parents were born in the country, and in the other countries, with the exception of Sweden, the corresponding figures were between 80 and 90 percent. In Sweden, 77 percent of physics students reported that they and their parents were born in Sweden, with 8 percent reporting that neither they nor their parents were born in Sweden, and 16 percent that they themselves or at least one parent were Swedish born. In Norway, the percentage of physics students reporting that both they and their parents were born in Norway declined from 1995 (by 7 percentage points) and the percentage of students reporting that they themselves or at least one parent born in Norway increased (by 5 percentage points). In the Netherlands, Norway, Slovenia, and Sweden, students who were born in the country and whose parents also were native born had higher average physics achievement than students who reported that either they or at least one of their parents were born in the country.

Out of School Time and Computer Usage Among Physics Students

Exhibit 10.4 presents physics students' reports about how they spent their time outside of school on a normal school day. According to their reports, students spread their time across a range of activities, including doing schoolwork, taking part in organized activities, using a computer for things other than schoolwork, spending time with friends, working at a paid job, and watching movies or television. Most physics students reported spending between 0.8 and 2 hours on each of these activities.

Exhibit 10.4 Time in Hours Physics Students Spend on Various Activities Outside of School on a Normal School Day

TIMSSAdvanced 2008 Physics

Country		Doing Schoolwork		Taking Part in Organized Activities		Using a Computer for Things Other than Schoolwork		Spending Time with Friends		Working at a Paid Job		Watching Movies or TV
Armenia	r	1.7 (0.07)	r	0.9 (0.05)	r	1.1 (0.05)	r	2.2 (0.08)	r	0.2 (0.03)	r	1.7 (0.07)
Iran, Islamic Rep. of		3.2 (0.04)		0.8 (0.03)		0.8 (0.03)		1.0 (0.03)		0.1 (0.02)		1.5 (0.03)
Italy		2.3 (0.07)		1.3 (0.04)		1.5 (0.04)		1.9 (0.05)		0.4 (0.03)		1.2 (0.04)
Lebanon		2.2 (0.04)		1.1 (0.03)		1.4 (0.03)		1.7 (0.04)		0.5 (0.03)		1.5 (0.03)
Netherlands		1.0 (0.02)		1.5 (0.03)		2.0 (0.04)		1.2 (0.03)		1.1 (0.04)		1.3 (0.03)
Norway		1.2 (0.04)		1.3 (0.03)		1.8 (0.04)		1.7 (0.04)		1.2 (0.06)		1.2 (0.03)
Russian Federation		2.1 (0.04)		1.4 (0.03)		1.8 (0.04)		2.7 (0.05)		0.2 (0.02)		1.3 (0.03)
Slovenia		1.3 (0.03)		– –		1.7 (0.03)		1.8 (0.03)		0.6 (0.03)		1.1 (0.02)
Sweden		1.1 (0.04)		1.1 (0.03)		2.1 (0.08)		1.7 (0.04)		0.6 (0.06)		1.3 (0.03)

SOURCE: IEA TIMSS Advanced 2008 ©

Data provided by students.
( ) Standard errors appear in parentheses.

A dash (–) indicates comparable data are not available.
An "r" indicates data are available for at least 70% but less than 85% of the students.

Exhibit 10.5 Time Students Spend Using a Computer Each Day

TIMSSAdvanced 2008 Physics

Country		No Time		Less than 1 Hour		1–2 Hours	
		Percent of Students	Average Achievement	Percent of Students	Average Achievement	Percent of Students	Average Achievement
Armenia	r	24 (1.6)	505 (7.6)	30 (2.0)	486 (10.0)	31 (1.3)	492 (9.0)
Iran, Islamic Rep. of		27 (1.4)	449 (7.5)	39 (1.3)	473 (8.7)	24 (0.8)	455 (9.2)
Italy		2 (0.4)	~ ~	28 (1.3)	417 (10.9)	37 (1.8)	426 (8.7)
Lebanon		4 (0.6)	431 (14.0)	24 (1.1)	443 (5.5)	40 (1.4)	446 (4.5)
Netherlands		0 (0.1)	~ ~	15 (1.2)	582 (6.4)	40 (1.4)	585 (4.5)
Norway		0 (0.0)	~ ~	20 (1.3)	531 (6.3)	37 (1.1)	535 (4.8)
Russian Federation		4 (0.5)	478 (19.2)	26 (1.0)	525 (12.0)	40 (0.9)	521 (10.5)
Slovenia		1 (0.3)	~ ~	22 (1.1)	547 (5.1)	40 (1.6)	530 (4.5)
Sweden		0 (0.2)	~ ~	16 (1.2)	501 (9.1)	32 (1.5)	503 (6.6)

Country		More than 2 but Less than 4 Hours		4 or More Hours	
		Percent of Students	Average Achievement	Percent of Students	Average Achievement
Armenia	r	9 (1.1)	490 (16.8)	7 (0.9)	497 (17.2)
Iran, Islamic Rep. of		7 (0.7)	458 (15.5)	3 (0.4)	433 (15.7)
Italy		23 (1.3)	425 (8.4)	10 (0.9)	424 (12.1)
Lebanon		23 (1.2)	456 (5.0)	9 (0.8)	426 (9.8)
Netherlands		29 (1.2)	582 (4.9)	16 (0.9)	582 (6.5)
Norway		28 (1.2)	535 (5.5)	15 (1.0)	539 (8.1)
Russian Federation		19 (0.8)	531 (10.5)	11 (0.7)	523 (13.7)
Slovenia		25 (1.4)	535 (4.3)	11 (1.0)	539 (7.0)
Sweden		30 (1.2)	496 (7.0)	21 (2.1)	487 (7.7)

SOURCE: IEA TIMSS Advanced 2008 ©

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

Students in Iran, Italy, Lebanon, and the Russian Federation reported spending more than 2 hours daily on schoolwork (outside of school). Spending time with friends, using a computer, and watching movies or TV were popular pastimes in all countries, whereas working at a paid job was less common.

Exhibit 10.5 presents more detailed information on the amount of time physics students spent using a computer each day. It is clear from these reports that physics students in all countries except Armenia and Iran were frequent computer users, with 30–50 percent of students spending more than 2 hours using a computer each day. Computer usage in Armenia and Iran was relatively less, and in these countries approximately one student in four reported spending no time at all using a computer. There was no clear relationship across the countries between spending time using a computer and achievement in physics.

To provide information about whether computer use by physics students was a home or school activity or whether they used computers somewhere else, Exhibit 10.6 summarizes students' reports on the frequency of computer usage at home, at school, and elsewhere. The results indicate that the home was the principal locus of computer usage among physics students, with a large majority (more than 80%) in six of the nine participating countries—Italy, the Netherlands, Norway, the Russian Federation, Slovenia, and Sweden—reporting that they used a computer at home "a lot". The majority of students in these countries reported sometimes using a computer in school also. In Armenia and Lebanon, relatively fewer physics students reported frequently using a computer at home (68% and 70%, respectively), and even fewer in Iran (44%). The relatively low level of home computer usage in these countries was offset somewhat by use in school and elsewhere. "Elsewhere" includes locations such as a public library, an Internet cafe, or a friend's home. In line with the previous exhibit, TIMSSAdvanced 2008 Physics

Exhibit 10.6 **Computer Use at Home and at School**

Country		Use a Computer at Home					
		A Lot		Sometimes		Never	
		Percent of Students	Average Achievement	Percent Students	Average Achievement	Percent Students	Average Achievement
Armenia	s	68 (2.6)	487 (9.3)	21 (2.4)	508 (20.7)	11 (1.3)	475 (15.9)
Iran, Islamic Rep. of		44 (1.6)	482 (10.4)	54 (1.5)	453 (8.5)	2 (0.5)	~ ~
Italy		82 (1.3)	424 (7.0)	18 (1.3)	421 (14.5)	0 (0.1)	~ ~
Lebanon		70 (1.2)	451 (3.9)	28 (1.3)	437 (5.0)	3 (0.4)	425 (13.3)
Netherlands		90 (0.8)	583 (3.7)	10 (0.8)	582 (7.1)	0 (0.0)	~ ~
Norway		85 (1.2)	538 (4.2)	15 (1.1)	524 (6.4)	0 (0.1)	~ ~
Russian Federation		86 (0.7)	529 (10.3)	11 (0.7)	503 (11.4)	3 (0.5)	491 (20.6)
Slovenia		95 (0.7)	536 (2.1)	5 (0.7)	538 (10.2)	0 (0.1)	~ ~
Sweden		85 (1.1)	497 (6.1)	15 (1.1)	500 (8.1)	0 (0.1)	~ ~

Country		Use a Computer at School					
		A Lot		Sometimes		Never	
		Percent of Students	Average Achievement	Percent Students	Average Achievement	Percent Students	Average Achievement
Armenia	s	20 (2.4)	483 (17.0)	62 (3.3)	494 (11.3)	18 (1.7)	467 (18.6)
Iran, Islamic Rep. of	r	1 (0.3)	~ ~	18 (2.3)	518 (15.7)	81 (2.3)	458 (7.8)
Italy		2 (0.3)	~ ~	72 (2.9)	421 (8.3)	26 (3.1)	427 (10.0)
Lebanon		2 (0.3)	~ ~	50 (1.9)	460 (4.6)	48 (1.8)	436 (3.1)
Netherlands		6 (0.7)	586 (5.9)	90 (0.8)	583 (3.8)	4 (0.8)	581 (8.3)
Norway		19 (2.0)	532 (7.6)	77 (2.0)	538 (4.4)	5 (0.7)	516 (12.3)
Russian Federation		8 (0.8)	533 (15.2)	84 (1.1)	526 (10.2)	8 (1.0)	511 (15.3)
Slovenia		4 (0.6)	515 (14.3)	70 (1.3)	541 (2.6)	26 (1.0)	531 (4.7)
Sweden		12 (1.4)	490 (9.0)	83 (1.8)	499 (6.1)	5 (1.4)	500 (20.1)

Country		Use a Computer Elsewhere					
		A Lot		Sometimes		Never	
		Percent of Students	Average Achievement	Percent Students	Average Achievement	Percent Students	Average Achievement
Armenia	s	22 (1.9)	503 (10.5)	58 (2.3)	476 (12.5)	20 (2.4)	492 (13.2)
Iran, Islamic Rep. of	r	2 (0.5)	~ ~	51 (1.6)	464 (8.9)	47 (1.6)	474 (10.2)
Italy		1 (0.3)	~ ~	34 (2.1)	420 (9.3)	65 (2.0)	424 (8.0)
Lebanon		15 (1.0)	438 (7.1)	67 (1.2)	449 (3.2)	17 (1.0)	451 (6.3)
Netherlands		1 (0.2)	~ ~	33 (1.3)	577 (3.8)	66 (1.3)	586 (4.0)
Norway		2 (0.4)	~ ~	53 (1.4)	532 (4.8)	45 (1.5)	540 (4.7)
Russian Federation		4 (0.4)	488 (17.0)	53 (1.2)	524 (9.7)	43 (1.3)	534 (11.3)
Slovenia		2 (0.4)	~ ~	54 (1.6)	533 (3.3)	44 (1.6)	544 (3.7)
Sweden		1 (0.3)	~ ~	46 (1.4)	495 (6.8)	52 (1.4)	502 (5.7)

SOURCE: IEA TIMSS Advanced 2008 ©

Data provided by students.

( ) 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.

An "r" indicates data are available for at least 70% but less than 85% of the students. An "s" indicates data are available for at least 50% but less than 70% of the students.

computer usage, whether at home, in school, or elsewhere, was lowest among students in Iran.

Because of the immense potential of the computer as an educational tool, TIMSS asked the physics students about the ways they used computers in doing their schoolwork. As shown in Exhibit 10.7, computer usage for schoolwork was widespread in all countries, with researching information from the Internet the most popular activity, followed by word processing, and analyzing and processing data. In the Netherlands, Norway, Slovenia, and Sweden, the percentage of physics students using computers for researching information on the Internet and for word processing was over 90 percent.

Despite the reported widespread use of computers for schoolwork, the physics students reported relatively little computer use for physics outside of class. As presented in Exhibit 10.8, the majority of students in all but two countries (the Russian Federation and Slovenia) reported never or almost never using a computer for physics outside class. Even in countries with very high levels of computer usage generally, such as the Netherlands, Norway, and Sweden, physics students reported only sporadic use for physics (about once a month for one student in four).

Exhibit 10.7 Various Ways Physics Students Use Computers for Schoolwork

TIMSSAdvanced 2008 Physics

Country	Percent of Students Using Computers in Various Ways for Schoolwork				
	Researching Information from the Internet	Word Processing	Analyzing and Presenting Data	Using Specialized Programs	Other
Armenia	r 76 (2.0)	r 64 (2.3)	s 31 (2.8)	s 35 (2.2)	s 33 (2.6)
Iran, Islamic Rep. of	81 (1.1)	38 (1.6)	25 (1.6)	16 (1.2)	68 (1.3)
Italy	98 (0.4)	37 (1.9)	53 (2.5)	26 (2.0)	71 (1.1)
Lebanon	88 (0.9)	42 (1.1)	40 (1.3)	34 (1.4)	71 (1.1)
Netherlands	99 (0.2)	98 (0.4)	68 (1.7)	33 (1.7)	23 (1.3)
Norway	99 (0.2)	96 (0.5)	57 (1.6)	19 (1.7)	70 (1.4)
Russian Federation	86 (1.0)	89 (0.8)	44 (1.5)	33 (1.5)	64 (1.2)
Slovenia	99 (0.3)	97 (0.5)	78 (1.2)	40 (1.7)	r 42 (1.7)
Sweden	100 (0.1)	95 (0.6)	51 (2.1)	17 (1.4)	68 (1.1)

SOURCE: IEA TIMSS Advanced 2008 ©

Data provided by students.

( ) Standard errors appear in parentheses.

An "r" indicates data are available for at least 70% but less than 85% of the students. An "s" indicates data are available for at least 50% but less than 70% of the students.

Exhibit 10.8 Frequency of Computer Use for Physics Outside of Class

TIMSSAdvanced 2008 Physics

Country	Almost Every Day		Once or Twice a Week		About Once a Month		Never or Almost Never	
	Percent of Students	Average Achievement	Percent of Students	Average Achievement	Percent of Students	Average Achievement	Percent of Students	Average Achievement
Armenia	8 (1.1)	489 (14.7)	14 (1.4)	515 (12.8)	13 (1.1)	482 (11.3)	65 (1.7)	488 (6.5)
Iran, Islamic Rep. of	1 (0.2)	~ ~	3 (0.4)	488 (22.6)	11 (0.7)	469 (12.9)	85 (0.8)	459 (7.0)
Italy	3 (0.5)	438 (18.2)	11 (1.0)	435 (14.9)	17 (1.5)	440 (13.3)	69 (2.1)	415 (8.3)
Lebanon	4 (0.6)	396 (12.5)	16 (1.2)	443 (8.2)	22 (1.1)	453 (5.4)	58 (1.4)	445 (3.2)
Netherlands	2 (0.3)	~ ~	6 (0.9)	582 (7.6)	25 (1.6)	580 (4.6)	67 (2.0)	584 (4.2)
Norway	2 (0.4)	~ ~	7 (1.2)	528 (10.1)	26 (2.5)	542 (4.2)	65 (3.2)	533 (4.7)
Russian Federation	5 (0.6)	553 (14.4)	22 (1.0)	534 (10.9)	26 (1.2)	534 (10.7)	47 (1.8)	505 (10.8)
Slovenia	7 (0.9)	508 (10.2)	18 (1.3)	521 (6.2)	37 (1.3)	544 (4.0)	38 (1.2)	539 (4.2)
Sweden	0 (0.1)	~ ~	3 (0.5)	479 (20.1)	15 (1.6)	496 (7.8)	82 (1.6)	498 (5.6)

SOURCE: IEA TIMSS Advanced 2008 ©

Data provided by students.

( ) 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.

Working with a Physics Tutor and Preparing for Physics Tests

As described in Chapter 7, in almost all of the nine countries that assessed physics in TIMSS Advanced 2008, physics students write public examinations that have serious consequences for their future educational opportunities and life chances. In this situation, students may have recourse to physics tutors or other outside support to help them improve their physics knowledge and understanding. Exhibit 10.9 shows, however, that the practice is rare among physics students, with only Armenia (15%) and the Russian Federation (9%) having appreciable percentages of students working with a physics tutor as often as once a week. In all countries except Armenia and the Russian Federation, the students who never or almost never work with a tutor had higher physics achievement that those who sought help even occasionally.

According to Exhibit 10.10, a majority of physics students in six of the nine TIMSS Advanced countries, including Armenia, Iran, Italy, Lebanon, the Russian Federation, and Slovenia, prepare for tests or examinations about once a month or more. Studying for a physics test was less common in the Netherlands, Norway, and Sweden, where the majority of students reported preparing for a test about five times a year. Across the participating countries, there was no discernible relationship between frequency of testing and physics achievement.

Exhibit 10.9 **Frequency of Working with Physics Tutor**

TIMSSAdvanced 2008 Physics

Country	More than Once a Week		About Once a Week		About Once a Month	
	Percent of Students	Average Achievement	Percent of Students	Average Achievement	Percent of Students	Average Achievement
Armenia	15 (1.3)	532 (9.9)	3 (0.8)	467 (33.5)	2 (0.6)	~ ~
Iran, Islamic Rep. of	6 (1.0)	440 (17.9)	7 (0.7)	459 (14.8)	1 (0.3)	~ ~
Italy	2 (0.5)	~ ~	5 (0.8)	392 (15.9)	3 (0.7)	413 (27.0)
Lebanon	5 (0.5)	394 (9.9)	8 (0.8)	398 (8.3)	5 (0.6)	395 (15.6)
Netherlands	0 (0.1)	~ ~	2 (0.5)	~ ~	1 (0.2)	~ ~
Norway	– –	– –	– –	– –	– –	– –
Russian Federation	9 (1.0)	571 (14.2)	16 (1.0)	562 (10.6)	1 (0.2)	~ ~
Slovenia	0 (0.2)	~ ~	1 (0.2)	~ ~	1 (0.3)	~ ~
Sweden	– –	– –	– –	– –	– –	– –

Country	Once in a While When I Need Extra Help		Never or Almost Never	
	Percent of Students	Average Achievement	Percent of Students	Average Achievement
Armenia	9 (0.7)	525 (11.6)	71 (1.6)	478 (7.4)
Iran, Islamic Rep. of	9 (0.8)	436 (11.5)	76 (1.3)	465 (7.3)
Italy	22 (1.5)	394 (11.4)	68 (2.3)	434 (8.1)
Lebanon	15 (0.9)	430 (5.2)	67 (1.4)	461 (3.0)
Netherlands	9 (0.9)	553 (6.1)	88 (1.2)	587 (3.6)
Norway	– –	– –	– –	– –
Russian Federation	10 (0.7)	521 (12.6)	64 (1.5)	505 (11.0)
Slovenia	8 (0.8)	491 (10.1)	91 (0.8)	540 (2.0)
Sweden	– –	– –	– –	– –

SOURCE: IEA TIMSS Advanced 2008 ©

Data provided by students.

A dash (–) indicates comparable data are not available. Norway and Sweden did not collect this information. According to the NRCs of these countries, tutors are not used.

( ) 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.

Exhibit 10.10 **Frequency of Preparing for Physics Test or Examination**

TIMSSAdvanced 2008 Physics

Country	About Once a Week		About Once a Month		About 5 Times a Year	
	Percent of Students	Average Achievement	Percent of Students	Average Achievement	Percent of Students	Average Achievement
Armenia	29 (2.0)	495 (7.5)	25 (1.9)	505 (9.7)	7 (0.9)	499 (11.6)
Iran, Islamic Rep. of	27 (1.6)	477 (11.6)	51 (1.3)	459 (7.2)	10 (0.8)	475 (12.1)
Italy	28 (1.6)	411 (10.3)	50 (1.9)	431 (8.7)	15 (1.4)	422 (12.3)
Lebanon	46 (1.4)	443 (4.4)	43 (1.4)	449 (4.7)	8 (0.8)	455 (11.0)
Netherlands	7 (0.7)	549 (7.9)	20 (2.3)	578 (5.1)	61 (2.4)	587 (4.2)
Norway	1 (0.2)	~ ~	35 (2.8)	527 (4.8)	61 (2.7)	542 (4.6)
Russian Federation	29 (1.4)	532 (10.7)	46 (1.6)	526 (10.2)	13 (1.3)	522 (15.9)
Slovenia	12 (1.0)	510 (8.1)	44 (1.7)	531 (3.4)	35 (1.5)	551 (3.9)
Sweden	1 (0.2)	~ ~	18 (1.3)	467 (8.1)	71 (1.7)	506 (5.9)

Country	About Twice a Year		Never	
	Percent of Students	Average Achievement	Percent of Students	Average Achievement
Armenia	17 (1.8)	501 (10.8)	23 (2.0)	462 (10.3)
Iran, Islamic Rep. of	7 (0.7)	413 (10.6)	4 (0.4)	407 (13.6)
Italy	4 (1.0)	379 (19.9)	3 (0.5)	445 (19.8)
Lebanon	2 (0.4)	~ ~	1 (0.3)	~ ~
Netherlands	10 (1.4)	596 (5.4)	1 (0.3)	~ ~
Norway	3 (0.6)	512 (18.1)	0 (0.2)	~ ~
Russian Federation	8 (0.7)	500 (18.4)	5 (0.5)	449 (23.0)
Slovenia	7 (0.9)	530 (9.9)	1 (0.4)	~ ~
Sweden	10 (1.7)	501 (12.7)	1 (0.2)	~ ~

SOURCE: IEA TIMSS Advanced 2008 ©

Data provided by students.

( ) 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.

Students' Reasons for Studying Physics

As discussed earlier, the students studying the physics assessed by TIMSS Advanced were a very select group in all countries, drawing from the most scientifically able in their age groups. Since it is very important to attract such students to study physics in the first place, and then to retain them for tertiary-level study and a career involving physics, it is useful to know what factors attracted them to the study of physics in secondary school. Exhibits 10.11, 10.12, and 10.13 present student reports on three general reasons for studying physics—having a positive affect toward physics, good teachers and teaching, and advice from others.

Exhibit 10.11 summarizes students' responses to three statements about having a positive orientation toward physics as a reason for studying the subject at an advanced level:

- I enjoy conducting experiments or investigations for physics.
- I usually do well in physics.
- Physics lessons are interesting.

Students were asked to indicate the degree of importance of each reason in deciding to study physics in secondary school. In Exhibit 10.11, students were assigned to one of four categories of the positive orientation factor—*very important*, *important*, *unimportant*, and *very unimportant*—according to their average response across the three statements based on a 4-point Likert scale. The exhibit shows the percentage of students in each of the four categories for each country, together with average physics achievement for each category. Countries are ordered by the percentage of students in the "very important" category.

Exhibit 10.11 **Students' Reasons for Studying Physics – Students Have Positive Affect Toward Physics**

TIMSSAdvanced 2008 Physics

Country		Very Important		Important		Unimportant		Very Unimportant	
		Percent of Students	Average Achievement	Percent of Students	Average Achievement	Percent of Students	Average Achievement	Percent of Students	Average Achievement
Lebanon		58 (1.3)	458 (4.0)	33 (1.3)	430 (5.0)	7 (0.6)	418 (6.7)	2 (0.3)	~ ~
Iran, Islamic Rep. of		42 (1.3)	486 (8.5)	37 (1.1)	454 (7.8)	15 (0.8)	422 (8.9)	6 (0.6)	413 (14.5)
Armenia	r	33 (2.4)	504 (4.7)	47 (1.9)	495 (7.7)	14 (1.6)	478 (10.2)	6 (1.2)	459 (16.8)
Slovenia		31 (1.5)	558 (3.8)	52 (1.7)	528 (4.3)	13 (1.0)	517 (7.4)	3 (0.5)	509 (14.9)
Norway		25 (1.4)	566 (5.7)	50 (1.2)	537 (4.4)	20 (1.2)	508 (6.1)	5 (0.6)	472 (9.9)
Russian Federation		20 (1.2)	562 (10.4)	51 (1.3)	531 (10.3)	23 (1.1)	488 (11.3)	6 (0.5)	444 (17.1)
Netherlands		20 (1.3)	607 (4.1)	54 (1.4)	585 (3.8)	22 (1.1)	563 (5.2)	4 (0.5)	546 (7.6)
Italy		17 (1.1)	458 (9.8)	45 (1.4)	435 (8.4)	25 (1.1)	399 (9.0)	13 (1.0)	373 (8.8)
Sweden		15 (1.0)	545 (6.4)	43 (1.4)	506 (5.6)	29 (1.6)	478 (7.3)	13 (0.8)	450 (12.3)

SOURCE: IEA TIMSS Advanced 2008 ©

Based on students' responses to three statements about why students study physics: 1) I enjoy conducting experiments or investigations for physics; 2) I usually do well in physics; and 3) Physics lessons are interesting. Average is computed across three statements based on a 4-point Likert scale: 1. Very important; 2. Important; 3. Unimportant; 4. Very unimportant. Very important indicates an average response score of 1 to less than 1.75. Important indicates an average of 1.75 through 2.5. Unimportant indicates an average response score of greater than 2.5 through 3.25. Very unimportant indicates an average greater than 3.25 through 4.

( ) 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.

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

Exhibit 10.12 **Students' Reasons for Studying Physics – Good Teachers and Teaching**

TIMSSAdvanced 2008 Physics

Country		Very Important		Important		Unimportant		Very Unimportant	
		Percent of Students	Average Achievement	Percent of Students	Average Achievement	Percent of Students	Average Achievement	Percent of Students	Average Achievement
Armenia	r	56 (2.5)	493 (7.7)	34 (2.0)	500 (7.9)	4 (0.9)	485 (24.8)	6 (1.0)	467 (17.5)
Russian Federation		55 (2.2)	529 (10.2)	36 (1.7)	516 (11.7)	6 (0.7)	512 (17.4)	4 (0.5)	493 (23.5)
Lebanon		49 (1.7)	446 (4.1)	34 (1.5)	445 (4.6)	9 (0.8)	459 (7.2)	8 (0.9)	438 (9.3)
Iran, Islamic Rep. of		29 (1.6)	447 (7.6)	37 (1.2)	466 (8.8)	15 (0.8)	467 (9.4)	18 (1.3)	466 (10.3)
Sweden		27 (1.5)	506 (6.3)	44 (1.3)	500 (6.5)	15 (1.0)	499 (9.0)	14 (1.0)	470 (10.0)
Slovenia		27 (1.3)	540 (4.6)	47 (1.4)	534 (3.0)	17 (1.3)	534 (7.1)	10 (0.8)	531 (7.9)
Norway		26 (2.0)	541 (6.3)	44 (1.2)	540 (4.1)	19 (1.6)	535 (6.0)	11 (1.4)	504 (9.4)
Italy		22 (2.1)	420 (9.8)	47 (1.5)	429 (8.3)	15 (1.3)	419 (9.5)	16 (1.6)	408 (12.3)
Netherlands		15 (1.5)	587 (5.7)	49 (1.7)	585 (3.7)	25 (1.4)	581 (6.2)	11 (1.2)	575 (4.7)

SOURCE: IEA TIMSS Advanced 2008 ©

Based on students' responses to the two statements about why students study physics: 1) Physics has good teachers; and 2) I like the way physics is taught in my school. Average is computed across two statements based on a 4-point Likert scale: 1. Very important; 2. Important; 3. Unimportant; 4. Very unimportant. Very important indicates an average response score of 1 to less than 1.75. Important indicates an average of 1.75 through 2.5. Unimportant indicates an average response score of greater than 2.5 through 3.25. Very unimportant indicates an average greater than 3.25 through 4.

( ) 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.

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

Perhaps not surprisingly, students in all countries considered having a positive orientation toward physics to be important in choosing to study the subject. In every country, the majority of students (ranging from 58% in Sweden to 91% in Lebanon) considered a positive orientation to be important or very important to their decision. In every country, also, students who considered a positive orientation to be important for choosing to study physics had higher average physics achievement than students who thought it less important.

Having physics teachers who are good mentors and role models and being exposed to good teaching are obvious positive sources of influence on the decision to study physics. Exhibit 10.12 presents students' responses to two statements about good teachers and teaching as reasons for studying physics:

- Physics has good teachers.
- I like the way physics is taught in my school.

Again, students were asked to indicate the degree of importance of each one in deciding to study physics in secondary school. As in the previous exhibit, students were assigned to one of four categories of the good teaching factor—*very important*, *important*, *unimportant*, and *very unimportant*—according to their average response based on a 4-point Likert scale. Exhibit 10.12 shows the percentage of students in each of the four categories for each country, together with the average physics achievement for each category. Countries are ranked by the percentage of students in the "very important" category.

Although in general, a large majority of students in all countries were in agreement that good teaching was an important reason to study physics, there was a wide range in the degree of importance across countries, ranging from Armenia, where 56 percent of students considered good teaching to be very important, to the Netherlands, where the corresponding figure was just 15 percent. In Iran, Sweden, Slovenia, Norway, Italy, and the Netherlands, between one fourth and one third of the physics students indicated that good teaching was not important in the decision to study physics in secondary school. There was no consistent relationship across countries between physics achievement and students' reports that good teaching was an important reason for studying physics.

