Pursuing Excellence

A Study of U.S. Eighth-Grade Mathematics and Science Teaching, Learning, Curriculum, and Achievement in International Context

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Initial Findings from the
Third International Mathematics and Science Study

U.S. Department of Education
Richard W. Riley
Secretary

Office of Educational Research and Improvement
Sharon P. Robinson
Assistant Secretary

National Center for Education Statistics
Pascal D. Forgione, Jr.
Commissioner of Education Statistics

National Center for Education Statistics

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National Center for Education Statistics
Office of Educational Research and Improvement
U.S. Department of Education
555 New Jersey Avenue NW
Washington, DC 20208-5574
Contact: (202) 219-1395

Suggested Citation:
U.S. Department of Education. National Center for Education Statistics,
Pursuing Excellence, NCES 97-198,
Washington D.C.: U.S. Government Printing Office, 1996.

November 1996

Available for downloading at http://www.ed.gov/NCES/timss

COMMISSIONER'S STATEMENT

With data on half a million students from 41 countries, the Third International Mathematics and Science Study (TIMSS) is the largest, most comprehensive, and most rigorous international study of schools and students ever. This report, *Pursuing Excellence*, is a synthesis of initial findings from TIMSS on U.S. eighth-grade mathematics and science education, providing a comparative picture of education in the United States and the world that can be used to examine our education system, scrutinize improvement plans, and evaluate proposed standards and curricula. Subsequent TIMSS reports will examine U.S. mathematics and science education for fourth and twelfth-grade students in an international context.

TIMSS is significant not only because of its scope and magnitude, but also because of innovations in its design. In this international study, the National Center for Education Statistics (NCES) combined multiple methodologies to create an information base that goes beyond simple student test score comparisons and questionnaires to examine the fundamental elements of schooling. Innovative research techniques include analyses of textbooks and curricula, videotapes, and ethnographic case studies. The result is a more complete and accurate portrait of how U.S. mathematics and science education differs from that of other nations, with extended comparisons to Germany and Japan.

The information in these reports can serve as a starting point for our efforts to define a "world-class" education. If the U.S. is to improve the mathematics and science education of its students, we must carefully examine not just how other countries rank, but also how their polices and practices help student achieve. TIMSS shows us where U.S. education stands — not just in terms of test scores, but also what is included in textbooks, taught in schools, and learned by students. Examining these data provides a unique opportunity to shed new light on education in the United States through the prism of other countries. As the same time, we should avoid the temptation to zero in on any one finding or leap to a conclusion without carefully considering the broader context.

This report is only the first of many NCES investigations into TIMSS data. Additional reports will be released throughout the coming year, including linkages of student achievement in U.S. states to achievement in the TIMSS countries, as well as findings on fourth and twelfth grade students. Moreover, NCES plans to make TIMSS the most accessible international education study ever by releasing the data to scholars and the research community, and actively disseminating the findings to policymakers, educators, parents, and others concerned with quality education. Beginning with this report, NCES is releasing the information in a variety of new forms, including CD-ROM, videotape, and the World-Wide Web. Visit the NCES TIMSS website at "http://www.ed.gov/NCES/timss" for further information.

In all these efforts, our purpose is not just to take a snapshot of the present, but to develop a valuable resource for school improvement efforts. TIMSS clearly and accurately provides a wealth of useful data and information on curriculum, instruction, teacher and student lives, and student achievement. The investment in TIMSS can enhance the quality of our nation's mathematics and science education, and improve the performance of our students to a more internationally competitive level.

Pascal D. Forgione Jr.
Commissioner of Education Statistics

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PREFACE

The Third International Mathematics and Science Study (TIMSS) is the largest, most comprehensive, and most rigorous international comparison of education ever undertaken. During the 1995 school year, the study tested the math and science knowledge of a half-million students from 41 nations at five different grade levels. In addition to tests and questionnaires, it included a curriculum analysis, videotaped observations of mathematics classrooms, and case studies of policy issues.

- TIMSS' rich information allows us not only to compare achievement, but also provides insights into how life in U.S. schools differs from that in other nations.

- This report on eighth-grade students is one of a series of reports that will also present findings on student achievement at fourth grade, and at the end of high school, as well as on various other topics.

ACHIEVEMENT

One of our national goals is to be "first in the world in mathematics and science achievement by the year 2000," as President Bush and 50 governors declared in 1989. Although we are far from this mark, we are on a par with other major industrialized nations like Canada, England, and Germany.

- In mathematics, U.S. eighth graders score below the international average of the 41 TIMSS countries. Our students' scores are not significantly different from those of England and Germany.

- In science, U.S. eighth graders score above the international average of 41 TIMSS countries. Our students' scores are not significantly different from those of Canada, England, and Germany.

- In mathematics, our eighth-grade students' standing is at about the international average in Algebra; Fractions; and Data Representation, Analysis, and Probability. We do less well in Geometry; Measurement; and Proportionality.

- In science, our eighth graders' standing is above the international average in Earth Science, Life Science, and Environmental Issues. Our students score about average in Chemistry and Physics.

- If an international talent search were to select the top 10 percent of all students in the 41 TIMSS countries, in mathematics 5 percent of U.S. students would be included. In science 13 percent would be included.