The third set of students' reasons for choosing to study physics involved advice from others—parents, teachers, school advisors—as well as simply doing what their friends were doing. More specifically, there were four statements about advice from others as reasons for studying physics:

- My parents advised me to study physics.
- A teacher advised me to study physics.
- My friends also are studying physics.
- The <study coordinator/mentor>[2] of my school advised me to study physics.

As with the other sets of reasons, students were asked to indicate the degree of importance of each reason in choosing to study physics. As in the previous exhibits, students were assigned to one of four categories of the advice-from-others factor—*very important*, *important*, *unimportant*, and *very unimportant*—according to their average response based on a 4-point Likert scale. Exhibit 10.13 shows the percentage of students in each of the four categories for each country, together with the average physics achievement for each category. Countries are ranked by the percentage of students in the "very important" category.

2 National Research Coordinators replaced the term <study coordinator/mentor> with a culturally appropriate term.

Exhibit 10.13 **Students' Reasons for Studying Physics – Advice from Others**

TIMSSAdvanced 2008 Physics

Country		Very Important		Important		Unimportant		Very Unimportant	
		Percent of Students	Average Achievement	Percent of Students	Average Achievement	Percent of Students	Average Achievement	Percent of Students	Average Achievement
Armenia	r	10 (1.1)	491 (11.3)	45 (2.1)	495 (7.9)	28 (1.8)	499 (9.8)	17 (1.9)	477 (16.8)
Lebanon		4 (0.5)	393 (12.0)	24 (1.4)	427 (5.8)	35 (1.3)	448 (4.2)	36 (1.1)	461 (3.9)
Iran, Islamic Rep. of		4 (0.5)	380 (15.8)	22 (1.2)	418 (8.0)	32 (1.2)	450 (7.8)	42 (1.5)	498 (8.8)
Russian Federation		2 (0.2)	~ ~	24 (1.1)	529 (10.6)	48 (1.3)	525 (10.2)	27 (1.3)	506 (13.9)
Italy		1 (0.3)	~ ~	9 (1.2)	406 (12.8)	27 (1.4)	417 (9.1)	63 (2.0)	426 (8.3)
Norway		1 (0.3)	~ ~	16 (1.0)	530 (5.9)	50 (1.6)	533 (4.2)	33 (1.6)	542 (5.0)
Slovenia		1 (0.3)	~ ~	8 (0.7)	516 (10.1)	42 (1.4)	535 (3.6)	49 (1.4)	539 (3.6)
Sweden		1 (0.2)	~ ~	11 (0.8)	462 (8.3)	40 (1.1)	502 (5.8)	49 (1.2)	502 (6.6)
Netherlands		0 (0.1)	~ ~	11 (1.0)	581 (6.4)	52 (1.4)	582 (4.0)	37 (1.5)	585 (3.9)

SOURCE: IEA TIMSS Advanced 2008 ©

Based on students' responses to the four statements about why students study physics: 1) My parents advised me to study physics; 2) A teacher advised me to study physics; 3) My friends also are studying physics; and 4) The <study coordinator/mentor> of my school advised me to study physics. Average is computed across four statements based on a 4-point Likert scale: 1. Very important; 2. Important; 3. Unimportant; 4. Very unimportant. Very important indicates an average response score of 1 to less than 1.75. Important indicates an average of 1.75 through 2.5. Unimportant indicates an average response score of greater than 2.5 through 3.25. Very unimportant indicates an average greater than 3.25 through 4.

( ) 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.

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

In general, students considered advice from others to be a relatively less important reason for studying physics than having a positive orientation or good teaching, with the majority of students in all countries except Armenia indicating that advice from others was unimportant or very unimportant. In Italy, Norway, Slovenia, Sweden, and the Netherlands more than 80 percent of students were in these categories. Similar to students taking advanced mathematics (see Chapter 4), the more able physics students were less likely to rely on advice from others in deciding to study physics. In a number of countries except Armenia, the Russian Federation, Norway and the Netherlands, students with higher achievement were those reporting that advice from others was unimportant or very unimportant.

Areas of Future Study for Students of Physics

A solid grounding in physics is an excellent basis for future study in many disciplines, particularly engineering, but also computer and information science, mathematics, general science, business, and the health and social sciences. Students' reports of the areas in which they intended to pursue further study are summarized in Exhibit 10.14. Almost all (94% or more) physics students in each of the participating countries indicated that they planned to continue their education after finishing secondary school.

Engineering was the most popular area for post-secondary study among students who studied physics in the final year of secondary school, with more students choosing it than any other in six of the nine countries—Iran, Lebanon, Netherlands, Norway, Slovenia, and Sweden. In addition, while it was not the most popular choice in Italy and the Russian Federation, about 20 percent of the students in these countries also chose engineering for their future area of study. After engineering, business was the next most popular subject choice,

Exhibit 10.14 **Physics Student's Aspirations for Future Study**

TIMSSAdvanced 2008 Physics

Country	Percent of Students Intending to Continue Education	Percent of Students with Intended Area of Study							
		Science	Health Science	Engineering	Business	Computer and Information Science	Mathematics	Social Science	Other Field of Study
Armenia	94 (1.0)	6 (1.0)	14 (1.6)	2 (0.8)	22 (2.1)	11 (1.6)	5 (0.9)	3 (0.6)	36 (2.5)
Iran, Islamic Rep. of	100 (0.1)	4 (0.5)	1 (0.2)	82 (1.2)	2 (0.4)	4 (0.6)	1 (0.3)	1 (0.2)	4 (0.5)
Italy	96 (0.8)	10 (1.0)	26 (1.5)	19 (1.0)	12 (1.0)	4 (0.5)	2 (0.4)	7 (0.7)	19 (1.3)
Lebanon	99 (0.2)	4 (0.5)	2 (0.3)	65 (1.7)	5 (0.7)	8 (0.9)	8 (0.7)	1 (0.2)	8 (0.8)
Netherlands	100 (0.2)	17 (1.2)	14 (1.0)	40 (1.5)	7 (0.8)	7 (0.7)	4 (0.5)	3 (0.5)	7 (0.7)
Norway	100 (0.0)	11 (1.1)	15 (1.1)	41 (1.3)	12 (1.1)	5 (0.7)	2 (0.4)	5 (0.5)	10 (0.7)
Russian Federation	100 (0.0)	8 (0.7)	4 (0.5)	21 (1.1)	23 (0.9)	17 (1.0)	4 (0.5)	12 (0.7)	11 (0.8)
Slovenia	100 (0.0)	19 (1.2)	10 (0.8)	36 (1.4)	5 (0.6)	12 (0.9)	8 (0.8)	7 (0.8)	4 (0.5)
Sweden	99 (0.3)	17 (1.9)	16 (1.4)	29 (2.9)	9 (1.0)	9 (1.2)	2 (0.4)	6 (0.6)	12 (1.1)

SOURCE: IEA TIMSS Advanced 2008 ©

Data provided by students.

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

with more than 20 percent of students in Armenia and the Russian Federation choosing this option. Relatively few physics students in any country (less than 20 percent) chose science, computer and information science, mathematics, or social science as their area of future study; and only Italy had more than 20 percent choosing health science. In Armenia (36%), most physics students chose a field of study other than those listed above.

To provide a more detailed perspective on the subject areas that physics students planned to study after secondary school, Exhibit 10.15 presents the percentage of females choosing each subject area for each country and the percentage of males. If there were no differences in gender preferences, the percentages for females and males in a subject area for a country would be the same (and would be equal to the corresponding entry in Exhibit 10.14). The most pervasive gender differences were in engineering, health science, and computer and information science. The percentage of male physics students intending to study engineering exceeded the percentage of female students in every country, and in computer and information science the percentage of male students was greater than the percentage of female students in all countries except Iran and Lebanon. In contrast, health science and, to a lesser extent, social science were the areas of choice by females more often than by males in most countries—in all countries but Iran for health science, and in Italy, the Netherlands, the Russian Federation, and Slovenia for social science. A greater percentage of female physics students than males in Lebanon and Sweden chose science as a future area of study, and a greater percentage of male physics students than females chose it in the Russian Federation. Similarly, there were not many gender differences in the students choosing business, although more male students than females chose this area in Armenia, Italy, and the Netherlands, and more females than males in the Russian

Exhibit 10.15 **Physics Student's Aspirations for Future Study by Gender**

TIMSSAdvanced 2008 Physics

Country		Percent of Students by Intended Area of Study							
		Science		Health Science		Engineering		Business	
		Females	Males	Females	Males	Females	Males	Females	Males
Armenia	r	5 (1.2)	8 (1.9)	20 (2.5) ▲	7 (1.3)	1 (0.4)	5 (1.7) ▲	19 (2.7)	27 (2.1) ▲
Iran, Islamic Rep. of		5 (0.8)	4 (0.6)	2 (0.4)	1 (0.3)	78 (2.1)	85 (1.3) ▲	3 (0.8)	1 (0.3)
Italy		9 (1.3)	10 (1.2)	35 (2.5) ▲	20 (1.8)	6 (1.0)	28 (1.9) ▲	9 (1.5)	15 (1.5) ▲
Lebanon		6 (1.1) ▲	3 (0.7)	4 (0.9) ▲	1 (0.4)	54 (2.4)	69 (2.0) ▲	7 (1.3)	5 (0.7)
Netherlands		21 (2.5)	16 (1.3)	26 (2.9) ▲	12 (1.0)	22 (2.7)	44 (1.6) ▲	5 (1.4)	8 (0.9) ▲
Norway		13 (2.1)	9 (1.1)	30 (3.2) ▲	8 (0.9)	30 (2.3)	46 (1.5) ▲	10 (1.4)	12 (1.4)
Russian Federation		6 (0.8)	9 (0.9) ▲	7 (1.0) ▲	2 (0.5)	10 (1.3)	30 (1.6) ▲	34 (1.5) ▲	14 (0.9)
Slovenia		18 (2.5)	19 (1.5)	22 (2.7) ▲	5 (0.9)	22 (2.9)	41 (1.6) ▲	4 (1.1)	5 (0.9)
Sweden		21 (2.1) ▲	15 (2.0)	31 (2.0) ▲	7 (0.8)	15 (2.1)	36 (3.3) ▲	9 (1.1)	9 (1.3)

Country		Percent of Students by Intended Area of Study							
		Computer and Information Science		Mathematics		Social Science		Other Field of Study	
		Females	Males	Females	Males	Females	Males	Females	Males
Armenia	r	6 (2.0)	17 (1.8) ▲	5 (1.1)	4 (1.0)	3 (0.8)	3 (1.0)	41 (3.2) ▲	30 (2.6)
Iran, Islamic Rep. of		5 (1.3)	3 (0.4)	1 (0.5)	1 (0.3)	1 (0.3)	0 (0.3)	5 (0.9)	3 (0.6)
Italy		1 (0.5)	6 (0.8) ▲	3 (0.8)	2 (0.4)	12 (1.2) ▲	5 (0.8)	25 (2.3) ▲	15 (1.3)
Lebanon		7 (1.6)	9 (1.0)	13 (1.8) ▲	6 (0.7)	1 (0.4)	0 (0.2)	8 (1.4)	7 (1.1)
Netherlands		2 (0.9)	8 (0.8) ▲	5 (1.4)	4 (0.5)	7 (1.4) ▲	2 (0.5)	12 (2.1) ▲	6 (0.7)
Norway		2 (0.6)	7 (0.8) ▲	2 (0.7)	2 (0.4)	4 (1.2)	5 (0.6)	10 (1.4)	10 (0.9)
Russian Federation		6 (0.7)	27 (1.3) ▲	5 (0.7)	4 (0.6)	19 (1.3) ▲	5 (0.7)	14 (1.2) ▲	9 (0.9)
Slovenia		1 (0.8)	16 (1.2) ▲	15 (2.2) ▲	5 (0.8)	12 (2.1) ▲	5 (0.8)	6 (1.4)	4 (0.7)
Sweden		1 (0.3)	13 (1.5) ▲	2 (0.5)	2 (0.5)	8 (1.3)	5 (0.8)	13 (1.6)	12 (1.3)

▲ Significantly higher than other gender

Data provided by students.

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

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

SOURCE: IEA TIMSS Advanced 2008 ©

Federation. In those planning to study mathematics, the only differences were in Lebanon and Slovenia, where the percentages of females were higher. Finally, more female physics students than males chose the "other" field of study in four of the nine countries, including Armenia, Italy, the Netherlands, and the Russian Federation.

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Chapter 11

Physics Teachers and Instruction in Physics

To help place students' achievement in physics in the context of their school and classroom situations, TIMSS Advanced asked students' teachers to complete questionnaires about their educational preparation to teach physics, their school and classroom situations, and the instructional practices they used in teaching physics to the students assessed. The chapter begins by presenting teachers' reports about their background characteristics, education, and participation in professional activities and development. The second part of the chapter provides information about a number of aspects of their pedagogical approaches to the teaching of physics, including the predominant learning activities and technology used as well as the roles of homework and assessments.

Results are generally shown as the percentages of students whose teachers reported various situations. That is, the student is the unit of analysis so that TIMSS Advanced 2008 can describe students' classroom contexts. The exhibits have special notations when relatively large percentages of students did not have teacher questionnaire information. For a country where teacher responses were available for 70 to 84 percent of the students, an "r" is included next to its data.

Where teacher responses were available for 50 to 69 percent of students, an "s" is included.

Background Characteristics of Physics Teachers

This section presents information about the background characteristics of the teachers of physics, including gender, age, and years of teaching experience. As shown in Exhibit 11.1, in Armenia and the Russian Federation, 87 and 77 percent, respectively, of physics students were taught by female teachers. In the other countries, the majority of physics students were taught by men. Italy, with 44 percent female and 56 percent male, came closest to achieving gender parity. However, in Lebanon, the Netherlands, Norway, and Sweden, from 89 to 95 percent of the students had male teachers.

Exhibit 11.1 also presents teachers' reports about their age and teaching experience. Perhaps the most striking feature of these results is that 38 to 47 percent of the physics students in Armenia, Italy, the Russian Federation, and Slovenia were taught by teachers who were at least 50 years old. In Lebanon, the Netherlands, Norway, and Sweden, the figure was from 57 to 64 percent. On the other hand, more than half of the Iranian students were taught by teachers less than 40 years old.

As might be expected, these physics students were taught by highly experienced teachers. Reported years of experience ranged from a low of 17 years in the Islamic Republic of Iran, who had a much larger proportion of younger teachers than was the case in other countries, to a high of 26 years in Lebanon. Teachers in the Netherlands, the Russian Federation, and Sweden, each with an average of 24 years, were nearly as experienced as the Lebanese teachers. In most countries, the teachers had been teaching physics throughout most of their teaching careers; but this was less often the case in Italy, the Russian Federation, and

Exhibit 11.1 Physics Teachers' Gender, Age, and Number of Years Teaching

TIMSSAdvanced 2008 Physics

Country	Percent of Students by Teacher Characteristics						Average Number of Years Teaching	
	Gender		Age					
	Female	Male	29 Years or Under	30–39 Years	40–49 Years	50 Years or Older	Teaching Altogether	Teaching Physics
Armenia	87 (2.2)	13 (2.2)	9 (1.9)	17 (3.6)	36 (4.0)	38 (3.4)	21 (0.3)	22 (0.3)
Iran, Islamic Rep. of	31 (2.5)	69 (2.5)	7 (2.5)	48 (4.6)	31 (3.9)	14 (2.5)	17 (0.6)	15 (0.6)
Italy	44 (4.9)	56 (4.9)	3 (1.6)	14 (4.6)	37 (5.3)	47 (5.4)	21 (0.8)	11 (0.6)
Lebanon	11 (1.9)	89 (1.9)	3 (0.9)	18 (1.7)	23 (2.4)	57 (2.5)	26 (0.5)	26 (0.4)
Netherlands	5 (2.1)	95 (2.1)	4 (1.9)	16 (4.4)	17 (3.6)	64 (5.9)	24 (1.4)	20 (1.3)
Norway	11 (2.9)	89 (2.9)	3 (1.9)	20 (3.5)	16 (3.7)	60 (4.8)	22 (1.2)	19 (1.3)
[a] Russian Federation	77 (3.4)	23 (3.4)	6 (2.8)	17 (3.6)	31 (4.3)	46 (4.6)	24 (0.9)	9 (0.7)
[b] Slovenia	27 (0.2)	73 (0.2)	7 (0.2)	14 (0.2)	36 (0.2)	42 (0.3)	20 (0.1)	13 (0.0)
Sweden	11 (3.0)	89 (3.0)	2 (1.4)	20 (3.1)	13 (3.0)	64 (4.1)	24 (1.1)	21 (1.1)

SOURCE: IEA TIMSS Advanced 2008 ©

Data provided by teachers.

a Russian physics teachers teach physics for their entire career. The figure reported under "Years of Teaching Physics" refers to Physics at advanced level.

b Slovenian physics teachers teach physics for their entire career. The figure reported under "Years of Teaching Physics" refers to the advanced physics program introduced 13 years ago.

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

Exhibit 11.2 Teachers' Plans to Continue Teaching Physics

TIMSSAdvanced 2008 Physics

Country	Percent of Students by Their Teachers' Plans to Continue Teaching			
	Plan to Continue Teaching as Long as I Can	Plan to Continue Teaching Until the Opportunity for a Better Job in Education Comes Along	Plan to Continue Teaching for Awhile But Probably Will Leave the Field of Education	Undecided at This Time
Armenia	86 (0.2)	12 (0.2)	0 (0.0)	2 (0.0)
Iran, Islamic Rep. of	83 (3.4)	10 (2.7)	3 (1.6)	4 (1.9)
Italy	84 (3.9)	12 (3.5)	2 (1.1)	3 (1.5)
Lebanon	81 (2.0)	7 (1.5)	4 (0.9)	8 (1.2)
Netherlands	79 (4.8)	8 (3.3)	4 (2.0)	9 (2.9)
Norway	75 (4.5)	3 (1.6)	4 (2.1)	18 (3.7)
Russian Federation	65 (4.2)	3 (2.1)	11 (3.0)	20 (3.4)
Slovenia	69 (0.2)	1 (0.0)	3 (0.1)	27 (0.2)
Sweden	73 (3.4)	2 (1.3)	5 (2.0)	20 (2.9)

SOURCE: IEA TIMSS Advanced 2008 ©

Data provided by teachers.

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

Slovenia, where teachers had significantly fewer years of experience teaching physics than of teaching generally.

Teachers were also asked about their plans for the future, insofar as teaching physics was concerned. The results, shown in Exhibit 11.2, indicate that most of the physics teachers in these countries plan to continue their teaching careers, although significant proportions in some countries—18 percent in Norway, 20 percent in the Russian Federation and Sweden, and 27 percent in Slovenia—were undecided about their future plans. Few teachers in any of these countries (less than 15 percent) indicated that they planned to leave the field of education or that they planned to look for a different position within the field of education. It appears that teachers of physics in these countries like their jobs and plan to continue in them at least for a while.

Teacher Education for Teaching Physics

Exhibit 11.3 indicates that virtually every teacher of physics in these countries had a university degree, either at the undergraduate or graduate level. In Armenia and Slovenia, essentially all students (98 to 100%) were taught physics by a teacher with a postgraduate degree, and most were in the the Netherlands (88%), Norway (87%), and the Russian Federation (78%).

Teachers were asked to indicate which, from a list of several choices, had been a “major or main area(s) of study” for them in their post-secondary studies. The options available were physics, science education, engineering, general education, mathematics, mathematics education, and other. Teachers were free to identify more than one main area of study, so the percents for each country total more than 100.

Exhibit 11.3 **Highest Educational Level of Physics Teachers***

TIMSSAdvanced 2008 Physics

Country	Percent of Students by Their Teachers' Educational Level		
	Completed Postgraduate University Degree**	Completed University But Not a Postgraduate Degree***	Did Not Complete University
Armenia	98 (0.0)	1 (0.0)	1 (0.0)
Iran, Islamic Rep. of	20 (3.7)	80 (3.7)	0 (0.0)
Italy	20 (4.7)	80 (4.7)	0 (0.0)
Lebanon	44 (2.6)	56 (2.6)	0 (0.0)
[a] Netherlands	88 (3.2)	10 (3.5)	1 (1.5)
[b] Norway	87 (3.3)	13 (3.3)	0 (0.0)
[c] Russian Federation	78 (3.6)	22 (3.6)	0 (0.0)
[d] Slovenia	100 (0.0)	0 (0.0)	0 (0.0)
Sweden	42 (5.4)	57 (5.4)	1 (0.6)

SOURCE: IEA TIMSS Advanced 2008 ©

Data provided by teachers.

* Based on countries' categorization to UNESCO's International Standard Classification of Education (Operational Manual for ISCED–1997).

** Level 5A, second degree or higher on the ISCED scale.

*** Level 5A, first degree on the ISCED scale.

a In the Netherlands, most teachers who have completed a postgraduate university degree have a university degree in mathematics or physics requiring 3 years of study at the bachelor's level and 2 years at the master's level, and one year of special teacher training. Recently, it has been possible to obtain a 2-year "education master" equivalent to a master's degree. Also, a few teachers in this category have a PhD. Teachers who have completed university but not a postgraduate degree have completed 4 years at a teacher training institute (or college) and obtained a diploma equivalent to a bachelor's degree. To be a teacher at the advanced level of the pre-university track, it also is necessary to complete postgraduate work at a teacher training institute, but this is not considered equivalent to a university's master's degree.

b Norwegian teachers who have completed postgraduate study typically have master's degrees requiring 5–7 years of university study.

c In the Russian Federation, teachers with a postgraduate university degree have completed 5–6 years of higher education, ending with defending a thesis to obtain a diploma (equivalent to a master's degree), and also have passed state examinations. Some teachers in this category may have two diplomas or a doctoral degree.

d Slovenian teachers all have obtained a diploma based on completing 4 years of university study followed by a successful thesis (equivalent to a master's degree). Some have a master's degree based on an additional 2 years of study or a doctoral degree based on 4 years of additional study.

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

Exhibit 11.4 **Teachers' Major or Main Area(s) of Study**

TIMSSAdvanced 2008 Physics

Country	Percent of Students by Their Teachers' Major or Main Area(s) of Study in Their Post-secondary Education								
	Physics	Chemistry	Biology	Engineering	Education – Science	Mathematics	Education – Mathematics	Education– General	Other
Armenia	96 (0.4)	12 (2.2)	2 (1.8)	4 (2.9)	22 (3.3)	42 (2.9)	18 (1.2)	28 (1.4)	12 (1.1)
Iran, Islamic Rep. of	92 (2.2)	2 (1.2)	1 (0.5)	14 (2.9)	9 (2.9)	11 (3.0)	6 (2.5)	4 (1.8)	3 (1.2)
Italy	40 (5.6)	0 (0.0)	0 (0.0)	10 (3.7)	– –	50 (5.8)	– –	– –	0 (0.0)
Lebanon	95 (0.6)	15 (1.6)	4 (1.0)	4 (0.7)	22 (1.6)	27 (2.0)	16 (1.5)	13 (1.3)	12 (1.0)
Netherlands	82 (4.0)	10 (3.0)	0 (0.0)	16 (4.0)	51 (4.9)	29 (4.8)	12 (3.2)	– –	9 (2.4)
Norway	95 (2.4)	19 (4.3)	1 (0.4)	13 (2.4)	2 (1.5)	95 (2.2)	2 (1.5)	17 (3.1)	35 (5.2)
Russian Federation	98 (1.3)	1 (0.7)	1 (0.6)	20 (3.7)	36 (4.4)	38 (4.2)	14 (3.3)	39 (4.6)	10 (3.0)
Slovenia	86 (0.2)	3 (0.1)	0 (0.0)	10 (0.1)	8 (0.0)	4 (0.0)	8 (0.1)	0 (0.0)	3 (0.1)
Sweden	97 (1.5)	16 (3.5)	4 (2.7)	15 (4.0)	44 (4.9)	90 (2.9)	60 (4.7)	32 (5.6)	12 (3.6)

SOURCE: IEA TIMSS Advanced 2008 ©

Data provided by teachers.
( ) Standard errors appear in parentheses.

A dash (–) indicates comparable data are not available.

Exhibit 11.5 **National Requirements for Being a Teacher of Physics**

TIMSSAdvanced 2008 Physics

Country	Requirements
Armenia	Teachers need the Certificate of Higher Education.
Iran, Islamic Rep. of	Teachers need at least a bachelor's degree in physics.
Italy	Teachers need to have taken a national examination and completed a degree in mathematics, physics, or engineering.
Lebanon	Teachers must have a degree in physics, pass an admission examination to a Faculty of Pedagogy at Lebanese University, and complete 2 years of pedagogical study.
Netherlands	Teachers either have a university master's degree in physics (or a related area) followed by a 1-year university education course, or have attended a polytechnic college obtaining a bachelor's degree in physics (education) followed by a master's course in physics education.
Norway	Teachers are required to have a university bachelor's degree consisting of 1 full year (60 credit points) of physics courses. They also need 1 year of teacher education courses, consisting of general pedagogy, science education, and teaching practice in schools.
Russian Federation	Teachers need the Certificate of Higher Education, with certificates of physics education and of professional development in advanced physics highly desirable.
Slovenia	To obtain a teaching license, it is necessary to complete physics study together with some pedagogical courses at the Faculty for Mathematics and Physics or the study of two educational science subjects (physics/mathematics, physics/chemistry) at the Faculty of Education and an additional 1 year course at the Faculty for Mathematics and Physics. They must also teach under supervision of a seminar teacher for 1 year, and pass a teaching certification examination organized by the ministry.
Sweden	Teachers of the Physics B course are expected to have a major in physics (at least 2 years of university study in physics) and at least 1.5 years of an additional subject, most commonly mathematics. A degree in teacher education also is expected.

SOURCE: IEA TIMSS Advanced 2008 ©

Data provided by National Research Coordinators.

As is shown in Exhibit 11.4, 82 percent or more of the students in every country except Italy had teachers who had specialized in physics. In Italy, only 40 percent of students had teachers with physics as a major area of study, but 50 percent had teachers whose major area of study was mathematics. On the other hand, relatively few students were taught physics by teachers who indicated that they had science education as a major area of study in university. In Norway (95%) and Sweden (90%), substantial proportions of students had physics teachers who also had mathematics as a main area of their program.

Exhibit 11.5 presents brief descriptions of national requirements for being a teacher of physics in each of the countries. There is a high degree of commonality across all of these descriptions. Basically, teachers of physics in all of these countries are required to have an extensive tertiary level academic background in physics and in teacher education.

Physics Teachers' Professional Activities and Development

Teachers in most countries have a choice of a number of professional or syndical organizations available to them. They may, as a condition of employment, be required to join, or at least pay membership dues to, the teachers' union that bargains with their employers regarding salaries, working conditions, and the like. However, they may also choose to become members of a professional association, either local or national, that brings together teachers with similar backgrounds and interests to discuss professional matters and promote the cause of physics education, for example.

Teachers of physics who participated in this study were asked whether they belonged to a professional association of physics teachers and whether they participated regularly in activities sponsored by such organizations. As Exhibit 11.6 makes clear, the results were not very encouraging. In most countries less than half the students were taught physics by a teacher who belonged to a professional organization of physics teachers. Results regarding participation in professional activities were not any more encouraging. Apparently, many teachers of physics in these countries do not have the opportunity or see the need to join professional organizations or to participate in activities sponsored by them.

Participating teachers were presented with five statements relating to their participation in a range of professional activities. The activities included attending workshops or conferences, making a presentation at a workshop or conference, having an article published in a journal or magazine directed at teachers, taking part in an innovative project for curriculum and instruction, and exchanging information online about teaching physics. Students whose teachers had participated in three or more of these activities were categorized at the high level of participation. Those whose teachers had not participated in any of these activities were categorized at the low level, and all the rest were categorized at the medium level. This information is summarized in Exhibit 11.7. In the table, the countries are presented in descending order of the percentage of students whose teachers were classified at the high level of participation. Also, the results are presented in relation to students' average achievement, although there appeared to be little relationship between more participation by teachers and students' achievement except in Armenia.

In Slovenia, the Russian Federation, and Iran, no more than 10 percent of students were taught by teachers who were classified at the low level of participation in professional activities; the rest of the students in those countries, 90 percent or more, were taught by teachers who reported a high or medium level of participation. Results from the other countries were rather disappointing, with 17 percent of Italian

Exhibit 11.6 Teachers' Participation in a Professional Organization for Physics Teachers

TIMSSAdvanced 2008 Physics

Country	Percent of Students Whose Teacher Was a Member of a Professional Organization for Physics Teachers	Percent of Students Whose Teacher Regularly Participated in Activities Sponsored by a Professional Organization for Physics Teachers
Armenia	41 (0.8)	60 (2.6)
Iran, Islamic Rep. of	42 (4.1)	33 (4.6)
Italy	22 (5.3)	37 (5.3)
Lebanon	25 (2.1)	33 (2.3)
Netherlands	74 (4.2)	46 (4.9)
Norway	39 (4.3)	7 (2.4)
Russian Federation	78 (3.1)	78 (2.7)
Slovenia	47 (0.2)	38 (0.2)
Sweden	30 (4.9)	17 (3.1)

SOURCE: IEA TIMSS Advanced 2008 ©

Data provided by teachers.

( ) Standard errors appear in parentheses.

Exhibit 11.7 Index of Teachers' Participation in Professional Activities in Physics (PAP)

TIMSSAdvanced 2008 Physics

Country	High PAP		Medium PAP		Low PAP	
	Percent of Students	Average Achievement	Percent of Students	Average Achievement	Percent of Students	Average Achievement
Slovenia	52 (0.2)	534 (2.9)	38 (0.2)	544 (3.0)	10 (0.2)	508 (3.9)
Russian Federation	41 (5.0)	533 (17.2)	51 (5.3)	516 (16.7)	8 (2.6)	491 (19.6)
Iran, Islamic Rep. of	24 (3.7)	453 (11.0)	67 (4.0)	462 (8.5)	10 (2.2)	461 (31.3)
Netherlands	21 (4.5)	574 (5.7)	55 (5.1)	584 (5.2)	23 (4.4)	589 (6.2)
Lebanon	19 (1.5)	460 (5.1)	48 (2.2)	439 (4.1)	33 (2.0)	441 (6.2)
Italy	18 (4.6)	429 (19.3)	65 (5.1)	417 (9.9)	17 (4.2)	445 (18.0)
Sweden	8 (2.3)	478 (24.0)	56 (4.8)	498 (7.3)	35 (4.8)	500 (6.4)
Armenia	5 (0.2)	502 (10.8)	70 (2.2)	500 (6.6)	25 (2.2)	479 (8.0)
Norway	4 (1.9)	532 (12.7)	49 (5.5)	530 (5.2)	47 (6.1)	538 (6.5)

SOURCE: IEA TIMSS Advanced 2008 ©

Based on teachers' responses to five statements about their participation in professional activities: 1) Attended a workshop or conference; 2) Gave a presentation at a workshop or conference; 3) Published an article in a journal or magazine for teachers (print or online); 4) Took part in an innovative project for curriculum and instruction; and 5) Exchanged information online about how to teach physics. Students whose teachers participated in three or more of the five activities were assigned to the high level. Students whose teachers did not participate in any activities were assigned to the low level. All other students were assigned to the medium level.

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

students, about one fourth of Dutch and Armenian students, about one third of Lebanese and Swedish students, and nearly half the Norwegian students taught by teachers who had low levels of participation.

Another questionnaire item asked teachers whether or not they had participated in professional development in one or more of six areas related to physics teaching in the previous two years. The areas were: physics content, physics pedagogy or instruction, physics curriculum, integrating information technology into physics, improving students' critical thinking or problem-solving skills, and physics assessment.

The results presented in Exhibit 11.8 indicate that in seven of the nine countries (everywhere except Lebanon and the Russian Federation) the most common professional development areas for teachers focused on either physics content, physics pedagogy and instruction, or physics curriculum. The least common professional development areas in most countries focused on physics assessment strategies or improving students' critical thinking and problem-solving skills. In general, greater percentages of students in Armenia, the Russian Federation, and Slovenia were taught by teachers who had participated in one or more of these professional development activities within the past two years than in the other six countries. The teachers of Italian students reported the lowest levels of participation.

Previous cycles of TIMSS have shown that the extent of professional collaboration among teachers in the same school varies widely across countries, and Exhibit 11.9 shows that this was the case with physics teachers at this level. On a positive note, results show that about half the students or more in every country were taught by teachers who consulted with colleagues in their school about pedagogical matters several times each month. In fact, in five countries, at least 80 percent of the students had teachers that met with their colleagues at least several times a month or even weekly. On the other hand, from 35 to

Exhibit 11.8 Teachers' Participation in Professional Development

TIMSSAdvanced 2008 Physics

Country	Percent of Students Whose Teachers Participated in Professional Development in Various Areas of Physics in the Past Two Years					
	Physics Content	Physics Pedagogy/ Instruction	Physics Curriculum	Integrating Information Technology into Physics	Improving Students' Critical Thinking or Problem-solving Skills	Physics Assessment
Armenia	69 (1.4)	69 (2.9)	81 (2.1)	30 (0.6)	46 (2.0)	40 (1.5)
Iran, Islamic Rep. of	62 (4.2)	70 (3.4)	41 (4.2)	34 (4.8)	24 (3.9)	29 (4.0)
Italy	49 (5.9)	43 (4.8)	16 (4.2)	23 (4.7)	20 (3.5)	4 (2.2)
Lebanon	36 (2.3)	40 (2.3)	30 (1.7)	37 (2.4)	36 (2.2)	49 (2.2)
Netherlands	41 (4.2)	42 (4.7)	33 (5.0)	36 (6.1)	13 (3.4)	15 (4.5)
Norway	59 (5.4)	31 (4.5)	46 (4.7)	40 (5.0)	2 (1.5)	12 (3.1)
Russian Federation	60 (4.9)	70 (4.6)	64 (4.0)	78 (3.8)	37 (4.1)	49 (4.6)
Slovenia	89 (0.2)	81 (0.2)	60 (0.3)	69 (0.3)	42 (0.2)	46 (0.3)
Sweden	63 (4.9)	32 (5.2)	17 (3.7)	22 (2.9)	10 (2.6)	24 (5.8)

SOURCE: IEA TIMSS Advanced 2008 ©

Data provided by teachers.

( ) Standard errors appear in parentheses.

Exhibit 11.9 Frequency of Collaboration Among Physics Teachers

TIMSSAdvanced 2008 Physics

Country	Percent of Students by Their Teachers' Frequency of Collaboration with Other Teachers		
	At Least Weekly	2 or 3 Times per Month	Never or Almost Never
Armenia	42 (1.8)	56 (1.9)	2 (0.1)
Iran, Islamic Rep. of	8 (2.1)	55 (4.3)	37 (4.2)
Italy	5 (2.5)	49 (5.4)	46 (5.5)
Lebanon	21 (1.8)	61 (2.4)	18 (2.1)
Netherlands	4 (2.0)	61 (5.5)	35 (5.2)
Norway	6 (2.4)	74 (4.6)	20 (4.2)
Russian Federation	46 (3.6)	49 (3.5)	5 (1.7)
Slovenia	7 (0.1)	50 (0.3)	43 (0.3)
Sweden	23 (4.6)	67 (4.6)	10 (2.1)

SOURCE: IEA TIMSS Advanced 2008 ©

Based on teachers' responses to four statements about types of interactions among physics teachers: discussion about how to teach a particular concept, working on preparing instruction materials, visit to another teachers' classroom to observe his/her teaching, and informal observation of my classroom by another teacher. Responses were provided on a 4-point Likert scale: 1) Never or almost never; 2) 2 or 3 times per month; 3) 1–3 times per week; 4) Daily or almost daily.

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

46 percent of students in Iran, Italy, the Netherlands, and Slovenia were taught by teachers who rarely, if ever, consulted with colleagues in their school about pedagogical matters such as how to teach a particular concept, worked collegially to prepare instructional materials, observed a colleague's teaching, or invited a colleague to observe their teaching.

Exhibit 11.10 presents school principals' reports about how teachers of physics were evaluated in each of the participating countries. The results are shown in terms of the percentage of students in each country taught by teachers who were evaluated on the basis of classroom observations by the school principal or a senior staff member, classroom observations by an external examiner or inspector, student achievement, or teacher peer reviews.

Evaluation of teachers on the basis of their students' achievement is frequently portrayed, by teachers and others, as inherently unjust since it does not take into account individual differences in students' abilities, work habits, and the like. In spite of such opposition, for these teachers of advanced students, it was by far the most commonly used approach for teacher evaluation in the TIMSS Advanced countries. At least three fourths of students in every one of the participating countries were taught by teachers who were being evaluated, at least in part, on the basis of how well those students performed in physics. The second most popular approach to teacher evaluation was classroom observations by the school principal or a senior staff member. Classroom observations by inspectors and peer reviews were less widely used. There appeared to be less emphasis given to teacher evaluation in the Netherlands and Norway than in the other participating countries, and more in Armenia and the Russian Federation.

Exhibit 11.10 **Schools' Reports on Ways They Evaluate Physics Teachers' Practices**

TIMSSAdvanced 2008 Physics

Country	Percent of Students by Ways Their Schools Evaluate Physics Teachers' Practice			
	Observations by the Principal or Senior Staff	Observations by Inspectors or Other Persons External to the School	Student Achievement	Teacher Peer Review
Armenia	96 (0.4)	45 (0.7)	96 (0.1)	91 (0.4)
Iran, Islamic Rep. of	74 (4.5)	43 (5.2)	98 (1.4)	41 (5.1)
Italy	72 (5.5)	3 (2.5)	92 (3.0)	39 (6.3)
Lebanon	89 (1.9)	43 (2.4)	95 (1.0)	60 (2.3)
Netherlands	37 (5.6)	27 (4.6)	86 (3.7)	37 (6.0)
Norway	24 (5.6)	0 (0.0)	81 (3.8)	46 (5.7)
Russian Federation	99 (1.0)	65 (4.8)	99 (0.7)	89 (2.5)
Slovenia	86 (0.2)	7 (0.2)	75 (0.2)	45 (0.2)
Sweden	63 (5.0)	8 (3.2)	88 (3.9)	49 (6.3)

SOURCE: IEA TIMSS Advanced 2008 ©

Data provided by schools.

( ) Standard errors appear in parentheses.

Characteristics of Physics Classes

Exhibit 11.11 addresses the issue of class size and the relationship between class size and student achievement in physics, using data supplied by the participating teachers about their TIMSS Advanced 2008 physics classes. The table first shows the average size of a participating physics class in each country. The rest of the table is divided into four sections, one for each of four ranges of class size: viz., 1–24 students, 25–32 students, 33–40 students, and over 40 students. For each of the four class-size categories, the table indicates the percentage of students in that country who were in a physics class within that size range and the average TIMSS Advanced 2008 physics scale score for those students.

Only in the Islamic Republic of Iran was the average class size as large as 32, and in the rest of the countries it was 25 or less. The smallest average class size, 17 students, was found in the Netherlands and Norway. The finding of relatively small class sizes is further illustrated by the fact that hardly any students were in classes with 33 or more students, although 29 percent of Iranian students were in classes with more than 40 students. There was a relationship between class size and students' average achievement in Armenia, Italy, and the Netherlands, with students in smaller classes having higher average physics achievement. However, the results were not consistent in the other countries.

Many factors are known to present challenges to effective teaching, including the student composition of the classes. The teachers of physics were asked to estimate to what extent five student-related factors limited their approaches to teaching. The five factors were: students with different academic abilities, students who came from a wide range of backgrounds, students with special needs, uninterested students, and disruptive students. Responses were given on a 4-point

Exhibit 11.11 **Achievement and Class Size for Physics Instruction**

TIMSSAdvanced 2008 Physics

Country		Overall Average Class Size	1–24 Students		25–32 Students		33–40 Students		41 or More Students	
			Percent of Students	Average Achievement	Percent of Students	Average Achievement	Percent of Students	Average Achievement	Percent of Students	Average Achievement
Armenia	r	25 (0.2)	43 (4.7)	514 (12.1)	48 (4.7)	480 (8.4)	9 (0.1)	445 (21.1)	0 (0.0)	~ ~
Iran, Islamic Rep. of		32 (1.1)	28 (3.6)	437 (9.2)	31 (4.4)	479 (13.9)	12 (3.2)	448 (23.9)	29 (4.3)	466 (16.2)
Italy		21 (0.4)	80 (5.1)	431 (8.5)	20 (5.1)	395 (15.1)	0 (0.0)	~ ~	0 (0.0)	~ ~
Lebanon		18 (0.2)	78 (1.0)	446 (3.6)	14 (0.9)	435 (4.7)	4 (0.1)	445 (9.4)	4 (0.1)	420 (5.1)
Netherlands		17 (0.6)	88 (4.1)	586 (3.2)	12 (4.1)	558 (13.6)	0 (0.0)	~ ~	0 (0.0)	~ ~
Norway		17 (0.4)	88 (3.6)	533 (4.6)	12 (3.6)	539 (9.6)	0 (0.0)	~ ~	0 (0.0)	~ ~
Russian Federation		22 (0.3)	63 (4.3)	514 (11.3)	37 (4.3)	533 (15.4)	0 (0.0)	~ ~	0 (0.0)	~ ~
Slovenia		23 (0.0)	51 (0.3)	526 (2.6)	38 (0.2)	547 (2.9)	7 (0.1)	538 (8.6)	3 (0.0)	607 (8.1)
Sweden		22 (0.5)	61 (5.1)	497 (6.7)	38 (5.0)	499 (10.0)	1 (1.0)	~ ~	0 (0.0)	~ ~

SOURCE: IEA TIMSS Advanced 2008 ©

Data provided by teachers.

( ) 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.

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

Exhibit 11.12 **Index of Student Factors Limiting Instruction in Physics**

TIMSSAdvanced 2008 Physics

Country		High (Few or No Limitations)		Medium (Some Limitations)		Low (Many Limitations)	
		Percent of Students	Average Achievement	Percent of Students	Average Achievement	Percent of Students	Average Achievement
Norway		54 (5.4)	534 (5.0)	44 (5.4)	533 (5.7)	2 (1.7)	~ ~
Sweden		45 (5.2)	516 (6.2)	51 (5.4)	485 (6.8)	4 (1.4)	451 (34.7)
Netherlands		43 (6.0)	591 (5.5)	54 (6.0)	577 (5.3)	2 (1.8)	~ ~
Slovenia		34 (0.3)	541 (3.7)	55 (0.3)	537 (2.9)	11 (0.2)	507 (4.8)
Lebanon		30 (1.9)	455 (4.8)	56 (2.5)	438 (4.0)	14 (1.8)	433 (10.6)
Armenia	r	23 (0.7)	470 (19.5)	58 (0.7)	509 (6.5)	19 (0.5)	498 (9.6)
Russian Federation		22 (4.1)	551 (18.9)	59 (4.8)	508 (13.8)	20 (3.8)	524 (24.8)
Iran, Islamic Rep. of		21 (3.8)	492 (17.1)	60 (4.6)	464 (10.2)	20 (3.6)	415 (11.1)
Italy		17 (4.0)	464 (17.4)	71 (4.9)	417 (9.7)	12 (3.4)	413 (15.6)

SOURCE: IEA TIMSS Advanced 2008 ©

Based on teachers' responses to five statements about student factors limiting physics instruction: 1) Students with different academic abilities; 2) Students who come from a wide range of backgrounds; 3) Students with special needs; 4) Uninterested students; and 5) Disruptive students. Responses were provided on a 4-point scale: 1. Not at all; 2. A little; 3. Some; and 4. A lot. Students in the high category had teachers who reported few (if any) limitations, on average (less than 2), and those in the low category had teachers that reported their instruction was limited a lot, on average (greater than 3). The remaining students fell into the medium category.

( ) 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.

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

scale: *not at all, a little, some*, and *a lot*. TIMSS Advanced used the teachers' responses to construct an Index of Student Factors Limiting Instruction in Physics. Students were included in the high category, if, on average, their teacher reported that their classroom was impacted only a little (if at all), and in the low category if, on average, these factors impacted instruction at least somewhat. The remaining students constituted the medium category.

The results are presented in Exhibit 11.12. In the table, the countries are presented in descending order of the percentage of students in the high category. Considering that the students taking physics are a select group and are in relatively small classes, it might be surprising that teachers said the composition of their classes did limit their teaching at least somewhat for substantial percentages of students. In general, students in the high category had higher achievement than students in the medium and low categories, but this was not the case in all countries. Results showed that no more than 20 percent of the students in all countries were taught by teachers who felt that these five student-related factors constituted major limitations on their instruction. However, except for Norway with 54 percent of students in the high category, the majority of students in the rest of the participating countries were in the medium category where teachers reported some limitations on their instruction.

Activities in Physics Lessons

Exhibits 11.13 and 11.14 summarize reports by students and their teachers, respectively, about the frequency of occurrence of seven instructional activities related to thinking skills covered in the TIMSS Advanced 2008 physics cognitive domains. The activities included watching the teacher demonstrate an experiment or investigation, conducting an experiment or investigation, using laws

Exhibit 11.13 **Students' Reports on Frequency of Various Learning Activities in Physics Lessons**

TIMSSAdvanced 2008 Physics

Country	Percent of Students Who Reported Doing the Activity in About Half the Lessons or More							
	Watch the Teacher Demonstrate an Experiment or Investigation	Conduct an Experiment or Investigation	Use Laws and Formulas of Physics to Solve Problems	Give Explanations About What We Are Studying	Relate What We Are Learning in Physics to Daily Lives	Memorize Formulas and Procedures of Physics	Read Our Physics Textbooks and Other Resource Materials	Watch the Teacher Demonstrate Physics on a Computer
Armenia	34 (2.1)	r 22 (2.2)	r 78 (2.3)	r 73 (2.5)	r 42 (2.6)	r 64 (3.1)	r 43 (2.3)	r 12 (1.8)
Iran, Islamic Rep. of	19 (1.3)	12 (1.0)	89 (0.8)	56 (1.6)	40 (1.3)	79 (1.0)	73 (1.3)	5 (0.8)
Italy	15 (1.8)	12 (2.0)	78 (1.6)	61 (2.4)	24 (2.0)	56 (2.0)	32 (2.3)	6 (1.9)
Lebanon	– –	– –	– –	– –	– –	– –	– –	– –
Netherlands	11 (1.6)	3 (0.6)	87 (1.1)	32 (1.8)	20 (1.4)	26 (1.3)	51 (2.2)	10 (1.5)
Norway	14 (1.6)	4 (0.6)	92 (0.8)	45 (2.0)	29 (1.7)	18 (1.7)	36 (2.1)	13 (1.4)
Russian Federation	23 (1.3)	9 (0.9)	94 (0.7)	77 (1.5)	41 (1.6)	74 (1.4)	53 (1.9)	21 (2.9)
Slovenia	41 (1.3)	19 (1.1)	76 (1.1)	79 (1.2)	51 (1.7)	20 (1.3)	11 (0.8)	37 (1.2)
Sweden	54 (2.3)	25 (1.8)	81 (1.3)	38 (1.5)	27 (1.7)	22 (1.4)	45 (2.0)	11 (1.8)

SOURCE: IEA TIMSS Advanced 2008 ©

Data provided by students.

( ) Standard errors appear in parentheses.

A dash (–) indicates comparable data are not available.

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

Exhibit 11.14 **Teachers' Reports on Frequency of Various Learning Activities in Physics Lessons**

TIMSSAdvanced 2008 Physics

Country	Percent of Students Whose Teachers Reported Students Doing the Activity in About Half the Lessons or More						
	Watch Me Demonstrate an Experiment or Investigation	Conduct an Experiment or Investigation	Use Laws and Formulas of Physics to Solve Problems	Give Explanations About Something They Are Studying	Relate What They Are Learning in Physics to Daily Lives	Have Students Memorize Formulas and Procedures	Read Their Textbooks or Other Resource Materials
Armenia	r 26 (0.7)	r 15 (0.3)	r 95 (0.1)	r 97 (0.0)	r 83 (0.3)	r 62 (0.7)	r 59 (1.9)
Iran, Islamic Rep. of	59 (4.5)	26 (4.2)	85 (3.7)	73 (3.8)	73 (3.7)	59 (4.2)	89 (3.0)
Italy	11 (3.1)	10 (3.1)	82 (5.2)	90 (2.9)	46 (5.8)	15 (3.5)	55 (5.3)
Lebanon	43 (2.0)	30 (2.3)	89 (1.4)	82 (1.3)	81 (1.8)	61 (2.5)	63 (2.4)
Netherlands	28 (4.6)	2 (1.5)	90 (2.8)	31 (5.4)	33 (4.6)	14 (3.8)	41 (5.0)
Norway	24 (4.1)	6 (2.2)	82 (3.7)	56 (5.6)	45 (5.3)	19 (4.9)	30 (4.1)
Russian Federation	48 (4.6)	19 (3.5)	100 (0.3)	91 (2.9)	75 (3.0)	53 (4.3)	26 (3.8)
Slovenia	50 (0.2)	15 (0.2)	77 (0.2)	20 (0.2)	60 (0.2)	5 (0.1)	10 (0.2)
Sweden	72 (4.7)	29 (4.7)	52 (5.6)	66 (5.0)	38 (4.4)	4 (1.6)	16 (4.2)

SOURCE: IEA TIMSS Advanced 2008 ©

Background data provided by teachers.

( ) Standard errors appear in parentheses.

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

and formulas of physics to solve problems, giving explanations about something students are studying, relating what students are learning in physics to their daily lives, memorizing formulas and procedures, and reading physics textbooks and other resource materials. Students were also asked about how frequently they watched the teacher demonstrate physics on a computer. The data in Exhibit 11.13 are the percentages of students reporting that an activity occurred in at least half the lessons in their physics class, and the data in Exhibit 11.14 are the percentages of students whose teachers reported the activity occurred in at least half the lessons.

Using the laws and formulas of physics to solve problems was the activity most often identified by students as occurring in at least half of their physics classes. According to their reports, this activity occurred this frequently for 76 to 94 percent of the students (data are not available for Lebanon for this question). In Armenia, the Russian Federation, and Slovenia, about three fourths of students also reported that giving explanations about what they were learning was a prevalent activity, as did students in Iran and the Russian Federation for memorizing, and students in Iran for reading the textbook. Interestingly, in Norway, 92 percent of the students reported using the laws and formulas of physics to solve problems in half or more of their physics classes, and the next highest was 45 percent for being asked to give explanations. Conducting an experiment or investigation or watching the teacher demonstrate physics on a computer were selected by the smallest proportions of students in every country.

Exhibit 11.14 shows that, according to teachers, most students were asked to use the laws and formulas of physics to solve problems in half or more of their classes, and except in the Netherlands and Slovenia, the majority of students were asked to give explanations about the topic being studied. Also, 60 percent or more were asked to relate physics topics to daily life in half or more of their classes except in Italy, the Netherlands, Norway, and Sweden. While students and teachers essentially were in agreement about the prevalence of solving physics problems and being asked to give explanations as well as a moderate occurrence of experiments (watching and conducting), there was less correspondence in several other areas. For example, teachers in all the participating countries were more likely to report asking students to relate physics lessons to daily life than were the students. In some countries students reported more memorization than teachers, particularly Italy, and in the Russian Federation and Sweden they reported more emphasis on reading the textbook.

Exhibit 11.15 presents information about the use of textbooks in physics classes in the participating countries. Eighty-nine percent of students in every country except Slovenia (62%) were taught by teachers who used one or more textbooks in their teaching, and from 95 to 100 percent of students had their own textbooks in all countries except Lebanon at 84 percent and Slovenia at 76 percent. The table also shows that textbooks were authorized for use in the schools by a national authority in five countries, but this was not the case in the other four.

The rightmost three columns in the table provide teachers' reports about how textbooks were used in physics classrooms. The largest percentages of students were asked to do exercises or problems from their textbooks, but there was variation across countries. At one end of the continuum, 95 to 96 percent of students in Iran and Norway were taught by teachers who had them do problems or exercises from the textbook, and at the other end of the continuum, less than half (46 percent) of the Slovenian students were asked to solve textbook problems. In the remaining participating countries, from 78 to 89 percent of the students were asked to do problems or exercises from their textbooks. The other two alternatives for textbook use, reading

Exhibit 11.15 **Policy and Usage of Textbooks**

TIMSSAdvanced 2008 Physics

Country	Textbooks Certified by National Authority	Percent of Students		Percent of Students Whose Teachers Require Them to Do the Following Activities in Half of the Lessons or More		
		Whose Teachers Use Textbooks for Teaching	Who Have Their Own Textbooks	Do Problems or Exercises from Their Textbooks	Read the Textbook Examples of How to Do Problems or Exercises	Read About Physics Theory from Their Textbooks
Armenia	●	r 89 (0.3)	r 95 (0.1)	r 78 (0.4)	r 70 (1.6)	r 48 (0.8)
Iran, Islamic Rep. of	●	95 (1.9)	99 (0.5)	96 (1.5)	90 (2.9)	82 (3.4)
Italy	○	99 (1.2)	97 (2.0)	82 (4.8)	60 (5.2)	69 (4.1)
Lebanon	●	89 (2.0)	84 (1.7)	89 (1.8)	70 (2.3)	73 (2.3)
Netherlands	○	100 (0.0)	100 (0.0)	89 (3.2)	52 (5.4)	62 (5.1)
Norway	○	100 (0.0)	100 (0.0)	95 (2.2)	54 (4.7)	47 (5.2)
Russian Federation	●	90 (2.8)	96 (1.2)	83 (3.4)	51 (4.3)	56 (4.6)
Slovenia	●	62 (0.2)	76 (0.2)	46 (0.2)	17 (0.2)	29 (0.2)
Sweden	○	100 (0.3)	100 (0.4)	84 (4.5)	31 (3.9)	42 (5.3)

● Yes ○ No

SOURCE: IEA TIMSS Advanced 2008 ©

Data provided by National Research Coordinators and by teachers.

( ) Standard errors appear in parentheses.

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

examples of problem or exercise solutions provided in the textbook and reading about physics theory from the textbook, were required for much smaller percentages of students except in Iran.

The final exhibit in this section, Exhibit 11.16, focuses on the percent of class time allocated by teachers of physics to each of several activities. The activities listed were teaching new material to the whole class, students working on problems or exercises either on their own or with other students, reviewing and summarizing what has been taught for the whole class, reviewing homework, reteaching and clarifying content or procedures for the whole class, oral or written tests or quizzes, classroom management tasks not related to the content or purpose of the lesson, and other activities. In responding to this item, teachers were asked to ensure that the total across all eight categories of activities came to 100 percent.

For students in the participating countries, the first two categories—teaching new material to the class as a whole and students working on their own or with other students—accounted for from 42 to 65 percent of the time in physics classes. The next biggest category was test and quizzes (from 11 to 20 percent of the time), except in the Netherlands, Norway, and Sweden. The three categories of reviewing what had been taught, reviewing homework, and reteaching and clarifying content/procedures each accounted for a range of from 5–6 to 11–13 percent of the time. Very little time was taken up with classroom management tasks, at most 6 percent, and the "other" category also accounted for only a small proportion of time.

Exhibit 11.16 **Teachers' Reports of the Percent of Time in Physics Lessons Spent on Various Activities in a Typical Week**

TIMSSAdvanced 2008 Physics

Country		Teaching New Material to the Whole Class		Students Working on Problems on Their Own or with Other Students		Reviewing and Summarizing What Has Been Taught for the Whole Class		Reviewing Homework
Armenia	r	29 (0.2)	r	19 (0.2)	r	11 (0.3)	r	8 (0.1)
Iran, Islamic Rep. of		40 (1.8)		17 (0.9)		8 (0.6)		8 (0.5)
Italy		30 (1.1)		12 (0.9)		10 (0.4)		10 (0.8)
Lebanon		27 (0.7)		19 (0.6)		11 (0.3)		10 (0.4)
Netherlands		33 (1.7)		28 (1.4)		9 (0.7)		13 (1.3)
Norway		31 (1.4)		34 (1.4)		8 (0.3)		8 (0.8)
Russian Federation		31 (0.9)		24 (0.9)		10 (0.4)		8 (0.3)
Slovenia		46 (0.1)		17 (0.1)		6 (0.0)		5 (0.0)
Sweden		36 (1.6)		25 (1.2)		11 (0.8)		5 (0.5)

Country		Reteaching and Clarifying Content/ Procedures for the Whole Class		Oral or Written Tests or Quizzes		Classroom Management Tasks Not Related to the Lesson's Content/Purpose (e.g., Interruptions and Keeping Order)		Other Activities
Armenia	r	12 (0.3)	r	13 (0.4)	r	5 (0.0)	r	3 (0.1)
Iran, Islamic Rep. of		7 (0.5)		11 (0.7)		5 (0.4)		4 (0.4)
Italy		10 (0.6)		20 (1.0)		3 (0.4)		4 (0.6)
Lebanon		10 (0.3)		12 (0.3)		6 (0.3)		5 (0.2)
Netherlands		8 (0.6)		2 (0.3)		4 (0.5)		5 (0.7)
Norway		6 (0.5)		8 (0.4)		1 (0.2)		4 (0.6)
Russian Federation		9 (0.5)		13 (0.6)		2 (0.3)		3 (0.4)
Slovenia		8 (0.0)		11 (0.0)		3 (0.0)		4 (0.0)
Sweden		9 (0.4)		6 (0.5)		2 (0.5)		5 (1.1)

Data provided by teachers.

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

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

SOURCE: IEA TIMSS Advanced 2008 ©

Technology Use in Physics Classes

Exhibit 11.17 focuses on the extent to which different technologies were used in physics classes in the participating countries. The exhibit is divided into three parts with the first part dealing with calculators, the second with computers, and the third with other computing technology. Students were asked to indicate how frequently each of the three was used: in every or almost every lesson, in about half the lessons, in some lessons, or never. The table shows, for each country and for each frequency-of-usage category, the percent of students who chose that category and the average physics achievement for those students.

There was a considerable range in students' reports about the frequency of using calculators in physics lessons. Ninety-two percent of the Norwegian students and 81 percent of the Dutch students reported that they used calculators in every or almost every lesson, as did about three fourths of the Slovenian and Swedish students. In Italy, Lebanon, and the Russian Federation, most students (68 to 90%) used calculators at least as frequently as in half their lessons. Calculators were used much less frequently in Armenia and Iran, where 16 and 21 percent, respectively, reported that they never used calculators in their physics classes.

Across countries, there was a general pattern for students with higher average achievement to report more calculator usage, although the results across usage categories were inconsistent. In Italy, the Netherlands, Norway, the Russian Federation, and Sweden, where calculators were used by students at least in some lessons, there was a relationship between more frequent use of calculators and higher achievement. In these countries, students reporting calculator use in every lesson had the highest achievement followed by those using calculators in half the lessons, and then, only some lessons.

Exhibit 11.17 **Students' Reports of Frequency of Using Different Technologies in Physics Lessons**

TIMSSAdvanced 2008 Physics

Country		Frequency of Using Calculators							
		Every or Almost Every Lesson		About Half the Lessons		Some Lessons		Never	
		Percent of Students	Average Achievement	Percent of Students	Average Achievement	Percent of Students	Average Achievement	Percent of Students	Average Achievement
Armenia	r	33 (2.2)	504 (7.8)	15 (1.3)	505 (12.5)	36 (2.0)	497 (7.5)	16 (2.0)	457 (12.1)
Iran, Islamic Rep. of		13 (1.1)	409 (8.3)	26 (1.3)	438 (7.8)	40 (1.4)	462 (8.3)	21 (1.6)	515 (10.9)
Italy		43 (2.6)	446 (8.1)	25 (1.7)	423 (10.1)	26 (2.0)	395 (12.9)	6 (1.0)	363 (12.2)
Lebanon		69 (1.3)	445 (3.4)	21 (1.0)	451 (5.7)	9 (0.7)	438 (8.5)	1 (0.3)	~ ~
Netherlands		81 (1.8)	587 (3.6)	14 (1.3)	568 (5.6)	5 (0.8)	566 (10.6)	1 (0.3)	~ ~
Norway		92 (1.0)	538 (4.2)	6 (0.9)	509 (10.3)	2 (0.3)	~ ~	0 (0.2)	~ ~
Russian Federation		62 (2.2)	542 (9.8)	21 (1.3)	511 (11.1)	15 (1.5)	463 (18.3)	2 (0.3)	~ ~
Slovenia		78 (1.1)	537 (2.7)	16 (1.0)	528 (6.9)	5 (0.7)	534 (13.5)	1 (0.3)	~ ~
Sweden		76 (2.5)	500 (5.8)	15 (1.4)	494 (9.8)	8 (1.6)	490 (16.2)	1 (0.2)	~ ~

Country		Frequency of Using Computers							
		Every or Almost Every Lesson		About Half the Lessons		Some Lessons		Never	
		Percent of Students	Average Achievement	Percent of Students	Average Achievement	Percent of Students	Average Achievement	Percent of Students	Average Achievement
Armenia	r	3 (0.7)	458 (22.6)	3 (0.6)	509 (31.1)	17 (2.5)	507 (11.2)	78 (3.0)	489 (6.6)
Iran, Islamic Rep. of		1 (0.2)	~ ~	3 (0.3)	439 (25.0)	12 (1.1)	478 (13.8)	84 (1.2)	459 (6.9)
Italy		2 (0.9)	~ ~	3 (0.7)	431 (28.6)	20 (2.0)	446 (13.3)	75 (2.6)	417 (7.5)
Lebanon		2 (0.3)	~ ~	5 (0.6)	423 (9.9)	25 (1.1)	448 (5.3)	67 (1.4)	447 (3.4)
Netherlands		1 (0.3)	~ ~	3 (0.7)	574 (12.4)	67 (2.0)	583 (3.6)	29 (2.1)	584 (5.7)
Norway		3 (1.1)	525 (14.5)	4 (0.8)	522 (13.7)	41 (4.5)	534 (5.0)	53 (5.0)	538 (4.9)
Russian Federation		3 (0.8)	525 (24.7)	8 (1.1)	537 (16.7)	27 (2.1)	536 (12.0)	62 (3.2)	514 (12.2)
Slovenia		9 (0.9)	536 (9.9)	19 (1.5)	540 (6.2)	49 (1.2)	542 (3.2)	23 (1.0)	516 (3.9)
Sweden		0 (0.2)	~ ~	2 (0.6)	~ ~	40 (4.2)	508 (8.4)	57 (4.4)	491 (6.7)

SOURCE: IEA TIMSS Advanced 2008 ©

Data provided by students.

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

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

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

Exhibit 11.17 **Students' Reports of Frequency of Using Different Technologies in Physics Lessons (Continued)**

TIMSSAdvanced 2008 Physics

Country		Frequency of Using Other Computing Technology							
		Every or Almost Every Lesson		About Half the Lessons		Some Lessons		Never	
		Percent of Students	Average Achievement	Percent of Students	Average Achievement	Percent of Students	Average Achievement	Percent of Students	Average Achievement
Armenia	r	2 (0.6)	~ ~	3 (0.8)	489 (27.1)	15 (1.9)	509 (14.7)	79 (2.1)	490 (6.0)
Iran, Islamic Rep. of		1 (0.2)	~ ~	3 (0.4)	416 (27.3)	12 (1.0)	456 (12.6)	84 (1.1)	463 (6.9)
Italy		2 (0.4)	~ ~	2 (0.6)	~ ~	15 (1.4)	420 (13.8)	82 (1.5)	424 (7.4)
Lebanon		2 (0.4)	~ ~	7 (0.7)	452 (8.7)	37 (1.2)	449 (4.5)	54 (1.5)	446 (4.1)
Netherlands		2 (0.4)	~ ~	5 (0.6)	577 (9.5)	54 (1.7)	582 (3.9)	40 (1.7)	585 (4.9)
Norway		0 (0.2)	~ ~	3 (0.4)	513 (14.0)	49 (3.3)	537 (5.1)	48 (3.4)	535 (5.4)
Russian Federation		5 (0.6)	546 (15.3)	6 (0.7)	535 (12.8)	36 (1.5)	520 (11.1)	53 (1.8)	519 (10.8)
Slovenia		4 (0.6)	528 (14.8)	11 (1.1)	537 (7.1)	54 (1.6)	540 (3.6)	31 (1.4)	528 (4.2)
Sweden		– –	– –	– –	– –	– –	– –	– –	– –

SOURCE: IEA TIMSS Advanced 2008 ©

Data provided by students.

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

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

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

The second part of Exhibit 11.17 deals with computer use in physics classes, and the results show that computer use remains far from common in these countries. A majority of students from every participating country except the Netherlands and Slovenia said that computers were never used in their physics classes. And at least 89 percent of students from every country except Slovenia reported that computers were used in less than half of their physics classes. Even for the usage categories with sufficient percentages of students, most of the between-group differences in average scale score did not consistently favor one group over the others.

The third part of Exhibit 11.17 concerns what was called "other computing technology" in the student questionnaire, and that term might not have been familiar to many students. The data show that such technologies are not in widespread use. Most students in Armenia, Iran, and Italy (79 to 84%) reported never using such technology. However, approximately half to two thirds of students in the other countries said that other computing technology was used in at least some lessons in their physics classes.

Students were also asked to indicate what type of calculator they usually used, if they did use a calculator in their physics class. Four types of calculators were listed and accompanied by brief descriptions, as follows:

- Simple calculator – basic functions only (+, –, ×, ÷, %, or √), without functions like log, sin, cos
- Scientific calculator – basic functions (+, –, ×, ÷, %, or √), and also functions like log, sin, cos
- Graphing calculator – scientific and also able to display some graphs
- Symbolic calculator – graphing and also able to solve expressions in symbolic terms

Exhibit 11.18 presents the percentage of students in each country who reported using each type of calculator. As discussed under 11.17 and reproduced here for reference (in the last data column), Armenia and Iran were the only two countries in which appreciable percentages of students reported that they never used calculators in physics classes. In these two countries, about half the students reported using simple calculators and about one fourth scientific calculators. In the Russian Federation, it was relatively equal—43 percent simple calculators and 53 percent scientific calculators. Nearly all students in Italy, Lebanon, and Slovenia reported using scientific calculators. In the Netherlands, Norway, and Sweden, most students used graphing calculators, but 16 percent in Norway and 10 percent in Sweden also reported using symbolic calculators.

Teachers were also asked about the kinds of calculators their students used during physics classes, and their responses are presented in Exhibit 11.19. On the whole, teachers' responses about calculator use in their classes coincided with those of their students; however, there were some differences, most no doubt stemming from a difference of opinion about what constituted, for example, a symbolic calculator as opposed to a graphing calculator.

Exhibit 11.20 presents data from teachers about the kinds of situations in which students were most likely to use calculators or computers in their physics classes. The data are presented in terms of the percentage of students taught by teachers who estimated that their students used calculators in a given situation in half of the lessons or more. The given situations were doing scientific procedures or experiments, modeling and simulations, solving equations, and processing and analyzing data.

According to their teachers, in general, a significant percentage of students used calculators in about half the lessons or more for each of

Exhibit 11.18 **Students' Reports on Types of Calculators Used During Physics Lessons**

TIMSSAdvanced 2008 Physics

Country		Percent of Students Using				Percent of Students Who Never Used a Calculator
		Simple Calculator	Scientific Calculator	Graphing Calculator	Symbolic Calculator	
Armenia	r	58 (2.5)	22 (1.9)	2 (0.7)	2 (0.4)	16 (2.0)
Iran, Islamic Rep. of		49 (1.6)	28 (1.5)	1 (0.2)	1 (0.2)	21 (1.6)
Italy		2 (0.5)	89 (1.3)	1 (0.3)	1 (0.3)	6 (1.0)
Lebanon		4 (0.6)	91 (0.9)	2 (0.5)	1 (0.3)	1 (0.3)
Netherlands		1 (0.3)	8 (0.8)	87 (0.9)	3 (0.5)	1 (0.3)
Norway		1 (0.2)	7 (1.0)	76 (2.1)	16 (1.8)	0 (0.2)
Russian Federation		43 (2.4)	53 (2.4)	1 (0.3)	1 (0.2)	2 (0.3)
Slovenia		4 (0.5)	93 (0.9)	1 (0.3)	1 (0.4)	1 (0.3)
Sweden		1 (0.2)	2 (0.4)	87 (1.1)	10 (1.0)	1 (0.2)

SOURCE: IEA TIMSS Advanced 2008 ©

Data provided by students.

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

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

Exhibit 11.19 **Teachers' Reports on the Types of Calculators Used by Students in the TIMSS Class During Physics Lessons**

TIMSSAdvanced 2008 Physics

Country		Percent of Students Using				Percent of Students Who Never Used a Calculator
		Simple Calculator	Scientific Calculator	Graphing Calculator	Symbolic Calculator	
Armenia	r	74 (1.4)	24 (1.4)	0 (0.0)	0 (0.0)	2 (0.0)
Iran, Islamic Rep. of		36 (3.6)	50 (4.5)	0 (0.0)	0 (0.0)	13 (2.8)
Italy		1 (0.1)	97 (1.5)	2 (1.1)	0 (0.0)	0 (0.0)
Lebanon		8 (1.3)	84 (1.6)	8 (0.8)	0 (0.1)	0 (0.0)
Netherlands		0 (0.0)	2 (1.4)	90 (3.1)	8 (2.8)	0 (0.0)
Norway		0 (0.0)	0 (0.0)	91 (3.2)	8 (3.1)	1 (0.0)
Russian Federation		35 (3.8)	65 (3.8)	0 (0.0)	0 (0.0)	0 (0.0)
Slovenia		6 (0.2)	94 (0.2)	0 (0.0)	0 (0.0)	0 (0.0)
Sweden		0 (0.0)	5 (2.2)	93 (2.7)	2 (1.5)	0 (0.0)

SOURCE: IEA TIMSS Advanced 2008 ©

Data provided by teachers.

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

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

Exhibit 11.20 **Teachers' Reports on Calculator or Computer Usage in Physics Class**

TIMSSAdvanced 2008 Physics

Country	Percent of Students Whose Teachers Reported on Calculator or Computer Usage in About Half of the Lessons or More			
	Doing Scientific Procedures or Experiments	Modeling and Simulations	Solving Equations	Processing and Analyzing Data
Armenia	r 7 (0.4)	r 16 (1.5)	r 17 (0.5)	r 13 (1.4)
Iran, Islamic Rep. of	26 (3.8)	4 (1.9)	37 (3.9)	15 (2.8)
Italy	20 (3.8)	7 (2.2)	40 (5.4)	41 (5.5)
Lebanon	r 25 (2.2)	r 12 (1.5)	r 50 (2.7)	r 33 (2.3)
Netherlands	31 (3.5)	21 (3.9)	50 (5.2)	34 (4.0)
Norway	25 (4.5)	14 (4.5)	64 (3.8)	32 (4.7)
Russian Federation	46 (4.5)	19 (4.0)	65 (4.1)	69 (4.1)
Slovenia	37 (0.2)	18 (0.2)	56 (0.3)	22 (0.3)
Sweden	65 (4.5)	10 (2.4)	47 (4.7)	32 (4.3)

SOURCE: IEA TIMSS Advanced 2008 ©

Data provided by teachers.
( ) Standard errors appear in parentheses.

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

the four purposes, although Armenia reported less use across categories than the other countries. In general, calculators were reported to be used most heavily for solving equations. However, they also were used relatively frequently for processing and analyzing data and for doing scientific procedures or experiments. The least supported category across countries was using calculators for modeling and simulation.

The last page of each TIMSS Advanced 2008 physics test booklet asked students to indicate whether or not they had used a calculator during the test, what type and brand of calculator they had used, and how extensively they had made use of it. They were given three choices for the last item: very little (for fewer than 5 questions), somewhat (for between 5 and 10 questions), and quite a lot (for more than 10 questions). The results are displayed in Exhibit 11.21, together with trend data on changes between the two cycles of TIMSS Advanced for the four countries that participated in both 1995 and 2008: Norway, the Russian Federation, Slovenia, and Sweden.

Relatively few students reported using their calculator on more than 10 questions on the TIMSS Advanced 2008 physics test. As might be anticipated based on the heavy use of calculators in their instruction, the most use of calculators on the TIMSS Advanced 2008 physics test was reported by students in the Netherlands; in addition to 8 percent reporting a lot of use, 43 percent said somewhat and another 47 percent a little. Next, 7 percent of Slovenian students reported a lot of use, 38 percent somewhat, and 48 a little. While only 3 percent of Norwegian students reported a lot of use, 29 reported some use and 60 percent little use. Swedish students also made moderate use of the calculator (3% a lot, 23% somewhat, and 61% a little). In contrast, about half the Armenian and Iranian students reported they did not use their calculators on the test at all as did about one fourth of the Russian students.

Exhibit 11.21 **Trends in Student's Reports of Calculator Use During the TIMSS Physics Test**

TIMSSAdvanced 2008 Physics

Country	Used Calculator Quite a Lot (More than 10 Questions)				Used Calculator Somewhat (5–10 Questions)			
	2008 Percent of Students	1995 Percentof Students	2008 Average Achievement	1995 Average Achievement	2008 Percent of Students	1995 Percentof Students	2008 Average Achievement	1995 Average Achievement
Armenia s	4 (0.8)	◊ ◊	497 (33.7)	◊ ◊	12 (1.1)	◊ ◊	564 (8.9)	◊ ◊
Iran, Islamic Rep. of	1 (0.2)	◊ ◊	~ ~	◊ ◊	5 (0.7)	◊ ◊	454 (12.8)	◊ ◊
Italy	2 (0.4)	◊ ◊	~ ~	◊ ◊	20 (2.1)	◊ ◊	453 (9.2)	◊ ◊
Lebanon	2 (0.4)	◊ ◊	~ ~	◊ ◊	20 (1.0)	◊ ◊	459 (6.4)	◊ ◊
Netherlands	8 (0.7)	◊ ◊	586 (6.2)	◊ ◊	43 (1.3)	◊ ◊	584 (3.6)	◊ ◊
Norway	3 (0.4)	3 (0.6)	564 (13.2) ▼	610 (11.4)	29 (1.3) ▼	37 (1.8)	549 (4.8) ▼	592 (5.1)
Russian Federation	2 (0.3)	1 (0.4)	~ ~	~ ~	19 (1.1) ▲	14 (1.3)	544 (9.9)	564 (13.8)
Slovenia	7 (0.7) ▲	2 (1.0)	565 (7.1)	~ ~	38 (1.4) ▲	16 (1.5)	552 (3.8)	560 (16.2)
Sweden	3 (0.4) ▼	5 (0.7)	510 (15.3) ▼	600 (19.8)	23 (1.4) ▼	38 (2.5)	530 (5.4) ▼	588 (5.0)

Country	Used Calculator Very Little (Less than 5 Questions)				Did Not Use a Calculator			
	2008 Percent of Students	1995 Percentof Students	2008 Average Achievement	1995 Average Achievement	2008 Percent of Students	1995 Percentof Students	2008 Average Achievement	1995 Average Achievement
Armenia s	28 (2.0)	◊ ◊	523 (8.6)	◊ ◊	56 (1.9)	◊ ◊	467 (8.0)	◊ ◊
Iran, Islamic Rep. of	44 (1.9)	◊ ◊	472 (8.5)	◊ ◊	51 (2.2)	◊ ◊	453 (9.2)	◊ ◊
Italy	50 (2.4)	◊ ◊	425 (9.7)	◊ ◊	28 (2.6)	◊ ◊	390 (10.3)	◊ ◊
Lebanon	64 (1.3)	◊ ◊	452 (4.2)	◊ ◊	14 (1.1)	◊ ◊	401 (6.0)	◊ ◊
Netherlands	47 (1.4)	◊ ◊	586 (3.4)	◊ ◊	3 (0.5)	◊ ◊	557 (12.7)	◊ ◊
Norway	60 (1.2) ▲	56 (1.8)	533 (4.5) ▼	575 (6.3)	7 (0.7) ▲	4 (0.8)	468 (9.6) ▼	570 (12.3)
Russian Federation	52 (1.2)	49 (2.2)	536 (10.6)	553 (9.0)	27 (1.8) ▼	36 (2.8)	472 (14.5) ▼	543 (13.9)
Slovenia	48 (1.6) ▼	65 (2.4)	525 (3.5)	539 (13.6)	7 (0.7) ▼	17 (2.2)	485 (9.5)	494 (17.3)
Sweden	61 (1.3) ▲	53 (2.6)	498 (5.0) ▼	570 (4.8)	13 (1.0) ▲	3 (0.6)	436 (11.1) ▼	558 (15.2)

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

Data provided by students.

Depending on the booklet assigned, students responded to 25–29 physics items. Items were designed to be answered without a calculator, and students were asked to show their work for constructed-response items. However, about 3–5 items could be answered using a graphing or symbolic calculator.

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

A diamond (◊) indicates the country did not participate in the 1995 assessment.

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

An "s" indicates data are available for at least 50% but less than 70% of the students.

SOURCE: IEA TIMSS Advanced 2008 ©

In the four countries that participated in both cycles of the study—Norway, the Russian Federation, Slovenia, and Sweden—the trend data for the proportions of students using calculators in 2008 compared to 1995 showed increases in Slovenia and the Russian Federation, and decreases in Norway and Sweden. In Slovenia, the percentages increased for the "a lot" and "somewhat" categories and decreased for the "little" and "did not use" categories. In the Russian Federation, there was no change in the "a lot" category, but an increase in "somewhat" category was accompanied by a decrease in the "did not use" category. In Sweden, the percentages in the "a lot" and "somewhat" categories decreased, while they increased in the "little" and "did not use" categories. In Norway, there was no change in the "a lot" category, but a decrease in the "somewhat" category was accompanied by increases in the "little" and "did no use" categories. The students' average achievement associated with the usage categories basically reflects students' overall patterns and changes between the two assessment cycles.

The Role of Homework in Physics Instruction

Exhibit 11.22 contains teachers' reports about their emphasis on homework. For the Index of Teachers' Emphasis on Physics Homework, students in the high category had teachers who reported giving relatively long homework assignments (more than 30 minutes) on a relatively frequent basis (in about half the lessons or more). Students in the low category had teachers who gave short assignments (less than 30 minutes) relatively infrequently (in about half the lessons or less). The medium level includes all other possible combinations of teachers' responses. The exhibit shows, for each country, the percentage of students in each category together with their average TIMSS Advanced 2008 physics scale score. The countries are listed in descending order of the proportion of students in the high category.

Exhibit 11.22 **Index of Teachers' Emphasis on Physics Homework (EPH)**

TIMSSAdvanced 2008 Physics

Country		High EPH		Medium EPH		Low EPH	
		Percent of Students	Average Achievement	Percent of Students	Average Achievement	Percent of Students	Average Achievement
Lebanon		86 (1.4)	444 (3.1)	10 (1.3)	432 (11.3)	3 (0.3)	439 (10.8)
Russian Federation		83 (3.2)	535 (11.1)	14 (3.2)	442 (15.9)	2 (1.2)	~ ~
Norway		77 (4.2)	531 (5.1)	14 (4.2)	548 (8.4)	9 (3.3)	533 (10.8)
Armenia	r	72 (0.7)	507 (7.8)	22 (0.4)	476 (9.3)	6 (0.8)	445 (7.9)
Iran, Islamic Rep. of		71 (3.5)	461 (8.1)	16 (3.0)	449 (19.8)	13 (3.0)	456 (18.0)
Italy		67 (5.7)	437 (8.4)	22 (4.9)	371 (14.5)	12 (4.0)	448 (34.5)
Netherlands		47 (5.8)	584 (6.2)	29 (4.9)	590 (5.5)	25 (4.6)	573 (5.7)
Sweden		34 (4.0)	505 (7.6)	33 (4.7)	491 (10.3)	33 (5.0)	493 (7.3)
Slovenia		15 (0.2)	551 (4.3)	39 (0.2)	541 (2.5)	47 (0.3)	524 (3.0)

SOURCE: IEA TIMSS Advanced 2008 ©

Based on teachers' responses to three questions about whether they assign physics homework, how often they usually assign physics homework and how many minutes of physics homework they usually assign. Students in the high category were assigned more than 30 minutes of homework about half of the lessons or more, and those in low category were assigned less than 30 minutes of homework about half of the lessons or less. The medium category includes all other possible combinations of responses.

( ) 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.

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

From 83 to 86 percent of students in Lebanon and the Russian Federation were in the high category, closely followed by Norway at 77 percent. At the other extreme, nearly half the students in Slovenia and a third in Sweden had teachers who assigned very little, if any homework (i.e., they assigned 30 minutes or less of homework in no more than half their lessons). The Netherlands had 25 percent of its students in this category. Teachers in the other countries responded such that 85 percent of more of their students were in either the high or medium group. Armenia and Slovenia were the only countries that showed a consistent relationship between more time on homework and higher achievement results.

Teachers were also asked about how frequently they included, as part of a physics homework assignment for their students, each of five activities: doing problem/question sets; reading the textbook; memorizing formulas and procedures; gathering, analyzing, and reporting data; finding one or more applications of the content covered; and working on projects. The results are presented in Exhibit 11.23 in terms of the percentage of students in each country whose teachers indicated that they assigned a particular activity *always or almost always, sometimes*, or *never* or *almost never*.

The most popular kind of homework assignment in every one of these countries included "doing problem/question sets." Virtually 100 percent of the students in every country were asked to complete such an assignment for homework at least sometimes, and about three fourths were asked to do so always or almost always. In Slovenia, for example, this homework activity was assigned always or almost always to 95 percent of the students and the other types of homework were assigned always or almost always to only to 2 to 4 percent of the students. In some countries, however, reading from the textbook and memorizing formulas and procedures were assigned very frequently

Exhibit 11.23 **Teachers' Reports on the Kinds of Physics Homework Assigned to the TIMSS Advanced Physics Class**

TIMSSAdvanced 2008 Physics

Country	Percent of Students by Types of Homework Assigned by Their Teachers								
	Doing Problem/Question Sets			Reading the Textbook			Memorizing Formulas and Procedures		
	Always or Almost Always	Sometimes	Never or Almost Never	Always or Almost Always	Sometimes	Never or Almost Never	Always or Almost Always	Sometimes	Never or Almost Never
Armenia	r 86 (0.3)	14 (0.3)	0 (0.0)	r 78 (0.7)	22 (0.7)	0 (0.0)	r 81 (0.5)	19 (0.5)	0 (0.0)
Iran, Islamic Rep. of	72 (4.0)	28 (4.0)	0 (0.0)	66 (3.9)	32 (3.9)	1 (1.4)	36 (4.6)	46 (4.6)	18 (3.6)
Italy	76 (5.2)	23 (5.1)	1 (0.9)	71 (5.1)	26 (5.1)	3 (1.8)	6 (2.4)	41 (5.7)	53 (6.0)
Lebanon	83 (2.1)	17 (2.1)	0 (0.0)	42 (2.4)	51 (2.4)	7 (1.5)	45 (2.6)	43 (2.5)	12 (1.5)
Netherlands	94 (2.9)	6 (2.9)	0 (0.0)	50 (7.2)	39 (6.5)	11 (4.0)	3 (2.2)	33 (5.4)	64 (5.8)
Norway	82 (3.8)	18 (3.8)	0 (0.0)	42 (4.9)	38 (4.6)	20 (4.6)	3 (2.0)	43 (4.6)	54 (5.2)
Russian Federation	94 (1.8)	6 (1.8)	0 (0.0)	76 (3.8)	24 (3.7)	1 (0.0)	57 (4.3)	40 (4.3)	3 (1.0)
Slovenia	95 (0.0)	5 (0.0)	0 (0.0)	2 (0.1)	55 (0.2)	44 (0.2)	2 (0.1)	9 (0.1)	89 (0.2)
Sweden	73 (5.3)	27 (5.3)	0 (0.0)	53 (7.1)	37 (6.6)	10 (3.8)	0 (0.3)	23 (5.8)	77 (5.8)

Country	Percent of Students by Types of Homework Assigned by Their Teachers								
	Gathering, Analyzing, and Reporting Data			Finding One or More Applications of the Content Covered			Working on Projects		
	Always or Almost Always	Sometimes	Never or Almost Never	Always or Almost Always	Sometimes	Never or Almost Never	Always or Almost Always	Sometimes	Never or Almost Never
Armenia	r 36 (1.3)	61 (1.4)	3 (0.1)	r 47 (0.8)	44 (0.6)	10 (0.2)	r 13 (0.8)	54 (2.2)	33 (2.2)
Iran, Islamic Rep. of	22 (4.0)	63 (4.8)	15 (3.5)	12 (2.9)	66 (4.2)	22 (3.8)	3 (1.8)	46 (4.7)	51 (4.5)
Italy	6 (2.3)	61 (5.9)	34 (5.7)	12 (3.7)	58 (6.0)	29 (6.1)	1 (0.1)	30 (5.0)	69 (5.1)
Lebanon	26 (2.0)	62 (2.3)	12 (1.6)	18 (2.0)	66 (2.5)	16 (2.0)	5 (1.4)	51 (2.4)	44 (2.4)
Netherlands	1 (1.1)	50 (6.0)	49 (6.1)	0 (0.0)	23 (4.5)	77 (4.5)	4 (1.8)	40 (6.0)	57 (6.1)
Norway	1 (0.9)	43 (5.1)	56 (4.9)	0 (0.0)	29 (4.0)	71 (4.0)	0 (0.0)	27 (4.5)	73 (4.5)
Russian Federation	12 (2.8)	81 (3.3)	7 (1.9)	27 (3.6)	69 (4.0)	4 (2.2)	2 (1.4)	68 (4.4)	29 (4.2)
Slovenia	4 (0.1)	68 (0.2)	28 (0.2)	2 (0.1)	53 (0.2)	45 (0.2)	2 (0.1)	39 (0.2)	59 (0.2)
Sweden	0 (0.0)	38 (6.1)	62 (6.1)	0 (0.0)	38 (6.4)	62 (6.4)	0 (0.0)	33 (5.5)	67 (5.6)

Data provided by teachers.

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

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

SOURCE: IEA TIMSS Advanced 2008 ©

to the majority of students. Assigning data analysis for homework or finding applications of recently covered content was highly variable—assigned to very few (0–6%) students up to as many as one third of the students depending on the country. Working on projects was rarely assigned in any country.

Students were asked about how much homework they did, and how frequently that homework involved three of the five activities that teachers had also been asked about: doing problem/question sets, reading the textbook, and memorizing formulas and procedures. Their responses are summarized in Exhibit 11.24. For each country, the exhibit indicates the average number of hours per week that the students spent on physics homework as well as the percentage of students who reported that they "always or almost always", "sometimes", or "never or almost never" had homework that involved each of those activities.

Students' reports tended to correspond with the reports of their teachers—that is, students appeared to be doing the assigned homework. Students in the Netherlands, Norway, Slovenia, and Sweden recorded the lowest average number of hours per week spent on physics homework: 1.6 hours or less in total. Students in Iran and Lebanon reported spending considerably more time on physics homework (at least 4 hours a week). Students in the Russian Federation also reported relatively heavy homework schedules (3.3 hours a week). Students agreed with their teachers about having to do problem/question sets for their physics homework "sometimes" or "always or almost always". The lowest levels of homework activity were reported for reading the textbook in Slovenia and for memorizing formulas and procedures in the Netherlands, Norway, and Slovenia. Apart from these exceptions, a majority of students in every country reported that their physics homework included one or more of these three activities at least sometimes.

Exhibit 11.24 **Students' Reports on the Time Spent Doing Various Kinds of Physics Homework**

TIMSSAdvanced 2008 Physics

Country	Average Hours per Week Spent Doing Physics Homework	Percent of Students Doing Various Activities for Physics Homework								
		Problem/Question Sets			Read the Textbook			Memorize Formulas and Procedures		
		Always or Almost Always	Sometimes	Never or Almost Never	Always or Almost Always	Sometimes	Never or Almost Never	Always or Almost Always	Sometimes	Never or Almost Never
Armenia	r 2.5 (0.15)	r 42 (3.0)	50 (2.8)	8 (1.1)	r 54 (3.2)	41 (2.7)	5 (1.2)	r 37 (2.5)	54 (2.1)	8 (1.0)
Iran, Islamic Rep. of	4.5 (0.09)	48 (1.5)	49 (1.5)	3 (0.4)	52 (1.7)	42 (1.6)	6 (0.7)	57 (1.4)	39 (1.3)	4 (0.5)
Italy	2.1 (0.07)	38 (2.8)	49 (2.1)	13 (1.6)	48 (2.8)	40 (2.1)	12 (1.4)	51 (2.3)	40 (1.9)	8 (1.1)
Lebanon	4.1 (0.10)	53 (1.6)	44 (1.6)	3 (0.4)	30 (1.4)	58 (1.5)	12 (0.8)	49 (1.6)	41 (1.4)	10 (1.0)
Netherlands	1.0 (0.03)	60 (2.1)	32 (1.7)	8 (1.1)	29 (1.6)	59 (1.1)	12 (1.3)	r 5 (0.6)	39 (1.6)	56 (1.6)
Norway	1.6 (0.06)	82 (1.2)	16 (1.2)	2 (0.3)	46 (2.1)	46 (1.5)	7 (1.4)	5 (0.5)	44 (1.6)	51 (1.7)
Russian Federation	3.3 (0.09)	74 (1.8)	25 (1.7)	1 (0.2)	57 (2.2)	38 (2.0)	5 (0.7)	70 (1.5)	27 (1.3)	3 (0.5)
Slovenia	r 0.7 (0.03)	44 (1.5)	50 (1.6)	6 (0.6)	r 2 (0.5)	29 (1.8)	69 (1.7)	r 4 (0.6)	28 (1.9)	68 (1.9)
Sweden	r 1.0 (0.04)	72 (2.1)	25 (1.9)	3 (0.4)	49 (2.1)	45 (1.8)	7 (0.8)	r 11 (1.0)	44 (1.7)	45 (1.9)

Background data provided by students.

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

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

SOURCE: IEA TIMSS Advanced 2008 ©

Types of Assessments Used in Physics Classes

This section concerns the assessment practices used by teachers of physics in the participating countries to monitor their students' progress. Teachers were asked about the degree of emphasis they assigned to each of three possible data sources: classroom tests (e.g., teacher-made or textbook tests), informal assessment, and other tests. For each source, teachers indicated whether it was given major emphasis, some emphasis, or little or no emphasis. Results are presented in Exhibit 11.25 in terms of the percentage of students who were taught by teachers who reported that a given data source was accorded major, some, or little emphasis in their evaluation procedures.

Teachers in all these countries indicated that they placed more emphasis on classroom tests (e.g., teacher-made or textbook tests) as sources of data on student progress than on either of the two other alternatives. More than 90 percent of students in every one of these countries except Armenia (77%) were taught by teachers who indicated that they placed either major or some emphasis on such tests. The two other forms of assessment—informal assessment and other tests—were used by many teachers, but less emphasis was given to them. In most participating countries, significant proportions of students were taught by teachers who gave little or no emphasis to either of these alternatives.

Exhibit 11.26 provides information about how often teachers administered tests or examinations to their TIMSS Advanced 2008 physics classes. Teachers were asked to select one of four alternatives: at least once a month, about every other month, about 2 or 3 times a year, and never. For each of these four groups, the results in Exhibit 11.26 show the percentage of students taught by teachers in that category and the average physics achievement for those students.

All students of physics in these countries were taught by teachers who gave tests or examinations at least several times during the year.

Exhibit 11.25 **Teachers' Emphasis on Sources to Monitor Students' Progress in Physics**

TIMSSAdvanced 2008 Physics

Country	Percent of Students by Their Teachers' Emphasis on Various Sources to Monitor Students' Progress								
	Classroom Tests (e.g., Teacher-made or Textbook Tests)			Informal Assessment			Other Tests		
	Major Emphasis	Some Emphasis	Little or No Emphasis	Major Emphasis	Some Emphasis	Little or No Emphasis	Major Emphasis	Some Emphasis	Little or No Emphasis
Armenia	29 (0.5)	49 (0.7)	23 (0.6)	8 (0.2)	50 (0.7)	42 (0.8)	r 5 (0.1)	43 (0.6)	51 (0.6)
Iran, Islamic Rep. of	74 (4.0)	24 (4.1)	3 (1.5)	8 (2.6)	58 (4.5)	33 (4.6)	18 (3.1)	36 (3.6)	46 (3.7)
Italy	63 (5.3)	37 (5.3)	0 (0.0)	14 (3.8)	67 (5.3)	19 (4.0)	16 (4.1)	56 (5.1)	28 (4.6)
Lebanon	68 (2.3)	22 (2.0)	9 (1.4)	29 (2.5)	40 (2.4)	31 (2.5)	r 19 (2.1)	39 (2.5)	42 (2.8)
Netherlands	96 (2.3)	4 (2.3)	0 (0.0)	7 (2.6)	21 (4.6)	72 (4.7)	– –	– –	– –
Norway	96 (2.1)	4 (2.1)	0 (0.0)	7 (2.5)	54 (5.3)	39 (5.3)	– –	– –	– –
Russian Federation	87 (3.1)	12 (2.9)	1 (0.8)	14 (3.1)	57 (4.4)	29 (3.3)	7 (2.2)	53 (5.1)	40 (4.8)
Slovenia	71 (0.2)	26 (0.2)	3 (0.1)	28 (0.3)	48 (0.2)	24 (0.2)	19 (0.2)	39 (0.2)	42 (0.3)
Sweden	74 (4.2)	25 (4.1)	1 (0.9)	15 (3.6)	70 (4.5)	14 (3.2)	54 (5.4)	29 (4.6)	18 (3.4)

SOURCE: IEA TIMSS Advanced 2008 ©

Data provided by teachers.

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

A dash (–) indicates comparable data are not available.

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

Exhibit 11.26 **Frequency of Physics Tests**

TIMSSAdvanced 2008 Physics

Country	Percent of Students Whose Teachers Give a Physics Test or Examination							
	At Least Once a Month		About Every Other Month		About 2 or 3 Times a Year		Never	
	Percent of Students	Average Achievement	Percent of Students	Average Achievement	Percent of Students	Average Achievement	Percent of Students	Average Achievement
Armenia	s 40 (0.8)	493 (13.8)	s 52 (0.7)	513 (6.1)	s 8 (0.1)	464 (18.2)	s 0 (0.0)	~ ~
Iran, Islamic Rep. of	57 (4.2)	466 (10.8)	27 (3.7)	446 (11.9)	16 (3.1)	465 (18.6)	0 (0.0)	~ ~
Italy	54 (5.7)	424 (11.2)	27 (4.8)	442 (16.7)	19 (4.9)	394 (13.3)	0 (0.0)	~ ~
Lebanon	87 (1.5)	443 (3.2)	9 (1.2)	458 (10.5)	3 (0.8)	413 (21.8)	1 (0.0)	~ ~
Netherlands	7 (2.4)	597 (10.8)	65 (5.3)	581 (4.9)	27 (5.0)	583 (5.8)	0 (0.0)	~ ~
Norway	35 (5.5)	538 (7.0)	63 (5.3)	531 (4.4)	2 (1.7)	~ ~	0 (0.0)	~ ~
Russian Federation	92 (2.1)	522 (10.7)	8 (2.1)	515 (32.8)	0 (0.0)	~ ~	0 (0.0)	~ ~
Slovenia	10 (0.2)	562 (4.3)	59 (0.2)	539 (2.6)	30 (0.2)	518 (3.3)	0 (0.0)	~ ~
Sweden	5 (2.3)	437 (21.4)	68 (4.9)	498 (6.0)	28 (4.8)	506 (9.1)	0 (0.0)	~ ~

SOURCE: IEA TIMSS Advanced 2008 ©

Data provided by teachers.

( ) 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.

An "s" indicates data are available for at least 50% but less than 70% of the students.

The most frequent testing was reported in Lebanon and the Russian Federation, where 87 to 92 percent of students were tested at least monthly. About half the students (54 to 57%) were tested this frequently in Iran and Italy as were a third of the students in Norway. From 27 to 30 percent of the students were tested only 2 or 3 times a year in the Netherlands, Slovenia, and Sweden. Generally speaking, the direction of the achievement differences in a given country across the four groups of students did not favor one group over the others in a consistent fashion.

Exhibit 11.27 provides information about the item formats physics students in these countries were most likely to see on tests and examinations. Teachers were asked to report whether the tests and examinations they administered to their students consisted of constructed-response items only, mostly constructed-response items, about half constructed-response and half objective items, mostly objective items, or only objective items. For each of these five groups, the results in Exhibit 11.27 show the percentages of students whose teachers used the various formats and the average achievement of those students.

There was substantial variation across countries in approaches to testing. In the Netherlands, 78 percent of students were taught by teachers whose tests consisted exclusively of constructed-response items, by far the largest percentage. Italy and Sweden also reported extensive use of constructed-response items, but exclusively for only 26 to 29 percent of the students. In Armenia (23%), Lebanon (46%), and Norway (25%), considerable percentages of students were taught by teachers whose tests consisted mainly or entirely of objective items (e.g., multiple-choice items). In the other countries, 9 percent or less of students were in that category. Once again, between-group, within-country differences in achievement did not favor one group over the others in a consistent fashion.

Exhibit 11.27 **Formats of Questions Used by Teachers in Physics Tests or Examinations**

TIMSSAdvanced 2008 Physics

Country	Only Constructed-response		Mostly Constructed-response		About Half Constructed-response and Half Objective (e.g., Multiple-choice)		Mostly Objective		Only Objective	
	Percent of Students	Average Achievement	Percent of Students	Average Achievement	Percent of Students	Average Achievement	Percent of Students	Average Achievement	Percent of Students	Average Achievement
Armenia	14 (0.2)	460 (13.6)	5 (0.7)	481 (63.8)	58 (0.7)	512 (5.6)	12 (0.6)	501 (9.0)	11 (0.5)	464 (11.1)
Iran, Islamic Rep. of	8 (2.4)	456 (17.5)	31 (4.3)	428 (9.7)	52 (4.2)	468 (10.5)	8 (2.3)	540 (23.0)	1 (0.7)	~ ~
Italy	26 (5.2)	418 (20.0)	43 (6.2)	422 (11.6)	22 (4.7)	424 (13.9)	8 (2.3)	456 (30.3)	0 (0.0)	~ ~
Lebanon	r 8 (1.6)	472 (11.2)	r 29 (2.4)	444 (7.3)	r 17 (2.8)	440 (9.3)	r 38 (2.6)	444 (6.3)	r 8 (1.4)	452 (13.2)
Netherlands	78 (5.0)	585 (4.0)	19 (4.8)	575 (10.6)	0 (0.0)	~ ~	3 (1.8)	568 (10.4)	0 (0.0)	~ ~
Norway	11 (2.6)	538 (13.8)	34 (4.9)	539 (6.4)	30 (4.8)	535 (5.8)	25 (5.6)	529 (8.7)	0 (0.0)	~ ~
Russian Federation	13 (3.1)	563 (22.8)	27 (4.1)	486 (22.0)	60 (4.9)	529 (10.9)	1 (0.6)	~ ~	0 (0.0)	~ ~
Slovenia	9 (0.1)	554 (3.8)	21 (0.2)	543 (4.7)	67 (0.2)	529 (2.1)	3 (0.0)	552 (13.5)	0 (0.0)	~ ~
Sweden	29 (4.3)	498 (9.0)	64 (5.2)	496 (7.7)	7 (2.6)	516 (14.7)	0 (0.0)	~ ~	0 (0.0)	~ ~

SOURCE: IEA TIMSS Advanced 2008 ©

Data provided by teachers.

( ) 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.

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

The focus of Exhibit 11.28 is the level of cognitive demand teachers emphasized in the physics tests they administered to their TIMSS Advanced 2008 students. Teachers were asked to indicate the frequency (always or almost always, sometimes, never or almost never) with which they included items requiring each of four levels of cognitive demand (knowing facts and concepts, application of knowledge and understanding, developing hypotheses and designing scientific investigations, and explanations or justifications) on their tests. For each of these four cognitive-demand categories, the results in Exhibit 11.28 show the percentage of students who were taught by teachers in that category.

In Iran, Italy, and Sweden, about three fourth of students (72 to 76%) were always or almost always asked questions based on knowing facts and concepts as were about two thirds of the students in the Russian Federation. In the rest of the countries except the Netherlands (65%), over 90 percent were taught by teachers who said that the tests they administered to their physics students at least sometimes included items based on knowing facts and concepts. Nearly all students (from 98 to 100%) in every country were taught by teachers who at least sometimes included items based on the application of knowledge and understanding on their tests, and nearly all (except for 12 to 14 percent in the Netherlands and Slovenia) were taught by teachers whose tests at least sometimes included items requiring students to explain or justify their responses. The smallest percentages of students were asked questions involving hypotheses and investigations, but taken as a whole, the results indicate that the tests and examinations physics students are administered in these countries typically contain items requiring all four levels of cognitive demand.

Exhibit 11.28 **Types of Questions in Physics Tests**

TIMSSAdvanced 2008 Physics

Country	Percent of Students by Types of Questions Teachers Include in Their Physics Tests								
	Questions Based on Knowing Facts and Concepts			Questions Based on the Application of Knowledge and Understanding			Questions Involving Developing Hypotheses and Designing Scientific Investigations		
	Always or Almost Always	Sometimes	Never or Almost Never	Always or Almost Always	Sometimes	Never or Almost Never	Always or Almost Always	Sometimes	Never or Almost Never
Armenia	r 46 (0.7)	54 (0.7)	0 (0.0)	r 66 (1.1)	34 (1.1)	0 (0.0)	r 29 (0.6)	69 (0.6)	2 (0.1)
Iran, Islamic Rep. of	72 (3.6)	28 (3.6)	1 (0.9)	67 (4.2)	31 (4.1)	2 (1.2)	5 (1.9)	52 (4.5)	43 (4.6)
Italy	76 (4.4)	23 (4.3)	1 (1.1)	86 (4.6)	13 (4.5)	1 (0.1)	2 (1.3)	30 (4.9)	68 (5.0)
Lebanon	r 40 (2.7)	54 (2.7)	7 (1.3)	r 81 (1.8)	19 (1.8)	0 (0.0)	r 41 (2.7)	50 (2.7)	9 (1.0)
Netherlands	15 (4.2)	50 (5.4)	35 (5.8)	89 (3.2)	11 (3.2)	0 (0.0)	5 (2.3)	61 (4.6)	33 (4.3)
Norway	46 (5.4)	47 (5.3)	7 (3.1)	90 (2.9)	10 (2.9)	0 (0.0)	0 (0.0)	34 (5.3)	66 (5.3)
Russian Federation	65 (4.6)	35 (4.6)	0 (0.2)	95 (1.7)	5 (1.7)	0 (0.0)	6 (2.8)	63 (4.5)	31 (4.4)
Slovenia	41 (0.2)	54 (0.2)	6 (0.1)	85 (0.2)	15 (0.2)	0 (0.0)	7 (0.1)	43 (0.2)	50 (0.2)
Sweden	72 (3.8)	25 (3.7)	3 (1.5)	88 (3.3)	11 (3.2)	1 (0.0)	2 (1.0)	51 (4.9)	47 (4.8)

Country	Percent of Students by Types of Questions Teachers Include in Their Physics Tests (Continued)		
	Questions Requiring Explanations or Justifications		
	Always or Almost Always	Sometimes	Never or Almost Never
Armenia	80 (0.4)	20 (0.4)	0 (0.0)
Iran, Islamic Rep. of	34 (4.2)	63 (4.3)	3 (1.2)
Italy	61 (6.0)	35 (5.8)	4 (1.9)
Lebanon	r 73 (2.4)	26 (2.4)	1 (0.5)
Netherlands	16 (3.6)	71 (5.0)	14 (3.7)
Norway	78 (4.2)	21 (4.2)	0 (0.5)
Russian Federation	56 (4.8)	44 (4.8)	0 (0.0)
Slovenia	21 (0.2)	67 (0.2)	12 (0.2)
Sweden	83 (3.4)	17 (3.4)	0 (0.0)

SOURCE: IEA TIMSS Advanced 2008 ©

Data provided by teachers.

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

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

Chapter 12

School Contexts for Physics Learning and Instruction

Chapter 12 presents information about the school contexts for teaching and learning physics during the final year of secondary school among the countries that participated in TIMSS Advanced 2008. Considerable research indicates that a school conducive to learning is important for students to have high achievement. This chapter describes the school environments in the participating countries and how supportive they may be in bringing students to high levels of learning. In particular, information is provided about the principals' roles in their schools and the availability of physics teachers, as well as principals' and teachers' perceptions of their schools' climates and of school safety. Information also is provided about the adequacy of resources for teaching physics, including the availability of various types of technology.

Much of the data in this chapter was collected through questionnaires administered to schools, and completed by the principals or school heads assisted by school personnel. Results are generally shown as the percentages of students whose schools reported various characteristics. That is, the student is the unit of analysis so that TIMSS Advanced 2008 can describe students' school contexts. The exhibits have special notations if relatively large percentages of students did not have school questionnaire information. That is, in several cases an “r” is included next to the data because data was available for less than 85 percent of the students, but available for at least 70 percent.

Role of the Principal and Availability of Physics Teachers

Even if a country has established a rigorous and coherent curriculum in physics, there are various ways that the school environment can help or hinder classroom instruction in that curriculum. This section presents information about two school staffing issues that can impact students’ opportunity to learn the intended curriculum. First, because research shows that achievement improves in schools where principals are effective instructional leaders, data is presented about how principals spend their time. Second, since qualified teachers are important for effective instruction, data is provided about the degree of difficulty schools are having in recruiting physics teachers to fill final year vacancies.

Principals that are effective instructional leaders may actively advocate, nurture, and sustain a positive school culture and an education program conducive to students’ learning and teachers’ professional growth. Because the primary roles that the principal fulfills provide a useful indication of the administrative and educational structures and priorities of the school, the principals of the schools offering physics courses were asked how they distributed their time across the competing demands of administrative, instructional, supervisory, disciplinary, teaching, and public relations tasks.

Exhibit 12.1 presents, for each country, the percentage of time that principals reported they would have spent on the different types of school-related tasks by the end of the school year. According to their reports, the vast majority of principals’ time is distributed across three broad categories of tasks: administrative duties, providing instructional

Exhibit 12.1 Principals' Percent of Time Spent on Various School-related Activities

TIMSSAdvanced 2008 Physics

Country	Administrative Duties (e.g., Hiring, Budgeting, Scheduling, Meetings)	Instructional Leadership (e.g., Developing Curriculum and Pedagogy)	Supervising and Evaluating Teachers and Other Staff	Issues Related to Student Discipline	Teaching	Public Relations and Fundraising	Other
Armenia	26 (0.2)	21 (0.2)	23 (0.1)	14 (0.2)	7 (0.1)	12 (0.1)	7 (0.1)
Iran, Islamic Rep. of	19 (0.9)	26 (1.1)	20 (0.8)	13 (0.8)	4 (0.5)	10 (0.7)	8 (0.4)
Italy	29 (1.6)	23 (1.1)	17 (0.8)	13 (1.3)	3 (0.5)	12 (0.9)	4 (0.7)
Lebanon	24 (0.6)	18 (0.4)	19 (0.4)	17 (0.4)	6 (0.3)	10 (0.3)	5 (0.3)
Netherlands	21 (1.4)	26 (1.6)	19 (1.2)	7 (0.8)	8 (1.0)	5 (0.4)	14 (1.3)
Norway	48 (2.2)	24 (1.0)	9 (0.5)	6 (0.6)	3 (0.5)	4 (0.5)	7 (1.4)
Russian Federation	25 (1.0)	21 (0.8)	19 (0.6)	7 (0.5)	8 (0.6)	12 (0.7)	8 (0.7)
Slovenia	35 (0.1)	21 (0.0)	13 (0.0)	6 (0.0)	7 (0.0)	11 (0.0)	8 (0.0)
Sweden	45 (2.6)	16 (1.2)	17 (1.2)	8 (1.0)	3 (0.6)	4 (0.4)	9 (0.9)

SOURCE: IEA TIMSS Advanced 2008 ©

Data provided by schools

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

leadership in the areas of curriculum and pedagogy, and supervising teachers and other staff. In Armenia, Iran, Lebanon, the Netherlands, and the Russian Federation, the distribution of time was similar across these three categories (about one fifth to one fourth of principals' time spent on each of the three areas). Among the three categories, a slightly larger percentage of time was devoted to administrative duties in Armenia, Lebanon, and the Russian Federation and to instructional leadership in Iran and the Netherlands. In comparison, in Italy and Slovenia, although principals reported that 23 and 21 percent, respectively, of their time was devoted to instructional leadership, they devote more of their time (29% and 35%, respectively) to administrative duties, and somewhat less of their time to evaluating teachers and other staff (17% and 13%, respectively). The distribution of time across these three areas was least balanced in Norway and Sweden, with principals' time considerably skewed toward the administrative side (48% and 45%, respectively). Although the percentages were not large, principals generally reported more time devoted to disciplining students (6 to 17%) than to teaching them the school's curriculum (3 to 7%), except in the Netherlands, the Russian Federation, and Slovenia. Public relations and fundraising took from 10 to 12 percent of the principals' time except in the Netherlands, Norway, and Sweden where these activities only took from 4 to 5 percent of their time.

Exhibit 12.2 presents schools' reports about the degree of difficulty they are having recruiting physics teachers to fill vacancies in the final year of secondary school. As discussed in Chapter 11, substantial percentages of the teachers of physics have been teaching for 20 to 26 years in nearly all of the TIMSS Advanced countries, and thus could be expected to be considering retirement. Also, as evidenced by the TIMSS Advanced data, there are not large pools of students currently being trained in physics and few of them plan to continue their study

Exhibit 12.2 **Schools' Reports on Physics Teacher Recruitment**

TIMSSAdvanced 2008 Physics

Country	Filling Physics Teaching Vacancies for the School Year							
	No Vacancies		Easy to Fill Vacancies		Somewhat Difficult to Fill Vacancies		Very Difficult to Fill Vacancies	
	Percent of Students	Average Achievement	Percent of Students	Average Achievement	Percent of Students	Average Achievement	Percent of Students	Average Achievement
Armenia	83 (0.8)	493 (4.4)	8 (0.4)	507 (7.9)	0 (0.0)	~ ~	10 (0.8)	500 (43.2)
Iran, Islamic Rep. of	28 (4.2)	468 (11.9)	26 (4.8)	438 (11.9)	36 (4.6)	457 (14.8)	10 (2.8)	494 (26.7)
Italy	45 (6.3)	413 (10.8)	26 (5.7)	440 (11.7)	25 (5.5)	418 (21.3)	4 (2.0)	434 (21.6)
Lebanon	47 (2.3)	444 (4.2)	17 (1.8)	462 (7.1)	22 (2.0)	430 (6.6)	14 (1.7)	456 (6.5)
Netherlands	65 (5.3)	584 (3.9)	5 (2.0)	605 (15.6)	20 (3.9)	585 (6.0)	10 (3.4)	580 (8.2)
Norway	32 (6.0)	535 (6.9)	36 (6.8)	537 (6.6)	21 (5.1)	530 (7.1)	10 (3.2)	536 (10.6)
Russian Federation	80 (3.8)	526 (10.6)	9 (2.0)	557 (21.0)	8 (2.9)	413 (36.5)	3 (1.2)	545 (52.1)
Slovenia	87 (0.2)	537 (2.3)	9 (0.2)	514 (6.1)	4 (0.1)	553 (7.6)	0 (0.0)	~ ~
Sweden	66 (6.0)	493 (7.9)	25 (5.4)	505 (9.4)	6 (2.3)	502 (23.5)	3 (2.4)	500 (11.3)

Country	Incentives to Recruit or Retain Physics Teachers			
	School Uses Incentives		School Does Not Use Incentives	
	Percent of Students	Average Achievement	Percent of Students	Average Achievement
Armenia	14 (0.9)	480 (29.4)	86 (0.9)	497 (4.0)
Iran, Islamic Rep. of	38 (4.1)	477 (13.4)	62 (4.1)	447 (8.8)
Italy	– –	– –	– –	– –
Lebanon	34 (2.1)	449 (4.5)	66 (2.1)	441 (3.9)
Netherlands	1 (0.8)	~ ~	99 (0.8)	585 (3.4)
Norway	10 (3.7)	534 (8.6)	90 (3.7)	535 (4.4)
Russian Federation	74 (4.2)	522 (12.5)	26 (4.2)	520 (19.1)
Slovenia	0 (0.0)	~ ~	100 (0.0)	535 (1.9)
Sweden	2 (1.0)	~ ~	98 (1.0)	498 (6.0)

Data provided by schools.

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

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

SOURCE: IEA TIMSS Advanced 2008 ©

of science (Exhibits 10.14 and 10.15), which would indicate even smaller percentages planning to become teachers. Since there does not seem to be a regular pipeline into the career of teaching physics in a number of the TIMSS Advanced countries, it is not surprising that physics students in some participating countries are attending schools that are having some difficulty recruiting physics teachers for the final year of secondary school.

In several countries, most physics students were in schools with hardly any vacancies for physics teachers in the final year of secondary school, including Armenia (83%), the Russian Federation (80%), and Slovenia (87%). In contrast, however, 46 percent of the Iranian physics students in their final year of secondary school were attending schools with vacancies for physics teachers that were at least somewhat difficult to fill, as were approximately one third (29 to 36%) of the Italian, Lebanese, Dutch, and Norwegian students.

As shown in the lower portion of Exhibit 12.2, schools were asked if they used any incentives (e.g., pay, housing, signing bonuses, smaller classes) to recruit or maintain physics teachers for students in the final year of secondary school. The results indicate that incentives were used most widely in the Russian Federation, and apparently with some success since nearly all vacancies were filled as discussed above. Iran and Lebanon also reported some use of incentives for schools with about one third of their physics students. Neither the percentage of difficult-to-fill vacancies nor the use of incentives was consistently related to average achievement in physics.

Orderly and Safe Schools

Although an orderly and safe school environment does not, in and of itself, guarantee high levels of student achievement, safe schools can be considered a necessary condition for providing a good learning environment for students. TIMSS 2007 showed that science achievement was related to teachers' and students' perceptions about how safe they felt at school at both the fourth and eighth grades, and it might be anticipated that school discipline and behavior problems in secondary schools might be of even greater concern. However, the TIMSS Advanced 2008 results indicate that school safety generally is not a problem for the select populations of final year students studying physics. According to their principals and teachers, these students generally are in orderly and safe school environments.

To provide an initial context for considering the degree of order and safety in the schools attended by physics students, TIMSS Advanced 2008 asked principals to rate the seriousness of the following behavior problems among final year students in their schools: vandalism, theft, intimidation or verbal abuse among students, students causing physical injury to other students, students intimidating or verbally abusing teachers, and students physically injuring teachers or staff. TIMSS Advanced used the principals' responses about each behavior (i.e., not a problem, minor problem, or serious problem) to create an Index of Good Behavior at School for Students in the Final Year of Secondary School. Students in the high category attended schools where principals reported that *none* of these six behaviors were a problem. In contrast, students in the low category attended schools where principals reported widespread minor and/or serious behavior problems. The medium category included students attending schools where these behaviors were minor problems.

Exhibit 12.3 presents the results for the Index of Good Behavior at School for Students in the Final Year of Secondary School. The countries are presented in order from the largest to smallest percentage of students in the high category. In six countries, the majority of physics students (from 55 to 78%) attended schools where *none* of these student

Exhibit 12.3 **Index of Good Behavior at School for Students in the Final Year of Secondary School (GBS)**

TIMSSAdvanced 2008 Physics

Country	High GBS		Medium GBS		Low GBS	
	Percent of Students	Average Achievement	Percent of Students	Average Achievement	Percent of Students	Average Achievement
Armenia	78 (0.5)	488 (6.4)	20 (0.5)	519 (8.4)	3 (0.1)	512 (13.2)
Russian Federation	74 (3.3)	523 (11.2)	26 (3.3)	519 (21.5)	0 (0.0)	~ ~
Netherlands	72 (5.0)	584 (4.2)	26 (4.9)	585 (5.6)	2 (1.3)	~ ~
Iran, Islamic Rep. of	71 (4.1)	464 (8.3)	29 (4.1)	447 (12.7)	0 (0.0)	~ ~
Slovenia	58 (0.2)	550 (2.7)	39 (0.2)	513 (2.9)	3 (0.1)	529 (10.2)
Norway	55 (5.7)	539 (4.8)	43 (5.6)	531 (6.7)	1 (0.1)	~ ~
Italy	46 (6.4)	424 (15.1)	48 (6.2)	426 (7.1)	7 (3.2)	381 (24.4)
Sweden	40 (6.6)	507 (9.2)	50 (7.1)	492 (8.5)	10 (4.6)	486 (20.1)
Lebanon	40 (2.4)	440 (5.5)	51 (2.4)	451 (4.1)	9 (0.6)	429 (12.6)

SOURCE: IEA TIMSS Advanced 2008 ©

Based on principals' responses about the seriousness of following behaviors in their school: vandalism, theft, intimidation or verbal abuse of other students, physical injury to other students, students intimidating or verbally abusing teachers or staff, and students causing physical injury to teachers or staff. Principals' responses were averaged across the six statements based on a 3-point scale: 1=Not a Problem, 2=Minor Problem, 3=Serious Problem. Students in the high category attended schools where principals reported none of these problems with students behavior (average of 1). Students in the low category attended schools where principals reported widespread minor and/or serious student behavior problems (average greater than 2). Students in the medium category attended schools where principals reported minor student behavior problems (average greater than 1 and less than or equal to 2).

( ) 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.

Exhibit 12.4 **Index of Physics Teachers' Perceptions of Safety in Their Schools (TPSS)**

TIMSSAdvanced 2008 Physics

Country	High TPSS		Medium TPSS		Low TPSS	
	Percent of Students	Average Achievement	Percent of Students	Average Achievement	Percent of Students	Average Achievement
Iran, Islamic Rep. of	99 (0.6)	463 (7.3)	1 (0.0)	~ ~	0 (0.0)	~ ~
Norway	99 (0.7)	534 (4.2)	1 (0.0)	~ ~	0 (0.0)	~ ~
Sweden	94 (2.1)	499 (5.8)	6 (2.1)	471 (24.5)	0 (0.0)	~ ~
Netherlands	94 (2.7)	585 (3.3)	5 (2.4)	542 (28.5)	1 (0.0)	~ ~
Armenia	88 (0.4)	490 (6.0)	8 (0.4)	527 (7.9)	3 (0.1)	506 (10.7)
Slovenia	88 (0.1)	538 (1.9)	8 (0.1)	518 (8.5)	3 (0.0)	482 (12.7)
Lebanon	86 (1.5)	446 (3.1)	13 (1.5)	429 (8.2)	1 (0.3)	~ ~
Russian Federation	80 (3.6)	522 (10.2)	18 (3.5)	512 (24.4)	1 (1.0)	~ ~
Italy	80 (5.0)	431 (8.5)	16 (4.5)	396 (19.1)	4 (2.4)	404 (54.6)

SOURCE: IEA TIMSS Advanced 2008 ©

Based on teachers' responses to three statements about their schools: 1) This school is located in a safe neighborhood; 2) I feel safe at this school; 3) This school's security policies and practices are sufficient. Teachers' responses were averaged across the three statements based on a 4-point Likert scale: 1=Agree a lot; 2=Agree; 3=Disagree; 4=Disagree a lot. Students were assigned to the high level when their teachers agreed or agreed a lot with all three statements and to the low category when their teachers disagreed or disagreed a lot with all three. Students whose teachers provided other response combinations were assigned to the medium category.

( ) 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.

behaviors were even minor problems according to principals. Forty-six percent of the physics students attended such "problem-free" schools in Italy, and 40 percent did in Sweden and Lebanon. Most notably, no more than 10 percent of the students in any country were in the low category; that is, attended schools where principals considered these student behaviors—including physical conflicts—to be widespread or serious problems. In Slovenia and Sweden, students in the schools with no behavior problems had higher achievement than their counterparts in schools with minor or major behavior problems. In Italy, the 7 percent of physics students in schools with serious problems had lower achievement than their counterparts in schools with fewer discipline problems.

Exhibit 12.4 presents the results of the Index of Physics Teachers' Perceptions of Safety in Their Schools. The index is based on physics teachers' responses to three statements pertaining directly to the safety of their schools:

- This school is located in a safe neighborhood
- I feel safe at this school
- The school's security policies and practices are sufficient.

Students were assigned to the high level when their teachers agreed with all three statements and to the low category when their teachers disagreed with all three. Students whose teachers provided other response combinations were assigned to the medium category. The results are presented according to the percentage of students in the high category from largest to smallest.

Nearly all teachers of physics students agreed that the schools offering courses in physics were safe. In Iran and Norway, 99 percent of the physics students were attending such schools and 94 percent were in Sweden and the Netherlands. From 86 to 88 percent of the physics students were attending schools judged to be safe by their teachers in Armenia, Slovenia, and Lebanon, and 80 percent were in the Russian Federation and Italy. The pattern was for physics students in schools where teachers perceived "medium" safety concerns to have lower average achievement than their counterparts attending schools in the high category (except in Armenia).

Principals' and Teachers' Perceptions of School Climate

Beyond an orderly and safe environment, a positive school climate helps to build better morale among teachers and students, encourages students to learn, and creates an expectation for high levels of academic success, all of which lead to higher student achievement. TIMSS Advanced 2008 asked both school principals and teachers to characterize the climate of their school according to important indicators of an environment conducive to learning. The principals and the teachers were asked to rate each of the following school characteristics on a 4-point scale from *very high* to *very low*.

- Teachers' job satisfaction
- Teachers' understanding of the school's curricular goals
- Teachers' degree of success in implementing the school's curriculum
- Teachers' expectations for student achievement
- Parental support for student achievement
- Parental involvement in school activities
- Students' regard for school property
- Students' desire to do well in school.

Based on the responses provided by the principals and teachers, respectively, TIMSS Advanced created two comparable scales: the Index of Principals' Perception of School Climate and the Index of Physics Teachers' Perception of School Climate. In each case, physics students were assigned to the high level if their principals or teachers, respectively, averaged a *high* or *very high* rating on these aspects of school climate, and to the low level if their principals or teachers, respectively, averaged *low* or *very low*. Students in the medium category had principals or teachers with other response combinations.

Exhibit 12.5 presents the results for the Index of Principals' Perception of School Climate, including the percentage of students at each level of the index in each country, together with their average achievement in physics. The countries are ordered according to the percentage of students in the high category. In every country except Armenia, there was a positive association between a climate more supportive of student learning and higher average achievement in physics. In most of the other countries, average physics achievement was highest among students at the high level of the principals' perception of school climate index, next highest at the medium level, and lowest at the low level.

In Slovenia, Sweden, Norway, and the Russian Federation, 90 percent or more of the physics students were in schools whose principals reported learning climates categorized as high or medium. At least one fourth of the students were in schools with learning climates categorized as high in Slovenia, Lebanon, and Iran. Across countries, Italian and Dutch principals had the lowest perceptions of the climates in their schools. According to their principals, only 3 percent of the physics students in either country were in schools with climates categorized as high and, respectively, 34 percent and 25 percent were in schools with climates in the low category.

Exhibit 12.5 Index of Principals' Perceptions of School Climate (PPSC)

TIMSSAdvanced 2008 Physics

Country	High PPSC		Medium PPSC		Low PPSC	
	Percent of Students	Average Achievement	Percent of Students	Average Achievement	Percent of Students	Average Achievement
Slovenia	31 (0.2)	565 (3.1)	61 (0.2)	530 (2.3)	7 (0.2)	447 (4.8)
Lebanon	25 (1.8)	450 (5.3)	59 (2.0)	445 (4.0)	16 (1.4)	424 (5.9)
Iran, Islamic Rep. of	25 (4.0)	496 (16.4)	59 (5.2)	462 (9.9)	17 (3.7)	390 (8.9)
Sweden	15 (4.9)	523 (7.5)	77 (5.5)	496 (6.9)	7 (2.4)	464 (24.7)
Norway	14 (5.8)	545 (10.3)	79 (5.1)	534 (4.5)	6 (3.3)	524 (15.1)
Russian Federation	8 (2.2)	572 (28.9)	82 (3.6)	521 (10.6)	10 (2.8)	479 (35.3)
Italy	3 (2.6)	494 (8.7)	63 (5.4)	436 (9.1)	34 (5.4)	390 (12.4)
Netherlands	3 (2.1)	609 (8.3)	72 (5.1)	583 (4.0)	25 (5.1)	586 (7.7)
Armenia	2 (0.0)	~ ~	83 (0.4)	493 (6.2)	15 (0.4)	516 (7.6)

SOURCE: IEA TIMSS Advanced 2008 ©

Based on principals' responses to the following aspects of school climate in their schools: teachers' job satisfaction, teachers' opportunities for professional development, teachers' understanding of the school's curricular goals, teachers' degree of success in implementing the school's curriculum, teachers' expectations for student achievement, parental support for student achievement, parental involvement in school activities, students' regard for school property, and students' desire to do well in school. Average is computed across the nine statements based on a 5-point scale: 1 = Very High, 2 = High, 3 = Medium, 4 = Low, 5 = Very Low. High level indicates students whose principals' perception of their school climate was very positive (average is less than or equal to 2). Medium level indicates students whose principals' perception of their school climate was moderately positive (average is greater than 2 and less than 3). Low level indicates students whose principals' perception of their school climate was not so positive (average is greater than or equal to 3).

( ) 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.

Exhibit 12.6 Index of Physics Teachers' Perceptions of School Climate (TPSC)

TIMSSAdvanced 2008 Physics

Country	High TPSC		Medium TPSC		Low TPSC	
	Percent of Students	Average Achievement	Percent of Students	Average Achievement	Percent of Students	Average Achievement
Lebanon	33 (2.0)	460 (4.5)	44 (2.2)	444 (4.4)	23 (1.8)	419 (6.3)
Iran, Islamic Rep. of	16 (3.3)	501 (16.6)	52 (5.0)	462 (9.9)	32 (4.2)	435 (13.9)
Slovenia	10 (0.2)	600 (8.0)	55 (0.3)	537 (1.8)	35 (0.3)	510 (3.8)
Sweden	9 (3.3)	524 (19.4)	58 (4.8)	505 (5.0)	33 (4.9)	477 (11.0)
Russian Federation	9 (2.7)	543 (30.0)	66 (4.1)	536 (11.1)	24 (4.1)	472 (22.5)
Norway	7 (2.3)	538 (18.6)	73 (3.6)	536 (4.9)	20 (3.4)	529 (9.1)
Armenia	7 (0.4)	479 (9.6)	58 (0.7)	487 (8.2)	35 (0.7)	508 (6.7)
Netherlands	2 (1.7)	~ ~	54 (6.3)	588 (4.9)	44 (6.3)	573 (6.1)
Italy	2 (1.5)	~ ~	46 (5.4)	429 (11.4)	52 (5.3)	420 (12.0)

SOURCE: IEA TIMSS Advanced 2008 ©

Based on teachers' responses to the following aspects of school climate in their schools: teachers' job satisfaction, teachers' understanding of the school's curricular goals, teachers' degree of success in implementing the school's curriculum, teachers' expectations for student achievement, support for teachers' professional development, parental support for student achievement, parental involvement in school activities, students' regard for school property, and students' desire to do well in school. Average is computed across the nine statements based on a 5-point scale: 1 = Very High, 2 = High, 3 = Medium, 4 = Low, 5 = Very Low. High level indicates students whose teachers' perception of their school climate was very positive (average is less than or equal to 2). Medium level indicates students whose teachers' perception of their school climate was moderately positive (average is greater than 2 and less than 3). Low level indicates students whose teachers' perception of their school climate was not so positive (average is greater than or equal to 3).

( ) 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.

Exhibit 12.6 presents the results for the Index of Physics Teachers' Perceptions of School Climate and, in general, they correspond to the results for the Index of Principals' Perceptions of School Climate shown above. Similar to the findings for the principals' index of school climate, average achievement in physics was positively related to teachers' perceptions of school climate in all of the countries, with the exception of Armenia.

The three countries with the highest percentages of physics students in the high category according to their teachers are the same as they were according to principals—Lebanon, Iran, and Slovenia—even though Slovenian teachers (10 percent of physics students in the high category) were quite a bit less positive about their school climates than were the Slovenian principals (31 percent in the high category). According to teachers in Iran, Slovenia, Sweden, and Armenia, about one third of the physics students were in schools categorized as low, and even greater percentages were in the Netherlands (44%) and Italy (52%).

As an additional indication of whether the school had an environment supportive of high academic learning, principals were asked whether these schools that were offering courses in physics had policies for encouraging students to choose physics courses. Exhibit 12.7 presents the results for each country for the percent of students in schools with physics courses that specifically encouraged students to study physics. Average achievement in physics is shown for schools with such policies and for schools that did not have such policies.

The majority of the students were in schools expressly encouraging students to study physics in Iran (73%), the Russian Federation (69%), Lebanon (63%), and Armenia (57%). Sweden was at the other end of the continuum, where none of the schools had such a policy, presumably because, as explained in Exhibit 7.1, choices about studying physics

Exhibit 12.7 **Schools' Policies for Encouraging Students to Study Physics**

TIMSSAdvanced 2008 Physics

Country		School Has Policy		School Does Not Have Policy	
		Percent of Students	Average Achievement	Percent of Students	Average Achievement
Armenia		57 (0.8)	487 (5.2)	43 (0.8)	510 (12.0)
Iran, Islamic Rep. of		73 (4.5)	468 (8.9)	27 (4.5)	433 (13.1)
Italy		40 (6.1)	423 (14.4)	60 (6.1)	421 (10.4)
Lebanon		63 (2.1)	442 (4.1)	37 (2.1)	441 (4.9)
Netherlands		26 (5.4)	584 (6.7)	74 (5.4)	585 (3.7)
Norway		30 (5.5)	534 (5.5)	70 (5.5)	535 (5.1)
Russian Federation	r	69 (4.3)	535 (13.3)	31 (4.3)	488 (23.0)
Slovenia		36 (0.2)	537 (3.0)	64 (0.2)	534 (2.3)
Sweden		0 (0.0)	~ ~	100 (0.0)	498 (5.7)

SOURCE: IEA TIMSS Advanced 2008 ©

Data provided by schools.

( ) 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.

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

are left to the students. Across the eight countries where some of the schools with students enrolled in physics had "encouraging" policies and others did not, there was no relationship with average achievement in five countries. In Armenia, students in schools with such policies had lower average achievement—perhaps the underlying reason for the policy of encouragement. In Iran and the Russian Federation, the students in schools with specific policies had higher achievement.

School Resources and Technology

The last section of this chapter presents information about the resources available in schools providing instruction to the TIMSS Advanced students in physics. Curriculum implementation can be made easier by ready access to the facilities, materials, and equipment necessary to achieve the specified learning goals. Results from successive TIMSS assessments indicate that fourth and eighth grade students attending schools that are well resourced generally have higher achievement than those in schools where shortages of resources affect teachers' capacity to implement the curriculum. In addition to schools' reports about the adequacy of general resources and resources particularly targeted to physics instruction, this section includes data about school availability of computers and Internet access for final year students.

To gather information about whether the lack of availability of school resources had an adverse impact on instruction in physics, principals were asked the degree to which shortages or inadequacies in six general areas affected their school's capacity to provide instruction: instructional materials (textbooks, for example); budget for supplies (paper, pencils, etc.); school buildings and grounds; heating/cooling and lighting systems; instructional space (classrooms, for example); and special equipment for students with disabilities. Principals also responded to questions about whether shortages or inadequacies in five resource areas specifically pertaining to physics instruction affected their school's capacity to provide instruction: computers for physics instruction; computer software for physics instruction; calculators for physics instruction; library materials relevant to physics instruction; and audio-visual resources for physics instruction. Responses to both types of questions were provided on a 4-point scale: *no*, *a little*, *some*, and *a lot*. TIMSS Advanced created two indices based on principals' responses to the two groups of questions about school resource shortages—one concerning shortages in general areas and the other concerning shortages in resources specifically related to physics instruction.

To create the Index of Adequacy of General School Resources, principals' responses were averaged across the six questions about shortages in general resources, and to create the Index of Adequacy of Resources Specifically for Physics Instruction, principals' responses were averaged across the five questions about shortages in resources pertaining specifically to physics instruction. For each of the two indices, students were placed in the high category if principals responded that shortages in resources affected the capacity to provide instruction only a little, if at all (average less than 2). In contrast, students were placed in the low category if principals responded that resource shortages had considerable impact on the schools' capacity to provide instruction (i.e., across all resource areas to some degree and/or shortages in several areas adversely affected instruction a lot (average 3 or higher)). Students in the medium category were in schools where the capacity to provide instruction was somewhat adversely affected by the lack of some resources.

Exhibit 12.8 displays the results for the Index of Adequacy of General School Resources for each country ordered by the percentage of student in the high category. As would be anticipated based on the range in the economic indicators for the participating countries, there was some variability in the principals' responses across countries. Nevertheless, according to their principals, the majority of students studying physics in their final year of secondary school were in schools where shortages in general resources had little or no impact on instruction. Approximately three fourths (74 to 75%) of the students studying physics attended schools in the high category in Armenia, Sweden, and the Russian Federation, as did 70 percent of the Norwegian students. Approximately three fifths (59 to 64%) of the students attended schools generally well-resourced in the Netherlands, Lebanon, Slovenia, Italy, and Iran. Slovenia and Iran had the strongest relationship between adequacy of general resources and average achievement in physics.

Exhibit 12.9 shows the results for the Index of Adequacy of Resources Specifically for Physics Instruction. There was more variability in the results for resources specifically for physics instruction than for general school resources. In a number of the TIMSS Advanced 2008 countries, principals reported more adverse affects on instruction from shortages in resources specifically for physics instruction than from shortages in general resources. Because the physics related resource areas primarily were technology related (i.e., computer hardware and software, calculators, and audio-visual resources), it makes sense that schools would have more difficulty keeping up-to-date in these areas. Sweden (79%), Norway (70%), and the Netherlands (68%) reported the largest percentages of physics students to be in schools well-resourced in physics-related instructional

Exhibit 12.8 **Index of Adequacy of General School Resources (Shortages Do Not Affect Capacity to Provide Instruction) (AGSR)**

TIMSSAdvanced 2008 Physics

Country	High AGSR		Medium AGSR		Low AGSR	
	Percent of Students	Average Achievement	Percent of Students	Average Achievement	Percent of Students	Average Achievement
Armenia	75 (0.5)	493 (6.4)	17 (0.3)	488 (8.7)	9 (0.3)	521 (20.4)
Sweden	74 (6.2)	496 (7.4)	23 (5.9)	504 (10.0)	3 (2.0)	493 (51.3)
Russian Federation	74 (4.1)	515 (10.9)	21 (3.8)	556 (21.4)	5 (2.1)	481 (6.9)
Norway	70 (5.0)	533 (5.0)	29 (5.0)	539 (6.5)	1 (0.4)	~ ~
Netherlands	64 (5.1)	582 (4.0)	35 (4.8)	590 (5.7)	2 (1.1)	~ ~
Lebanon	62 (2.3)	443 (4.0)	27 (2.1)	444 (5.5)	11 (1.4)	443 (8.8)
Slovenia	61 (0.2)	541 (2.3)	28 (0.2)	524 (3.3)	11 (0.2)	527 (5.1)
Italy	61 (6.4)	426 (8.3)	34 (6.1)	410 (13.8)	6 (2.1)	454 (24.0)
Iran, Islamic Rep. of	59 (5.1)	471 (10.7)	29 (4.6)	451 (15.2)	12 (3.3)	415 (13.1)

SOURCE: IEA TIMSS Advanced 2008 ©

Based on principals' responses to how much the school's capacity to provide instruction is affected by shortages or inadequacies of the following: instructional materials (e.g., textbooks), budget for supplies (e.g., paper, pencils), school buildings and grounds, heating/cooling and lighting systems, instructional space (e.g., classrooms), and special equipment for students with disabilities. Principals' responses were averaged across the six statements based on a 4-point scale: 1 = No, 2 = A little, 3 = Some, 4 = A lot. Students were placed in the high category if principals responded that shortages in general resources affected only a little, if at all (average is less than 2). Students were placed in the low category if principals responded that shortages in all the general resource areas had some adverse affect on capacity to provide instruction and/or shortages in several general resource areas adversely affected instruction a lot (average is greater than or equal to 3). Students in the medium category were in schools where the capacity to provide instruction was adversely affected somewhat by the lack of general resources (average is greater than or equal to 2 and less than 3).

( ) 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.

Exhibit 12.9 **Index of Adequacy of Resources Specifically for Physics Instruction (Shortages Do Not Affect Capacity to Provide Instruction) (ARPI)**

TIMSSAdvanced 2008 Physics

Country	High ARPI		Medium ARPI		Low ARPI	
	Percent of Students	Average Achievement	Percent of Students	Average Achievement	Percent of Students	Average Achievement
Sweden	79 (4.2)	502 (6.1)	17 (4.4)	482 (16.0)	4 (2.1)	483 (35.0)
Norway	70 (6.4)	537 (4.5)	29 (6.4)	531 (6.5)	1 (0.4)	~ ~
Netherlands	68 (4.6)	586 (4.0)	31 (4.5)	582 (5.1)	2 (1.2)	~ ~
Slovenia	57 (0.2)	538 (3.0)	36 (0.2)	538 (2.8)	7 (0.1)	490 (4.0)
Italy	52 (6.1)	422 (10.4)	42 (5.8)	422 (12.2)	6 (2.4)	420 (37.5)
Russian Federation	46 (4.2)	521 (15.6)	40 (4.5)	526 (14.6)	14 (3.3)	514 (18.9)
Lebanon	45 (2.1)	447 (4.7)	31 (2.4)	444 (6.0)	23 (2.4)	434 (6.8)
Armenia	38 (0.8)	511 (11.7)	44 (0.7)	486 (6.5)	18 (0.4)	482 (7.5)
Iran, Islamic Rep. of	32 (4.3)	484 (14.0)	43 (5.0)	454 (10.2)	25 (3.9)	434 (14.3)

SOURCE: IEA TIMSS Advanced 2008 ©

Based on principals' responses to how much the school's capacity to provide physics instruction is affected by shortage or inadequacy of the following: physics laboratory equipment and materials, computers for physics instruction, computer software for physics instruction, calculators for physics instruction, library materials relevant to physics instruction, audio-visual resources for physics instruction. Average is computed across the six responses based on a 4-point scale: 1 = No, 2 = A little, 3 = Some, 4 = A lot. High Level indicates that instruction is not affected or affected a little by a shortage of resources (average is less than 2). Medium level indicates that instruction is affected some by a shortage of resources (average is greater than or equal to 2 and less than 3). Low level indicates that instruction is affected a lot by a shortage of resources (average is greater than or equal to 3).

( ) 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.

materials and equipment. In contrast, from 23 to 25 percent of the physics students in Lebanon and Iran were in the low category for physics instructional resources as were 18 percent in Armenia and 14 percent in the Russian Federation.

Exhibit 12.10 presents information about the degree to which schools offering physics courses in the final year of secondary school had computers and access to the Internet. The first data column for each country provides the average number of computers per school available for use by final year students. Care should be taken in interpreting these results because these computers most likely are not for the exclusive use of final year students and could also be used by other students attending the schools, and the total number of students having access to computers most like varies considerably depending on such factors as the type of school and school enrollment.

Taking the above caveats into consideration, there still was a considerable range in the results. Sweden reported 221 computers per school, on average, available for use by final year students. The average number of computers per school available was closer to 100 in the Netherlands (91) and Norway (107). For the remaining countries, the averages dropped considerably to 59 in Italy, 43 in Slovenia, 30 in the Russian Federation, and 27 in Lebanon. The lowest averages were 15 computers per school on average in Armenia and 8 on average in Iran.

The remaining data columns in Exhibit 12.10 provide information about the percentages of physics students in each country attending schools where “all”, “most”, “some”, or “none” of the school computers available for their use had Internet access, together with the average achievement for students in each category. In Italy, the Netherlands, Norway, Slovenia, and Sweden, 80 to 93 percent of the physics students were attending schools where all of the computers had Internet access, and (except for 4% in Italy) the rest of the students were in schools

Exhibit 12.10 **Computer Availability and Internet Access in School**

TIMSSAdvanced 2008 Physics

Country		Average Number of Computers Available for Use by Final Year Students	Internet Access for Educational Purposes							
			All Computers		Most Computers		Some Computers		No Computers	
			Percent of Students	Average Achievement	Percent of Students	Average Achievement	Percent of Students	Average Achievement	Percent of Students	Average Achievement
Armenia		15 (0.2)	40 (0.6)	516 (5.4)	19 (0.8)	496 (21.2)	16 (0.4)	470 (13.1)	25 (0.6)	477 (6.5)
Iran, Islamic Rep. of		8 (0.7)	33 (4.6)	475 (12.8)	8 (2.7)	536 (31.9)	29 (4.7)	456 (13.9)	29 (4.3)	423 (11.8)
Italy		59 (5.9)	82 (4.1)	421 (9.3)	14 (3.7)	427 (10.9)	2 (1.5)	~ ~	2 (1.6)	~ ~
Lebanon		27 (0.7)	34 (2.3)	462 (5.5)	15 (1.5)	456 (6.3)	22 (2.4)	447 (6.7)	29 (2.4)	419 (5.1)
Netherlands	r	91 (5.3)	80 (3.9)	587 (4.0)	20 (3.9)	574 (6.4)	0 (0.0)	~ ~	0 (0.0)	~ ~
Norway		107 (8.9)	93 (2.4)	535 (4.3)	7 (2.4)	537 (8.7)	0 (0.0)	~ ~	0 (0.0)	~ ~
Russian Federation		30 (1.6)	51 (4.4)	520 (11.8)	31 (3.8)	526 (18.3)	16 (2.6)	511 (26.4)	1 (1.0)	~ ~
Slovenia		43 (0.2)	85 (0.2)	536 (1.9)	15 (0.2)	534 (6.1)	0 (0.0)	~ ~	0 (0.0)	~ ~
Sweden	r	221 (29.2)	84 (5.5)	497 (7.0)	16 (5.5)	500 (15.3)	0 (0.0)	~ ~	0 (0.0)	~ ~

SOURCE: IEA TIMSS Advanced 2008 ©

Data provided by schools.

( ) 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.

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

where most computers had Internet access. In these five countries, there was little difference in average physics achievement between schools with all computers having Internet access and schools with most computers having Internet access.

In Iran and Lebanon, the two participating countries reporting the least Internet access in schools, one third of the physics students were in schools where all the computers had Internet access and a few more (8% and 15%, respectively) were in schools where most computers had Internet access. However, according to the last column in Exhibit 12.10, in Iran and Lebanon 29 percent of the physics students as well as 25 percent in Armenia attended schools where no computers had Internet access, and these students had lower average achievement than their counterparts in schools where all or most of the computers had Internet access.

Appendix A

Supporting Documentation

TIMSS Advanced 2008 Advanced Mathematics and Physics Assessments

The *TIMSS Advanced 2008 Assessment Frameworks*[1] define the advanced mathematics and physics to be addressed in the TIMSS Advanced 2008 assessment and provide an outline of the assessment design. As described in that document, the frameworks for advanced mathematics and physics were built around content and cognitive domains within each subject. Algebra (35%), calculus (35%), and geometry (30%) made up the advanced mathematics content domains and their targeted percentages, and knowing (35%), applying (35%), and reasoning (30%) were the cognitive domains and target percentages. The physics content domains were mechanics (30%), electricity and magnetism (30%), heat and temperature (20%), and atomic and nuclear physics (20%). The cognitive domains in physics were the same as in mathematics, but the target percentages slightly different—knowing (30%), applying (40%), and reasoning (30%). Exhibit A.1 presents these content and cognitive domains together with the number of items and score points in each domain and the distribution of score points across domains.

1 For the complete framework for the TIMSS Advanced 2008 assessment, see 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.

Exhibit A.1 **Distribution of Advanced Mathematics and Physics Items by Content Domain and Cognitive Domain**

TIMSSAdvanced2008

Advanced Mathematics

Content Domain	Number of Multiple-choice Items	Number of Constructed-response Items	Total Number of Items	Total Number of Score Points[1]	Percentage of Score Points
Algebra	17	9	26	30	37
Calculus	13	12	25	29	35
Geometry	16	5	21	23	28
Total	**46**	**26**	**72**	**82**	**100**

Cognitive Domain	Number of Multiple-choice Items	Number of Constructed-response Items	Total Number of Items	Total Number of Score Points[1]	Percentage of Score Points
Knowing	21	7	28	30	37
Applying	14	13	27	31	38
Reasoning	11	6	17	21	26
Total	**46**	**26**	**72**	**82**	**100**

Physics

Content Domain	Number of Multiple-choice Items	Number of Constructed-response Items	Total Number of Items	Total Number of Score Points[1]	Percentage of Score Points
Mechanics	11	9	20	24	29
Electricity and Magnetism	13	8	21	24	29
Heat and Temperature	7	8	15	20	24
Atomic and Nuclear Physics	11	4	15	16	19
Total	**42**	**29**	**71**	**84**	**100**

Cognitive Domain	Number of Multiple-choice Items	Number of Constructed-response Items	Total Number of Items	Total Number of Score Points[1]	Percentage of Score Points
Knowing	12	6	18	18	21
Applying	25	11	36	41	49
Reasoning	5	12	17	25	30
Grand Total	**42**	**29**	**71**	**84**	**100**

1 In scoring the tests, correct answers to most items were worth one point. However, responses to some constructed-response items were evaluated for partial credit with a fully correct answer awarded two points. Thus, the number of score points exceeds the number of items in the test.

SOURCE: IEA TIMSS Advanced 2008 ©

The advanced mathematics assessment had a total of 72 items: 26 items in algebra, 25 items in calculus, and 21 items in geometry. Each item also was categorized according to its cognitive domain, with 28 items in the knowing domain, 27 in the applying domain, and 17 in the reasoning domain. A little more than one third of the items (26) were in constructed-response format and the rest (46) were multiple-choice items. The constructed-response items required students to generate and write their own answers. Some items required short answers while others demanded a more elaborate response. In scoring the assessment, correct answers to most questions (including all those in multiple-choice format) were worth 1 point. However, responses to questions seeking more elaborate responses were evaluated for partial credit, with a fully-correct answer being awarded 2 points. Thus, the total number of score points available for analyses (82) somewhat exceeds the number of items in the assessment. The percentages of score points for the content and cognitive domains were nearly identical to the target percentages designated in the advanced mathematics assessment framework.

In the physics assessment, there were 71 items in total: 20 mechanics items, 21 electricity and magnetism items, 15 heat and temperature items, and 15 atomic and nuclear physics items. Of these, 18 were classified as measuring knowing, 36 as measuring applying, and 17 as measuring reasoning skills. Compared to the target percentages in the physics framework, there was a relatively greater percentage of applying items and lesser percentage of knowing and reasoning items in the assessment. Two fifths of the items (28) were constructed response and the remainder (42) multiple choice.

Sample Implementation and Participation Rates

The TIMSS Advanced 2008 assessment was administered to scientifically-selected random samples of students from the target populations for advanced mathematics and physics in each country. These target populations were defined as follows: *students in the final year of secondary schooling who have taken courses in advanced mathematics*, and *students in the final year of secondary schooling who have taken courses in physics*. The tracks or programs that define these target populations are presented in detail in Chapter 1 for advanced mathematics and Chapter 7 for physics.

Because the accuracy of the TIMSS results depends on the quality of the national samples, TIMSS Advanced worked with participating countries on all phases of sampling to ensure efficient sampling design and implementation. National coordinators were trained in how to select the school and student samples, and how to use the *WinW3S* sampling software provided by the IEA Data Processing and Research Center. Staff from Statistics Canada reviewed the national sampling plans, sampling data, sampling frames, and sample selections. The sampling documentation was used by the TIMSS & PIRLS International Study Center (in consultation with Statistics Canada and the sampling referee) to evaluate the quality of the samples.

Exhibit A.2 shows that the TIMSS Advanced countries were very successful in developing comprehensive national sampling schemes that covered 100 percent of their intended advanced mathematics and physics target populations. No country found it necessary to restrict coverage by, for example, omitting specific regions or language groups. The countries also were successful in ensuring that the percentage of students excluded from the target populations was below the 5% limit. In fact, in no country was the percentage of excluded students greater

Exhibit A.2: **Coverage of TIMSS Advanced 2008 Target Populations for Advanced Mathematics and Physics**

TIMSSAdvanced2008

Advanced Mathematics

Country	Coverage	School-level Exclusions	Within-sample Exclusions	Overall Exclusions
Armenia	100%	0.0%	0.0%	0.0%
Iran, Islamic Rep. of	100%	0.0%	0.0%	0.0%
Italy	100%	0.0%	0.5%	0.5%
Lebanon	100%	1.3%	0.0%	1.3%
Netherlands	100%	2.5%	0.0%	2.5%
Norway	100%	0.9%	0.1%	1.0%
Philippines	100%	0.0%	0.0%	0.0%
Russian Federation	100%	0.0%	0.0%	0.0%
Slovenia	100%	0.0%	1.3%	1.3%
Sweden	100%	1.5%	0.2%	1.7%

Physics

Country	Coverage	School-level Exclusions	Within-sample Exclusions	Overall Exclusions
Armenia	100%	0.0%	0.0%	0.0%
Iran, Islamic Rep. of	100%	0.0%	0.0%	0.0%
Italy	100%	0.0%	0.9%	0.9%
Lebanon	100%	1.3%	0.0%	1.3%
Netherlands	100%	2.5%	0.2%	2.7%
Norway	100%	0.4%	0.0%	0.5%
Russian Federation	100%	0.0%	0.0%	0.0%
Slovenia	100%	0.0%	0.5%	0.5%
Sweden	100%	2.1%	0.1%	2.3%

SOURCE: IEA TIMSS Advanced 2008 ©

than 3 percent, and Armenia, Iran, the Philippines, and the Russian Federation had no excluded students at all. Usually when students are excluded from testing in large-scale assessments, it is because they are in schools that would be very difficult or resource intensive to test (e.g., schools that were very small or located in remote rural areas) or because they do not have sufficient knowledge of the language of the test or have a disability. However, in order to be part of the advanced mathematics or physics target populations in TIMSS Advanced, students have had to demonstrate a strong track record of achievement in these subjects so there may be relatively fewer students with language learning limitations or disabilities than might be encountered at lower grades.

The differences in how countries organize their education systems to provide advanced courses in mathematics and physics are reflected in marked differences across countries in the proportion of the age cohort that attend such courses in the final year of secondary education. In some countries, only a very select group of students were considered eligible for the study, while in others a much larger group was included. To measure differences in coverage of the national age cohorts, coverage indices were calculated for both the advanced mathematics and physics populations. The TIMSS Advanced Mathematics Coverage Index (TAMCI) and the TIMSS Advanced Physics Coverage Index (TAPCI) identify the percentage of the school-leaving age cohort represented by the advanced mathematics and physics samples, respectively.

The TIMSS Advanced coverage indices for advanced mathematics and physics are defined as follows:

$$\text{TAMCI} = \frac{\text{Estimated total number of students in advanced mathematics target population in 2008}}{\text{Total national population in the corresponding age cohort in 2008}} \times 100\%$$

$$\text{TAPCI} = \frac{\text{Estimated total number of students in physics target population in 2008}}{\text{Total national population in the corresponding age cohort in 2008}} \times 100\%$$

For each index, the *numerator* is the total number of students eligible for TIMSS Advanced, estimated from the weighted sample data. The *denominator* is size of the population age cohort corresponding to the average age of the students in the target populations. Exhibit A.3[2] presents these data for the advanced mathematics and physics populations for each country and the resulting coverage indices. Data on the size of the age cohort were provided by National Research Coordinators from official national statistics (except for Armenia, where data were obtained from the U.S. Census Bureau's International Database). For Armenia, Lebanon, and Slovenia, population data were not available for the specific age cohort corresponding to the TIMSS Advanced sample, but had to be estimated from data spanning several years. In the case of Armenia and Slovenia, the available population figure for the age group 15–19 was divided by 5 to derive an estimate of the single year age cohort: 18-year-olds for Armenia and 19-year-olds for Slovenia. In Lebanon, the population figure for the 18–20 age group was divided by 3 to get an estimate of the size of the 18-year age cohort.

The TIMSS Advanced coverage indices show that the population of students taking advanced course in mathematics or physics (i.e., enrolled in the tracks or programs targeted by TIMSS Advanced 2008) represented a low percentage of the students in the corresponding age cohort. Highest values on the TIMSS Advanced Mathematics Coverage Index were found in Slovenia (40.5%), Italy (19.7%), Sweden (12.8%), and Norway (10.9%), each of which had more than 10 percent of the age cohort eligible for TIMSS Advanced. Countries with lower values included Iran (6.5%), Lebanon (5.9%), Armenia (4.3%), the Netherlands (3.5%), the Russian Federation (1.4%), and the Philippines (0.7%). Only Sweden (11.0%) had more than 10 percent of the age cohort enrolled in advanced physics courses. For the other

2 Exhibit A.3 is derived from Exhibits 1.2 in Chapter 1 and 7.2 in Chapter 7.

Exhibit A.3 **Size of the TIMSS Advanced 2008 Target Populations for Advanced Mathematics and Physics, Age Cohorts, and Coverage Indices**

TIMSSAdvanced2008

Advanced Mathematics

Country	Estimated Size of the Population of Students in the Final Year of Secondary School Taking the Advanced Mathematics Track or Program Targeted by TIMSS Advanced (Derived from TIMSS Advanced Student Sample)	Age Cohort Corresponding to the Final Year of Secondary School	Size of the Age Cohort Corresponding to the TIMSS Advanced Population Based on National Census Figures[a]	TIMSS Advanced Mathematics Coverage Index – the Percentage of the Entire Corresponding Age Cohort Covered by the TIMSS Advanced Target Population
Armenia	2,684	18	62,758	4.3%
Iran, Islamic Rep. of	111,298	18	1,705,000	6.5%
Italy	119,162	19	605,507	19.7%
Lebanon	4,702	18	79,784	5.9%
Netherlands	7,091	18	205,200	3.5%
Norway	6,668	19	61,093	10.9%
Philippines	14,007	16	1,900,656	0.7%
Russian Federation	29,672	17	2,073,041	1.4%
Slovenia	8,836	19	21,815	40.5%
Sweden	16,116	19	125,923	12.8%

Physics

Country	Estimated Size of the Population of Students in the Final Year of Secondary School Taking the Physics Track or Program Targeted by TIMSS Advanced (Derived from TIMSS Advanced Student Sample)	Age Cohort Corresponding to the Final Year of Secondary School	Size of the Age Cohort Corresponding to the TIMSS Advanced Population Based on National Census Figures[a]	TIMSS Physics Coverage Index – the Percentage of the Entire Corresponding Age Cohort Covered by the TIMSS Advanced Target Population
Armenia	2,684	18	62,758	4.3%
Iran, Islamic Rep. of	111,908	18	1,705,000	6.6%
Italy	23,176	19	605,507	3.8%
Lebanon	4,724	18	79,784	5.9%
Netherlands	6,889	18	205,200	3.4%
Norway	4,181	19	61,093	6.8%
Russian Federation	52,934	17	2,073,041	2.6%
Slovenia	1,635	19	21,815	7.5%
Sweden	13,873	19	125,923	11.0%

SOURCE: IEA TIMSS Advanced 2008 ©

a Armenia: Estimate derived by dividing the population of 15–19-year olds by 5 for the single year estimate for the year 2008. Data taken from the U.S. Census Bureau's International Database (www.census.gov/). Iran, Islamic Rep. of: Total population of 18-year olds in Iran in 2008. Data taken from the Statistical Center of Iran (SCI) (http://www.sci.org.ir/portal/faces/public/sci_en). Italy: Total population of 19-year olds in Italy for the year 2008. Data taken from the Italian Bureau of Statistics (ISTAT) (http://demo.istat.it/pop2008/index.html). Lebanon: Estimate derived by dividing the population of 18–20-year olds by 3 for the single year estimate. Data taken from the Central Bureau for Statistics in the Ministry of Interior. Netherlands: Estimate based on data taken from the Central Bureau of Statistics in the Netherlands (www.cbs.nl). Norway: Total population of 19-year olds in Norway on 1 January 2008. Data taken from the Norwegian National Bureau of Statistics (SSB) (http://www.ssb.no/english/). Philippines: Population of 16-year olds for 2008 projected from the 2000 census. Data taken from the National Statistics Office, Philippines (NSO) (http://www.census.gov.ph/). Russian Federation: Total population of 17-year olds in 2008. Data taken from the Federal State Statistics Service (http://www.gks.ru/wps/portal/english). Slovenia: Estimate was derived by dividing the population of 15–19-year olds by 5 for the single year estimate for the year 2008. Data taken from the Statistical Office of the Republic of Slovenia (www.stat.si). Sweden: Total population of 19-year olds in Sweden for the year 2008. Data taken from Statistics Sweden (SCB) (http://www.scb.se/default____2154.aspx). Data provided by National Research Coordinators.

countries, the values of the TIMSS Advanced Physics Coverage Index were as follows: Slovenia (7.5%), Norway (6.8%), Iran (6.6%), Lebanon (5.9%), Armenia (4.3%), Italy (3.8%), the Netherlands (3.4%), and the Russian Federation (2.6%).

The basic sampling design used in TIMSS Advanced 2008 was a two-stage stratified cluster design, with schools sampled at the first stage and one or more intact classes from a list of eligible classes in the school at the second stage.[3] In countries with large school populations (Iran, Italy, and the Russian Federation), schools were selected with probability proportional to size. In Lebanon, the Netherlands, Norway, the Philippines, and Sweden, which had smaller school populations, schools were sampled with equal probabilities, and in Armenia and Slovenia, all schools were included in the sample. In all countries, classes within sampled schools were selected using a systematic random sampling method.

Although TIMSS Advanced aimed for a uniform sampling approach for all countries, the implementation was influenced by the relationship between the advanced mathematics and physics populations and how classrooms were organized in each country. In Armenia, Iran, and Lebanon, with completely overlapping populations (i.e., the populations of advanced mathematics and physics students were identical), there was a single school and class sample, with half the students in the sampled classes randomly assigned a mathematics booklet and the other half a physics booklet. In the Netherlands, Norway, and Sweden, where students could belong to the advanced mathematics population, the physics population, or both, separate school samples were selected, with only the advanced mathematics classes listed for sampling in one sample and only physics classes listed in the other. The Philippines, which assessed students in advanced mathematics only, could be considered a special case of this

3 See LaRoche, S., Zuehlke, O., and Joncas, M. (2009). TIMSS Advanced 2008 sampling. 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.

approach. Italy, the Russian Federation, and Slovenia each had specific issues that required more complex adaptations to the basic sampling approach. These are described in detail in the *TIMSS Advanced 2008 Technical Report*.

Most countries sampled at least 120 schools and at least one intact classroom from each school for each population. This approach was designed to yield a representative sample of at least 2,000 students for each population in each country. Armenia and Slovenia had fewer than 120 eligible schools, and so all were included in the sample.

Exhibits A.4 and A.5 present achieved sample sizes for schools and students, respectively. Exhibit A.6 shows the participation rates for schools, classes, students, and overall—both with and without the use of replacement schools. With the exception of the physics sample in Slovenia, all countries achieved the minimum acceptable participation rates—85 percent of both the schools and students, or a combined rate (the product of school and student participation) of 75 percent—although the Netherlands did so only after including replacement schools. The results for the Netherlands in both subjects and for Slovenia in physics have been annotated in the achievement exhibits contained in this report (see Chapters 2, 3, 8, and 9).

Because an important goal for the TIMSS Advanced 2008 countries that also participated in 1995—Italy, the Russian Federation, Slovenia, and Sweden in advanced mathematics and Norway, the Russian Federation, Slovenia, and Sweden in physics—was to measure changes in students' achievement since 1995, it was important to track any changes in population composition and coverage since they might be related to student achievement. Exhibit A.7 presents, for each of these countries, five attributes of the advanced mathematics and physics populations sampled in 2008 and 1995: number of years of formal schooling, average student age at time of testing, percentage

Exhibit A.4: **School Sample Sizes – Advanced Mathematics and Physics**

TIMSSAdvanced2008

Advanced Mathematics

Country	Number of Schools in Original Sample	Number of Eligible Schools in Original Sample	Number of Schools in Original Sample That Participated	Number of Replacement Schools That Participated	Total Number of Schools That Participated
Armenia	38	38	38	0	38
Iran, Islamic Rep. of	120	120	119	0	119
Italy	100	92	88	3	91
Lebanon	240	240	203	9	212
Netherlands	135	133	102	10	112
Norway	120	120	107	0	107
Philippines	121	120	118	0	118
Russian Federation	143	143	143	0	143
Slovenia	87	82	79	0	79
Sweden	127	126	111	5	116

Physics

Country	Number of Schools in Original Sample	Number of Eligible Schools in Original Sample	Number of Schools in Original Sample That Participated	Number of Replacement Schools That Participated	Total Number of Schools That Participated
Armenia	38	38	38	0	38
Iran, Islamic Rep. of	120	120	119	0	119
Italy	112	91	91	0	91
Lebanon	240	240	201	9	210
Netherlands	135	133	98	18	116
Norway	120	120	101	0	101
Russian Federation	149	149	149	0	149
Slovenia	66	64	54	0	54
Sweden	127	125	119	2	121

SOURCE: IEA TIMSS Advanced 2008 ©

Exhibit A.5: **Student Sample Sizes – Advanced Mathematics and Physics**

TIMSSAdvanced2008

SOURCE: IEA TIMSS Advanced 2008 ©

Advanced Mathematics

Country	Within School Student Participation (Weighted Percentage)	Number of Sampled Students in Participating Schools	Number of Students Withdrawn from Class/ School	Number of Students Excluded	Number of Students Eligible	Number of Students Absent	Number of Students Assessed
Armenia	95%	899	0	0	899	41	858
Iran, Islamic Rep. of	97%	2,556	55	0	2,501	76	2,425
Italy	96%	2,269	15	8	2,246	103	2,143
Lebanon	95%	1,767	36	0	1,731	116	1,615
Netherlands	92%	1,876	200	0	1,676	139	1,537
Norway	89%	2,206	17	2	2,187	255	1,932
Philippines	96%	4,253	3	0	4,250	159	4,091
Russian Federation	98%	3,269	11	0	3,258	73	3,185
Slovenia	85%	2,577	3	22	2,552	396	2,156
Sweden	89%	2,645	26	1	2,618	315	2,303

Physics

Country	Within School Student Participation (Weighted Percentage)	Number of Sampled Students in Participating Schools	Number of Students Withdrawn from Class/ School	Number of Students Excluded	Number of Students Eligible	Number of Students Absent	Number of Students Assessed
Armenia	97%	926	0	0	926	32	894
Iran, Islamic Rep. of	97%	2,556	43	0	2,513	79	2,434
Italy	97%	1,968	18	15	1,935	74	1,861
Lebanon	94%	1,755	35	0	1,720	120	1,600
Netherlands	90%	1,911	203	3	1,705	194	1,511
Norway	86%	1,935	17	1	1,917	275	1,642
Russian Federation	97%	3,269	9	0	3,260	94	3,166
Slovenia	82%	1,404	0	6	1,398	278	1,120
Sweden	92%	2,537	29	4	2,504	213	2,291

Exhibit A.6: **Participation Rates (Weighted) – Advanced Mathematics and Physics**

TIMSSAdvanced 2008

Advanced Mathematics

Country	School Participation Before Replacement	School Participation After Replacement	Class Participation	Student Participation	Overall Participation Before Replacement	Overall Participation After Replacement
Armenia	100%	100%	100%	95%	95%	95%
Iran, Islamic Rep. of	99%	99%	100%	97%	96%	96%
Italy	97%	99%	100%	96%	93%	95%
Lebanon	86%	89%	99%	95%	81%	83%
Netherlands	77%	84%	100%	92%	71%	77%
Norway	94%	94%	100%	89%	83%	83%
Philippines	98%	98%	100%	96%	95%	95%
Russian Federation	100%	100%	100%	98%	98%	98%
Slovenia	96%	96%	100%	85%	81%	81%
Sweden	90%	94%	100%	89%	80%	84%

Physics

Country	School Participation Before Replacement	School Participation After Replacement	Class Participation	Student Participation	Overall Participation Before Replacement	Overall Participation After Replacement
Armenia	100%	100%	100%	97%	97%	97%
Iran, Islamic Rep. of	99%	99%	100%	97%	96%	96%
Italy	100%	100%	100%	97%	97%	97%
Lebanon	85%	88%	99%	94%	80%	82%
Netherlands	73%	87%	100%	90%	65%	78%
Norway	85%	85%	100%	86%	73%	73%
Russian Federation	100%	100%	100%	97%	97%	97%
Slovenia	83%	83%	98%	82%	67%	67%
Sweden	97%	97%	100%	92%	89%	89%

SOURCE: IEA TIMSS Advanced 2008 ©

Exhibit A.7: **Trends in Characteristics of TIMSS Advanced Student Populations**

TIMSSAdvanced 2008

Advanced Mathematics

Country	Years of Formal Schooling*		Average Age at Time of Testing		Exclusion Rates		Mathematics Coverage Index		Overall Participation Rate (After Replacement)	
	2008	1995	2008	1995	2008	1995**	2008	1995	2008	1995
Italy	13	13	19.0	19.1	0.5%	3.8%	19.7%	20.2% ***	94.8%	67.5%
Russian Federation	10/11	11	17.0	16.9	0.0%	2.0%	1.4%	2.0%	97.6%	95.9%
Slovenia	12	12	18.8	18.9	1.3%	6.0%	40.5%	75.4%	81.4%	42.4%
Sweden	12	12	18.8	18.9	1.7%	0.2%	12.8%	16.2%	83.6%	88.6%

Physics

Country	Years of Formal Schooling*		Average Age at Time of Testing		Exclusion Rates		Physics Coverage Index		Overall Participation Rate (After Replacement)	
	2008	1995	2008	1995	2008	1995**	2008	1995	2008	1995
Norway	12	12	18.8	19.0	0.5%	3.8%	6.8%	8.4%	73.0%	83.0%
Russian Federation	10/11	11	17.1	16.9	0.0%	2.0%	2.6%	1.5%	97.3%	95.1%
Slovenia	12	12	18.7	18.8	0.5%	6.0%	7.5%	38.6%	67.1%	43.0%
Sweden	12	12	18.8	18.9	2.3%	0.2%	11.0%	16.3%	89.3%	88.6%

SOURCE: IEA TIMSS Advanced 2008 ©

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

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

*** The 1995 mathematics coverage index for Italy was recomputed for this report and is different from the figure reported in 1995.

of students excluded from the assessment, the advanced mathematics or physics coverage index, and overall sampling participation rate (after replacement).

The participating countries were very similar in 2008 and 1995 for both the advanced mathematics and physics populations with regard to years of formal schooling, average age at time of testing, and exclusion rates. The greatest changes involved Slovenia, which had an TIMSS Advanced Mathematics Coverage Index of 40.5 percent in 2008 compared to 75.4 percent in 1995, and a TIMSS Advanced Physics Coverage Index of 7.5 percent in 2008 compared to 38.6 percent in 1995. Sweden also had a lower coverage index in 2008 than in 1995, although the difference was not so great (12.8% in 2008 compared to 16.2% in 1995 for mathematics, and 11.0% in 2008 compared to 16.3% in 1995 for physics). Slovenia had higher student sampling participation in 2008 than in 1995 (81.4% vs. 42.4% for advanced mathematics, and 67.1% vs. 43.0% for physics). Slovenia did not meet the TIMSS standards for sampling participation in 1995.

Translation and Layout Verification

Participants were given detailed guidelines for translating the TIMSS Advanced 2008 instruments developed in English into their target language(s) and adapting them to be appropriate for their cultural contexts. They also were urged to work with an experienced translator who would be well-suited to the task of working with the TIMSS materials. Because the goal was to create a set of instruments comparable to the originals in terms of difficulty and accessibility, the instruments were subjected to a stringent international translation verification process. Each participant was asked to submit the following materials for verification prior to both the field test and main data collection: items and directions; questionnaires for students, teachers, and schools; manuals; and scoring guides for constructed-response items, where necessary. Verifiers documented their suggestions, and the National Research Coordinators were responsible for reviewing the suggestions and revising the instruments. The verified instruments were used to generate the booklets and questionnaires in their final form and these were submitted to the TIMSS & PIRLS International Study Center for international layout verification. Participants who tested in English also were required to go through the verification steps. Although they had not translated the instruments, the materials were reviewed for national adaptations and comparable layout. Further information is provided in the *TIMSS Advanced 2008 Technical Report*.

Survey Operations for Data Collection

Designing the survey operations for data collection was a collaborative effort between the TIMSS & PIRLS International Study Center, the IEA Secretariat, the IEA Data Processing and Research Center, and Statistics Canada. Data collection involved contacting schools and sampling classes, preparing materials for data collection, administering the assessment, conducting quality control, scoring the assessment, and creating the data files. Detailed information is provided in the *TIMSS Advanced 2008 Technical Report*. However, in brief, guidelines for each of these activities were described in an international set of materials, software, and manuals provided to each National Research Coordinator; for example, manuals for the school coordinator, the test administrators, and the national quality control observers. The school coordinator was responsible for coordinating the testing, including arranging for test administrators, receiving the testing materials, and returning the completed materials to the national center. Within the schools, the assessment was conducted by the test administrator for each class which involved distributing materials to the appropriate students, following the script for the administration, and timing the sessions accurately. During the test administrations, 10 percent of the schools were visited by an International Quality Control Monitor hired by the IEA Secretariat and trained to verify the quality of the materials and adherence to the test administration procedures in each country. Additionally, countries were asked to conduct their own quality control procedures in another 10 percent of sampled schools, based on the international quality control program.

Scoring the Constructed-response Items

Because more than half of the score points on the assessment came from constructed-response items, TIMSS Advanced 2008 had to develop procedures for reliably evaluating student responses within and across countries. To ensure reliable scoring procedures based on the TIMSS Advanced scoring rubrics, the TIMSS & PIRLS International Study Center prepared detailed guides containing the rubrics and explanations of how to implement them, together with example student responses for the various rubric categories. These guides, along with training packets containing extensive examples of student responses for practice in applying the rubrics, were used as a basis for intensive training in scoring the constructed-response items. The training sessions were designed to help representatives of national centers, who would then be responsible for training personnel in their own countries to apply the scoring rubrics reliably.

To gather and document information about the within-country agreement among scorers, TIMSS Advanced arranged to have systematic sub-samples of at least 200 students' responses to each item scored independently by two scorers. Scoring reliability within countries was high. The percentage of agreement for score points, on average, across countries, was 98 percent for advanced mathematics and 97 percent for physics. Country-by-country results are provided in the *TIMSS Advanced 2008 Technical Report*.

While the double scoring of a sample of the student test booklets provided a measure of the consistency with which the constructed-response questions were scored within each country, TIMSS Advanced also took steps to monitor the consistency with which the scoring rubrics were applied across countries. TIMSS Advanced assembled a sample of 100 student responses in English to each of 9 constructed-response items in advanced mathematics and in physics. The set of 900 student responses in each subject was then sent to each TIMSS Advanced participant that had scorers proficient in English, and all responses were scored independently by two of these scorers. Seven countries participated in this exercise for each subject—Armenia, Iran, Italy, Norway, Slovenia, and Sweden participated for both subjects, and were joined by the Philippines for advanced mathematics and by the Russian Federation for physics. With 2 scorers from each of the 7 countries, each student response to an item was scored independently by 14 scorers. Comparing each assigned score with all others gives 91 comparisons for each student response (the number of different pairs of scores that can be made from 14 scores is ${}^{14}C_2 = (14 \times 13) \div 2$). Since there were 100 responses to each item, this gives 9,100 comparisons for each item, and further multiplying by 9 items gives 81,900 comparisons in total for each of advanced mathematics and physics. Agreement across countries was defined in terms of the percentage of these comparisons that were in exact agreement, and it was high: 94 percent for advanced mathematics and 88 percent for physics. Details may be found in the *TIMSS Advanced 2008 Technical Report*.

Test Reliability

As an indication of the reliability of the measurement of student achievement, TIMSS calculated a test reliability coefficient for each country. This coefficient is the median KR-20 reliability across the four test booklets for each subject. Reliabilities ranged across countries from 0.70 to 0.90 for advanced mathematics and from 0.68 to 0.88 for physics. Across all countries, the median reliability coefficient was 0.80 for advanced mathematics and 0.82 for physics. More information may be found in the *TIMSS Advanced 2008 Technical Report*.

Scaling the Achievement Data

The primary approach to reporting the TIMSS Advanced 2008 achievement data was based on item response theory (IRT) scaling methods.[4] Student achievement in advanced mathematics and physics was summarized using 2- and 3-parameter IRT models for dichotomously-scored items (right or wrong), and generalized partial credit models for constructed-response items with two available score points. The IRT scaling method produces a score by averaging the responses of each student to the items that he or she took in a way that takes into account the difficulty and discriminating power of each item. The methodology used in TIMSS Advanced included refinements enabling reliable scores to be produced even though individual students responded to just one assessment booklet. With four advanced mathematics booklets and four physics booklets, each booklet contained about three sevenths of the TIMSS Advanced achievement items in one subject. Thus, TIMSS Advanced has two separate achievement scales: one for advanced mathematics and one for physics.

4 For a detailed description of the TIMSS Advanced 2008 scaling, see 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.

To improve the estimation of summary statistics for student subpopulations, the TIMSS Advanced scaling made use of conditioning and plausible-value technology, whereby five separate estimates of each student's score were generated on each scale, based on the student's responses to the items in that student's booklet and on the student's background characteristics. The five score estimates are known as "plausible values," and the variability between them encapsulates the uncertainty inherent in the score estimation process. The IRT analysis provides a common scale on which performance can be compared across countries. In addition to providing a basis for estimating mean achievement, scale scores permit estimates of how students within countries vary and provide information on percentiles of performance.

An overall advanced mathematics achievement scale and an overall physics achievement scale were produced. In order to measure trends in advanced mathematics achievement and physics achievement between the 1995 and 2008 assessments, the TIMSS Advanced mathematics and physics achievement scales were designed to provide reliable measures on a common scale spanning 1995 and 2008. However, because achievement scaling in TIMSS Advanced 1995 was originally conducted using a 1-parameter model, the 1995 assessment was rescaled using the 2- and 3-parameter model approach.[5] The metric of the scales was established with the re-scaled 1995 assessment data. Treating all countries participating in TIMSS Advanced 1995 equally, the TIMSS Advanced scale average for each subject across those countries was set at 500, and the standard deviation was set at 100. The average and standard deviation of the scale scores are arbitrary and do not affect scale interpretation. Since the countries varied in size, each country was weighted to contribute equally to the mean and standard deviation of the scale. To preserve the metric of the original 1995 scale for use with the 2008 data, the 2008 assessment was scaled using

5 The rescaling of the TIMSS Advanced 1995 data is described in the scaling chapter by Foy, Galia, & Li in the *TIMSS Advanced 2008 Technical Report*. The rescaled 1995 data have been used in all trend analyses.

students from all countries that participated in 1995 and all countries that participated in 2008. All advanced mathematics and physics items from 1995 and 2008 were included in this scaling, including about one third of the items that were used in both assessments and that formed the foundation for linking the 1995 and 2008 assessment data.

Scale Anchoring Analysis

For the scale anchoring analysis described in Chapters 3 and 9, the students' achievement results from all the participating countries were pooled so that the benchmark descriptions refer to all students achieving at that benchmark level. Thus, in determining performance in relation to the benchmarks, it does not matter what country a student is from, only how he or she performed on the test. Considering students' advanced mathematics and physics achievement scores, criteria were applied to identify the sets of items that students reaching each international benchmark were likely to answer correctly and that those at the next lower benchmark were unlikely to answer correctly.

For example, a multiple-choice item anchored at the Advanced International Benchmark if at least 65 percent of students scoring at 625 answered the item correctly and fewer than 50 percent of students scoring at the High International Benchmark (550) answered correctly. Similarly, a multiple-choice item anchored at the High International Benchmark if at least 65 percent of students scoring at 550 answered the item correctly and fewer than 50 percent of students scoring at the Intermediate International Benchmark (475) answered it correctly. A multiple-choice item anchored at the Intermediate International Benchmark if at least 65 percent of students scoring at 475 answered correctly. Since constructed-response questions virtually eliminate guessing, the criterion for the constructed-response items was simply

50 percent at the particular benchmark. Also, the analysis was conducted based on the percentage of students receiving full credit.

The sets of items identified by the scale anchoring analysis represented the accomplishments of students reaching each successively higher benchmark, and were used by the committee of experts[6] that worked with staff of the TIMSS & PIRLS International Study Center to develop the benchmark descriptions. For each benchmark, the work of the committee involved developing a short description for each anchor item that characterized the content knowledge and skills demonstrated by students answering it successfully. These item-by-item descriptions were then summarized by the committee members to provide the more general statements of achievement at each of the benchmarks. The item-by-item descriptions and further details about the analysis can be found in the *TIMSS Advanced 2008 Technical Report*.

The descriptions of achievement at the benchmarks are based solely on student performance on the TIMSS Advanced 2008 items and do not purport to be comprehensive. There are undoubtedly other curriculum elements on which students at the various benchmarks would have been successful if they had been included in the assessment. Also, some students scoring below a benchmark may indeed know or understand some of the concepts that characterize a high level. Finally, describing mathematics or physics concepts or familiarity with procedures was more straightforward than describing the cognitive behavior necessary to answer the item correctly. An item may require only simple recall for a student familiar with the item's content, but necessitate problem-solving strategies from a student unfamiliar with the material. The descriptions are based on what the committee believed to be the way the great majority of advanced mathematics or physics students could be expected to respond to the item.

6 In addition to Robert A. Garden, the TIMSS Advanced Mathematics Coordinator, and Svein Lie, the TIMSS Physics Coordinator, committee members included Carl Angell, Wolfgang Dietrich, Liv Sissel Gronmo, Torgier Onstad, and David F. Robitaille.

Estimating Standard Errors

Because the statistics presented in this report are estimates of national performance based on samples of students—rather than on the values that could be calculated if every student in every country had answered every question—it is important to have measures for the degree of uncertainty of the estimates. The jackknife procedure was used to estimate the standard error associated with each statistic presented in this report.[7] As well as sampling error, the jackknife standard errors also include an error component due to variation among the 5 plausible values generated for each student. The use of confidence intervals (based on the standard errors) provides a way to make inferences about the population means and proportions in a manner that reflects the uncertainty associated with the sample estimates. An estimated sample statistic plus or minus 2 standard errors represents a 95 percent confidence interval for the corresponding population result.

7 Procedures for computing jackknifed standard errors are presented in the scaling chapter by Foy, Galia, & Li in the *TIMSS Advanced 2008 Technical Report*.

Appendix B

The Test-Curriculum Matching Analysis

TIMSS Advanced 2008 went to great lengths to ensure that comparisons of student achievement in advanced mathematics and physics across countries would be as fair and equitable as possible. The *TIMSS Advanced 2008 Assessment Frameworks* was designed to specify the important aspects of advanced mathematics and physics that participating countries agreed should be the focus of an international assessment of student achievement. The assessment items were developed through a collaborative process with national representatives to faithfully represent the specifications in the frameworks, and the items were field tested extensively in participating countries. Finalizing the TIMSS Advanced 2008 assessments involved a series of reviews by representatives of the participating countries, experts in mathematics and physics, and testing specialists. At the end of this process, the National Research Coordinators from each country formally approved the TIMSS Advanced 2008 assessments, accepting them as being sufficiently fair to compare their students' advanced mathematics and physics achievement with that of students from other countries.

Although the assessments were developed to represent agreed-upon frameworks and were intended to have as much in common across countries as possible, it was unavoidable that the match between the TIMSS Advanced 2008 assessments (or tests) and the advanced mathematics and physics curricula would not be the same in all countries. To restrict test items to just those topics included in the curricula of all participating countries and covered in the same sequence would severely limit test coverage and restrict the research questions that the study is designed to address. The tests, therefore, include some items measuring topics unfamiliar to some students in some countries.

The Test-Curriculum Matching Analysis (TCMA) was conducted to investigate the extent to which the TIMSS Advanced 2008 mathematics and physics assessments were relevant to each country's curriculum. The TCMA also investigated the impact on a country's performance of including only achievement items that were judged to be relevant to its own curriculum.[1]

To gather data about the extent to which the TIMSS Advanced 2008 tests were relevant to the curricula of the TIMSS countries, National Research Coordinators were asked to examine each achievement item and indicate whether the item was in their country's intended curriculum for the advanced mathematics and physics programs or tracks assessed by TIMSS Advanced. The National Research Coordinator was asked to assemble a team familiar with these curricula in order to make this determination. Since an item might be in the curriculum for some but not all students in a country, coordinators were asked to consider an item included if it was in the intended curriculum for more than 50 percent of the students. All TIMSS Advanced 2008 participants took part in the TCMA analysis.

1 Because there may also be curriculum areas covered in some countries that are not covered by the TIMSS Advanced 2008 tests, the TCMA does not provide complete information about how well the tests cover the curricula of the countries.

Exhibits B.1 and B.2 present the TCMA results for the TIMSS Advanced 2008 advanced mathematics and physics tests. Exhibit B.1 shows the average percent correct on the advanced mathematics and physics items judged appropriate by each country. Exhibit B.2 shows the standard errors corresponding to the percentages presented in Exhibit B.1.

In Exhibit B.1, the bottom row of the exhibit shows the number of items, in terms of score points, on the entire assessment and the number identified as appropriate in each country. For advanced mathematics, the maximum number of score points in the assessment was 79 points.[2] Generally, the match between the advanced mathematics assessment and the curricula of the countries was very good, with a high proportion of items judged appropriate in each country. Reading along the bottom row, it can be seen that the Russian Federation and the Philippines judged all of the items (all 79 score points) to be appropriate, and the Netherlands (72), Lebanon (76), Iran (76), Slovenia (73), Italy (74), and Norway (73), almost all. Armenia (66) and Sweden (64) had the fewest items judged to be appropriate, but still had more than 80 percent of the total.

In physics, the match between the assessment and the countries' curricula was very good as well, with almost all of the 77 item points[3] judged appropriate in the Netherlands (71), Norway (76), Slovenia (74), the Russian Federation (73), Armenia (77), Sweden (75), and Iran (74). Fewer items were judged appropriate in Italy (57) and especially in Lebanon (47).

Since most countries indicated that at least some items were not included in their intended curriculum at the grade tested, the data were analyzed to determine whether the inclusion of these items had any effect on the international performance comparisons.[4]

2 The TIMSS Advanced 2008 advanced mathematics assessment contained 72 items yielding 82 score points. However, following item review, one item was deleted and response categories were combined for a number of items, resulting in data for reporting on 71 items and 79 score points.

3 The TIMSS Advanced 2008 physics assessment contained 71 items yielding 84 score points. However, following item review, three items were deleted and response categories were combined for a number of items, resulting in data for reporting on 68 items and 77 score points.

4 The advanced mathematics and physics achievement presented in Exhibit B.1 is based on average percent correct, which is different from the average scale scores that are presented in Chapters 2 and 8.

Exhibit B.1 **Average Percent Correct for Test-Curriculum Matching Analysis in Advanced Mathamatics and Physics**

TIMSSAdvanced 2008

Based on Subset of Items Identified by Each Country as Addressing its Curriculum (See Exhibit B.2 for corresponding standard errors)

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

Advanced Mathematics

Country	Average Percent Correct on All Items	Russian Federation	Netherlands	Lebanon	Iran, Islamic Rep. of	Slovenia	Italy	Norway	Armenia	Sweden	Philippines
Russian Federation	57 (1.6)	57	58	57	57	57	57	58	58	58	57
Netherlands	54 (0.5)	54	56	53	55	54	54	55	54	56	54
Lebanon	53 (0.5)	53	53	54	52	53	54	54	53	53	53
Iran, Islamic Rep. of	43 (1.4)	43	44	43	44	43	43	44	47	40	43
Slovenia	36 (0.7)	36	37	36	36	37	36	37	37	35	36
Italy	35 (1.1)	35	36	35	35	35	36	36	36	35	35
Norway	33 (0.7)	33	34	33	34	34	32	34	34	33	33
Armenia	32 (0.7)	32	33	32	33	33	32	33	36	32	32
Sweden	31 (0.7)	31	31	30	31	31	31	31	31	33	31
Philippines	24 (0.6)	24	25	24	24	25	24	25	25	24	24
International Avg.	40 (0.3)	40	41	40	40	40	40	41	41	40	40
Number of Items (Score Points) Identified	79	79	72	76	76	73	74	73	66	64	79

Of the 72 items in the Advanced Mathematics assessment, some extended-response items were scored on a 2-point scale, resulting in 82 total score points. Following item review, one item was deleted and response categories were combined for a number of items, resulting in 71 items and 79 score points.

Physics

Country	Average Percent Correct on All Items	Netherlands	Norway	Slovenia	Russian Federation	Armenia	Sweden	Iran, Islamic Rep. of	Lebanon	Italy
Netherlands	57 (0.7)	57	57	57	57	57	57	57	60	55
Norway	47 (0.7)	47	47	47	46	47	47	47	50	48
Slovenia	47 (0.5)	47	47	47	47	47	47	48	50	49
Russian Federation	46 (1.6)	45	46	46	46	46	45	46	49	47
Armenia	42 (0.7)	42	42	42	42	42	42	42	43	42
Sweden	42 (0.8)	41	42	41	41	42	41	42	46	41
Iran, Islamic Rep. of	37 (1.1)	37	38	37	37	37	37	38	38	40
Lebanon	33 (0.4)	33	33	33	33	33	32	33	40	32
Italy	32 (0.9)	31	32	32	31	32	31	32	35	33
International Avg.	42 (0.3)	42	42	42	42	42	42	43	46	43
Number of Items (Score Points) Identified	77	71	76	74	73	77	75	74	47	57

Of the 71 items in the Physics assessment, some extended-response items were scored on a 2-point scale, resulting in 84 total score points. Following item review, three items were deleted and response categories were combined for a number of items, resulting in 68 items and 77 score points.

( ) Standard errors for the average percent of correct responses on all items appear in parentheses.

SOURCE: IEA TIMSS Advanced 2008 ©

Exhibit B.2 **Standard Errors for the Test-Curriculum Matching Analysis in Advanced Mathematics and Physics**

TIMSSAdvanced 2008

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

Advanced Mathematics

Country	Average Percent Correct on All Items	Russian Federation	Netherlands	Lebanon	Iran, Islamic Rep. of	Slovenia	Italy	Norway	Armenia	Sweden	Philippines
Russian Federation	57 (1.6)	1.6	1.5	1.6	1.5	1.6	1.6	1.5	1.5	1.6	1.6
Netherlands	54 (0.5)	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Lebanon	53 (0.5)	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Iran, Islamic Rep. of	43 (1.4)	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4
Slovenia	36 (0.7)	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
Italy	35 (1.1)	1.1	1.2	1.1	1.2	1.1	1.2	1.2	1.2	1.2	1.1
Norway	33 (0.7)	0.7	0.7	0.6	0.7	0.6	0.6	0.7	0.7	0.7	0.7
Armenia	32 (0.7)	0.7	0.7	0.7	0.7	0.7	0.6	0.7	0.7	0.7	0.7
Sweden	31 (0.7)	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.8	0.7
Philippines	24 (0.6)	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.7	0.6	0.6
International Avg.	40 (0.3)	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Number of Items (Score Points)Identified	79	79	72	76	76	73	74	73	66	64	79

SOURCE: IEA TIMSS Advanced 2008 ©

Of the 72 items in the Advanced Mathematics assessment, some extended-response items were scored on a 2-point scale, resulting in 82 total score points. Following item review, one item was deleted and response categories were combined for a number of items, resulting in 71 items and 79 score points.

Physics

Country	Average Percent Correct on All Items	Netherlands	Norway	Slovenia	Russian Federation	Armenia	Sweden	Iran, Islamic Rep. of	Lebanon	Italy
Netherlands	57 (0.7)	0.8	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.8
Norway	47 (0.7)	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.8	0.7
Slovenia	47 (0.5)	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Russian Federation	46 (1.6)	1.6	1.6	1.6	1.7	1.6	1.6	1.6	1.6	1.7
Armenia	42 (0.7)	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
Sweden	42 (0.8)	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
Iran, Islamic Rep. of	37 (1.1)	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.2
Lebanon	33 (0.4)	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.5	0.4
Italy	32 (0.9)	0.9	0.9	0.9	0.9	0.9	0.9	0.9	1	1
International Avg.	42 (0.3)	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Number of Items (Score Points) Identified	77	71	76	74	73	77	75	74	47	57

Of the 71 items in the Physics assessment, some extended-response items were scored on a 2-point scale, resulting in 84 total score points. Following item review, three items were deleted and response categories were combined for a number of items, resulting in 68 items and 77 score points.

( ) Standard errors for the average percent of correct responses on all items appear in parentheses. The matrix contains standard errors corresponding to the average percent correct responses based on TCMA subset of items, as displayed in Exhibit B.1.

The first data column in the advanced mathematics section of Exhibit B.1 shows the average percent correct on all advanced mathematics test items for each country, together with its standard error. Subsequent columns show the performance of every other country on those items judged appropriate by the country listed at the head of the column. Countries are presented in order of their performance based on average percent correct on all of the advanced mathematics items, from highest to lowest. To interpret this exhibit, choosing a country and reading across its row provides the average percent correct for the students in that country on the items selected by each of the countries listed along the top of the exhibit. For example, the Netherlands, where the average percent correct was 56 percent on the set of advanced mathematics items that it judged appropriate, had, on average, 54 percent of the items judged appropriate by the Russian Federation answered correctly by its students,[5] 53 percent of the items selected by Lebanon, 55 percent of the items selected by Iran, 54 percent of the items selected by Slovenia, and so forth.

The column for a country listed at the top of the matrix for advanced mathematics shows how each of the other countries performed on the set of items selected as appropriate for the students of the country listed at the top. Again using the set of advanced mathematics items selected by the Netherlands as an example, 58 percent of these items, on average, were answered correctly by students in the Russian Federation, 53 percent by students in Lebanon, 44 percent by students in Iran, 37 percent by students in Slovenia, and so forth. The shaded diagonal element in the exhibit shows how each country performed on the set of items that it selected based on its own curriculum. Thus, students from the Netherlands averaged 56 percent correct on the set of items identified by the Netherlands for the analysis.

5 The Russian Federation judged all of the advanced mathematics items to be appropriate to their curriculum, so results based on the Russian selection are identical to the results based on the entire item pool.

For each country's selected items, the international averages across the participating countries are presented in a row in the lower part of the exhibit for each subject. The advanced mathematics averages show that the selections of advanced mathematics items by the participating countries varied only slightly in average difficulty, which is not surprising given that countries included most items in the advanced mathematics assessment. The international averages for physics also did not vary much, although Lebanon's item selection resulted in an international average of 46 percent, some 4 percentage points above the average based on all of the physics items. Clearly, the physics items judged not appropriate for their curriculum were among the more difficult for all of the countries, and omitting them from the analysis resulted in higher achievement for all countries.

Comparing the diagonal element for a country with the overall average percent correct shows the difference between performance on the set of items chosen as appropriate for that country and performance on the test as a whole. In advanced mathematics, countries generally performed better on their own item sets than on the items overall, although not by much. To illustrate, the average percent correct for the Netherlands across all the advanced mathematics items was 54 percent. The diagonal element shows that students from the Netherlands had a slightly greater average percent correct (56 percent) across the set of items selected as appropriate for Dutch students than they did overall. Almost all participants had a difference of 1 or 2 percentage points between the two performance measures, with the largest difference in Armenia (4 percentage points). Armenia also was one of the two countries with relatively fewer advanced mathematics items judged appropriate to their curriculum.

In physics, the Netherlands, Norway, Slovenia, the Russian Federation, and Armenia, all of which rejected very few items, had the same average achievement on their selected items as on the test as a whole. Sweden performed slightly less well on its own item selection, but Iran, Italy, and especially Lebanon performed better on their selected items than on the assessment as a whole.

It is clear that the selection of items did not have a major effect on the relative performance in advanced mathematics or physics among TIMSS Advanced 2008 countries. In both subjects, countries that had relatively high or low performance across all of the items in the assessment also had relatively high or low performance on each of the various sets of items selected for the TCMA. For example, in advanced mathematics, the Russian Federation had the highest average percent correct not only on the assessment as a whole, but also on all of the different item selections, with the Netherlands, Lebanon, and Iran next in order of performance on practically all selections of items.[6] The situation was similar in physics, with the order of average country performance preserved across all item selections.

Even when countries performed better on the items judged by them to be included in their curriculum than they did overall, their performance relative to other participants was little changed. As an example, consider the set of advanced mathematics items selected by the Netherlands (72 score points). The students in the Netherlands did better on these items (56% correct) than on the test as a whole (54% correct). However, most other countries also did better on those items, with an international average of 41 percent correct compared with 40 percent correct overall. A more extreme example may be found in physics, where Lebanon, which rejected more physics items than any other country, had an average percent correct of 40 percent on the physics items it selected, compared to 33 percent on the complete set

6 Small differences in performance between adjacent countries shown in this exhibit usually are not statistically significant. The standard errors for the average percent correct statistics based on the TIMSS Advanced 2008 sample are provided in Exhibit B.2. For any sample average shown in Exhibit B.1, it can be said with 95 percent confidence that the corresponding value in the population falls between the sample estimate plus or minus 2 standard errors.

of physics items. However, every other country also performed better on the Lebanese item selection than on the complete item set, so that relative performance differences among countries were unchanged.

The TCMA results provide evidence that the TIMSS Advanced 2008 advanced assessments constitute a reasonable basis for comparing the advanced mathematics and physics achievements of the participating countries. This result is not unexpected, since making the assessment as fair as possible was a major consideration in test development. The fact that all countries indicated that most items were appropriate for their students means that the different average percent correct estimates were based on many of the same items. Insofar as countries rejected items that would be difficult for their students, these items tended to be difficult for students in other countries as well. The analysis shows that omitting such items tends to improve the results for that country, but also tends to improve the results for all other countries, so that the overall pattern of relative performance is largely unaffected.

Appendix C

Percentiles and Standard Deviations of Achievement

Exhibit C.1 **Percentiles of Achievement in Advanced Mathematics and Physics**

TIMSSAdvanced 2008

SOURCE: IEA TIMSS Advanced 2008 ©

Advanced Mathematics

Country	5th Percentile	10th Percentile	25th Percentile	50th Percentile	75th Percentile	90th Percentile	95th Percentile
Armenia	282 (14.4)	313 (6.6)	363 (3.5)	428 (6.6)	499 (5.2)	562 (7.4)	590 (13.2)
Iran, Islamic Rep. of	345 (6.8)	376 (6.3)	426 (3.8)	491 (9.2)	564 (7.4)	629 (7.7)	666 (11.4)
Italy	287 (13.1)	321 (12.9)	384 (9.7)	453 (10.5)	515 (6.5)	568 (5.5)	599 (17.2)
Lebanon	446 (4.7)	468 (6.4)	504 (2.3)	545 (3.7)	586 (4.2)	622 (3.3)	642 (3.0)
Netherlands	477 (4.8)	494 (2.9)	522 (2.8)	552 (3.3)	582 (2.9)	610 (2.9)	628 (3.2)
Norway	290 (12.5)	324 (10.3)	383 (8.8)	444 (5.9)	499 (5.2)	546 (5.1)	574 (4.7)
Philippines	191 (7.6)	224 (5.9)	281 (5.5)	349 (6.3)	425 (8.0)	494 (8.7)	539 (8.3)
Russian Federation	412 (10.8)	445 (6.9)	499 (7.8)	561 (6.4)	621 (8.0)	677 (13.7)	711 (14.7)
Slovenia	316 (10.4)	350 (4.9)	401 (5.0)	457 (5.1)	513 (4.0)	567 (6.6)	602 (7.5)
Sweden	238 (11.7)	276 (7.9)	340 (6.4)	419 (5.9)	489 (8.3)	544 (7.9)	574 (10.0)

Physics

Country	5th Percentile	10th Percentile	25th Percentile	50th Percentile	75th Percentile	90th Percentile	95th Percentile
Armenia	326 (8.1)	368 (9.7)	430 (7.3)	495 (4.3)	562 (4.4)	623 (13.5)	659 (13.6)
Iran, Islamic Rep. of	278 (7.4)	314 (8.3)	377 (6.4)	454 (7.8)	540 (12.9)	616 (9.2)	656 (9.5)
Italy	252 (10.3)	291 (15.8)	351 (12.8)	422 (8.6)	493 (10.9)	556 (6.7)	593 (9.6)
Lebanon	312 (6.5)	342 (10.5)	391 (5.1)	446 (2.9)	499 (3.3)	544 (4.9)	568 (4.3)
Netherlands	492 (10.3)	512 (4.5)	547 (2.8)	584 (5.9)	619 (4.0)	650 (4.3)	669 (6.1)
Norway	398 (9.5)	434 (8.7)	486 (4.4)	538 (5.0)	586 (5.5)	629 (5.0)	657 (9.6)
Russian Federation	314 (17.3)	361 (21.4)	440 (12.1)	527 (11.6)	605 (13.7)	672 (15.0)	717 (19.7)
Slovenia	403 (7.6)	431 (5.5)	480 (5.0)	538 (3.2)	588 (4.4)	634 (5.9)	666 (6.1)
Sweden	339 (9.8)	375 (13.7)	438 (7.9)	502 (6.5)	563 (4.3)	611 (4.3)	637 (5.1)

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

Exhibit C.2 **Standard Deviations of Achievement in Advanced Mathematics and Physics**

TIMSSAdvanced2008

SOURCE: IEA TIMSS Advanced 2008 ©

Advanced Mathematics

Country	Overall		Females		Males	
	Mean	Standard Deviation	Mean	Standard Deviation	Mean	Standard Deviation
Armenia	433 (3.7)	95 (2.7)	428 (4.8)	89 (3.3)	438 (6.2)	102 (4.9)
Iran, Islamic Rep. of	497 (6.4)	99 (3.2)	480 (6.7)	82 (4.5)	510 (10.0)	108 (4.0)
Italy	449 (7.1)	95 (4.1)	454 (9.3)	87 (6.0)	446 (8.3)	99 (4.4)
Lebanon	545 (2.3)	60 (1.7)	554 (3.2)	56 (2.4)	541 (2.7)	62 (2.1)
Netherlands	552 (2.6)	46 (1.1)	549 (4.2)	45 (2.2)	553 (3.0)	46 (1.1)
Norway	439 (5.0)	87 (2.6)	434 (5.4)	83 (3.9)	443 (5.7)	89 (2.9)
Philippines	355 (5.5)	106 (3.4)	337 (5.5)	98 (2.5)	386 (7.8)	111 (5.2)
Russian Federation	561 (7.2)	91 (3.6)	551 (7.7)	87 (3.8)	569 (7.4)	93 (3.8)
Slovenia	457 (4.2)	85 (2.1)	448 (5.2)	81 (2.6)	472 (4.3)	88 (3.3)
Sweden	413 (5.6)	103 (2.3)	404 (6.9)	101 (3.8)	419 (6.2)	104 (2.7)

Physics

Country	Overall		Females		Males	
	Mean	Standard Deviation	Mean	Standard Deviation	Mean	Standard Deviation
Armenia	495 (5.4)	100 (3.5)	498 (6.0)	96 (4.6)	492 (6.7)	105 (3.8)
Iran, Islamic Rep. of	460 (7.2)	116 (3.8)	437 (7.3)	100 (5.1)	478 (11.5)	124 (4.4)
Italy	422 (7.6)	103 (3.8)	407 (10.6)	95 (5.1)	433 (7.7)	106 (4.4)
Lebanon	444 (3.0)	79 (1.9)	451 (4.3)	71 (2.7)	441 (3.7)	81 (2.7)
Netherlands	582 (3.7)	54 (2.4)	566 (5.1)	53 (2.9)	586 (3.6)	53 (2.5)
Norway	534 (4.2)	78 (2.5)	517 (6.0)	73 (4.3)	541 (4.3)	79 (2.4)
Russian Federation	521 (10.2)	120 (5.5)	498 (10.5)	119 (6.4)	540 (10.3)	119 (5.3)
Slovenia	535 (1.9)	80 (1.8)	535 (5.3)	81 (3.6)	535 (2.7)	80 (2.4)
Sweden	497 (5.7)	92 (3.1)	491 (6.9)	91 (4.6)	500 (6.3)	92 (3.4)

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

Appendix D

Organizations and Individuals Responsible for TIMSS Advanced 2008

Introduction

TIMSS Advanced 2008 was a collaborative effort involving many individuals around the world. This appendix recognizes the individuals and organizations for their contributions. Given the work on TIMSS Advanced 2008 has spanned approximately four years and has involved so many people and organizations, this list may not include all who contributed. Any omission is inadvertent.

Of the first importance, TIMSS Advanced 2008 is deeply indebted to the students, teachers, and school principals who contributed their time and effort to the study.

Management and Coordination

TIMSS Advanced 2008 was conducted by the TIMSS & PIRLS International Study Center at Boston College, which has responsibility for the overall direction and management of IEA's TIMSS and PIRLS projects. Headed by Ina V.S. Mullis and Michael O. Martin, the study center is located in the Lynch School of Education. In carrying out the project, the TIMSS & PIRLS International Study Center worked closely with the IEA Secretariat in Amsterdam, which provided guidance overall and was responsible for verification of all translations produced by the participating countries. The IEA Data Processing and Research Center in Hamburg was responsible for processing and verifying the internal consistency and accuracy of the data submitted by the participants. Statistics Canada in Ottawa was responsible for school and student sampling activities. Educational Testing Service (ETS) in Princeton, New Jersey provided psychometric methodology recommendations addressing calibration and scaling, and also made available software for scaling the achievement data.

The Project Management Team, comprised of the Directors and Senior Management from the TIMSS & PIRLS International Study Center, the IEA Secretariat, the IEA Data Processing and Research Center, Statistics Canada, and ETS, met twice a year throughout the study to discuss progress, procedures, and schedule. In addition, the Directors of the TIMSS & PIRLS International Study Center met with members of IEA's Technical Executive Group twice yearly to review technical issues.

Dr. Robert Garden from New Zealand was the TIMSS Advanced 2008 Mathematics Coordinator and Dr. Svein Lie, from the University of Oslo, was the TIMSS Advanced 2008 Physics Coordinator. Together with the Physics and Mathematics task force, a panel of internationally recognized experts in mathematics and physics research, curriculum, instruction, and assessment, they provided excellent guidance throughout TIMSS Advanced 2008.

To work with the international team and coordinate within-country activities, each participating country designated one or two individuals to be the TIMSS National Research Coordinator or Co-Coordinators, known as the NRCs. The NRCs had the complicated and challenging task of implementing the TIMSS Advanced 2008 study in their countries in accordance with TIMSS guidelines and procedures. The quality of the TIMSS Advanced 2008 assessment and data depends on the work of the NRCs and their colleagues in carrying out the very complex sampling, data collection, and scoring tasks involved.

Continuing the tradition of truly exemplary work established in other TIMSS assessments, the TIMSS Advanced 2008 NRCs performed their many tasks with dedication, competence, energy, and goodwill, and have been commended by the IEA Secretariat, the TIMSS & PIRLS International Study Center, the IEA Data Processing and Research Center, and Statistics Canada for their commitment to the project and the high quality of their work.

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