CURRICULUM

U.S. policy makers are concerned about whether expectations for our students are high enough, and in particular whether they are as challenging as those of our foreign economic partners. In all countries, the relationship between standards, teaching, and learning is complex. This is even more true in the U.S., which is atypical among TIMSS countries in its lack of a nationally defined curriculum.

- The content taught in U.S. eighth-grade mathematics classrooms is at a seventh-grade level in comparison to other countries.

- Topic coverage in U.S. eighth-grade mathematics classes is not as focused as in Germany and Japan.

- In science, the degree of topic focus in the U.S. eighth-grade curriculum may be similar to that of other countries.

- U.S. eighth graders spend more hours per year in math and science classes than German and Japanese students.

TEACHING

In recent years, concern about the quality of instruction in U.S. classrooms has led mathematics professional organizations to issue calls for reform. However, TIMSS data cannot tell us about the success of these reform efforts for several reasons, including the fact that this assessment occurred too soon after the beginning of the reform for states and districts to have designed their own programs, retrained teachers, and nurtured a generation of students according to the new approach. Also, we do not have comparable earlier baseline information against which to compare the findings from TIMSS. However, TIMSS includes the first large-scale observational study of U.S. teaching ever undertaken, and this can form a baseline against which future progress may be judged.

- U.S. mathematics classes require students to engage in less high-level mathematical thought than classes in Germany and Japan.

- U.S. mathematics teachers' typical goal is to teach students how to do something, while Japanese teachers' goal is to help them understand mathematical concepts.

- Japanese teachers widely practice what the U.S. mathematics reform recommends, while U.S. teachers do so infrequently.

- Although most U.S. math teachers report familiarity with reform recommendations, only a few apply the key points in their classrooms.

TEACHERS' LIVES

The training that teachers receive before they enter the profession and the regular opportunities that they have for on-the-job learning and improvement of their teaching affect the quality of the teaching force. The collegial support that teachers receive and the characteristics of their daily lives also affect the type of teaching they provide.

- Unlike new U.S. teachers, new Japanese and German teachers undergo long-term structured apprenticeships in their profession.

- U.S. teachers have more college education than their colleagues in all but a few TIMSS countries.

- Japanese teachers have more opportunities to discuss teaching-related issues than do U.S. teachers.

- Student diversity and poor discipline are challenges not only for U.S. teachers, but for German teachers as well.

STUDENTS' LIVES

The manner in which societies structure the schooling process gives rise to different opportunities and expectations for young people. The motivators, supports, and obstacles to study in each country are outgrowths of the choices provided by society and schools.

- Eighth-grade students of different abilities are typically divided into different classrooms in the U.S., and into different schools in Germany. In Japan, no ability grouping is practiced at this grade level.
- In mathematics, U.S. students in higher ability-level classes study different material than students in lower-level classes. In Germany and Japan, all students study basically the same material, although in Germany the depth and rigor of study depends on whether the school is for students of higher or lower ability levels.
- Japanese eighth-graders are preparing for a high-stakes examination to enter high school at the end of ninth grade.
- U.S. teachers assign more homework and spend more class time discussing it than teachers in Germany and Japan. U.S. students report about the same amount of out-of-school math and science study as their Japanese and German counterparts.
- Heavy TV watching is as common among U.S. eighth graders as it is among their Japanese counterparts.

CONCLUSIONS

This report presents initial findings from TIMSS for eighth-grade mathematics and science. A fuller understanding of our nation's educational health must await data from the fourth and twelfth-grade levels. The search for factors associated with student performance is complicated because student achievement after eight years of schooling is the product of many different factors. Furthermore, the U.S. education system is large and decentralized with many interrelated parts. No single factor in isolation from others should be regarded as the answer to improving the performance of U.S. eighth-grade students. With these cautions in mind, this report offers the following insights into factors that may be associated with our students' performance:

- The content of U.S. eighth-grade mathematics classes is not as challenging as that of other countries, and topic coverage is not as focused.
- Most U.S. mathematics teachers report familiarity with reform recommendations, only a few apply the key points in their classrooms.
- Evidence suggests that U.S. teachers do not receive as much practical training and daily support as their German and Japanese colleagues.

TIMSS is not an answer book, but a mirror through which we can see our own education system in international perspective. Careful study of our nation's reflection in the mirror of international comparisons will assist educators, business leaders, teachers, and parents as they guide our nation in the pursuit of excellence.

PREFACE

KEY POINTS:

The Third International Mathematics and Science Study (TIMSS) is the largest, most comprehensive, and most rigorous international comparison of education ever undertaken.

TIMSS' rich information allows us not only to compare achievement, but also to understand how life in U.S. schools differs from that in other nations.

This report on eighth-grade students is the first of a series of reports that will present findings on student achievement at the fourth grade, at the end of high school, as well as on various other topics.

OVERVIEW

The Third International Mathematics and Science Study is the largest and most comprehensive comparative international study of education that has ever been undertaken. A half-million students from 41 countries were tested in 30 different languages at five different grade levels to compare their mathematics and science achievement. Intensive studies of students, teachers, schools, curriculum, instruction, and policy issues were also carried out to understand the educational context in which learning takes place.

TIMSS COUNTRIES

AUSTRALIA	KOREA
AUSTRIA	KUWAIT
BELGIUM (FLEMISH)	LATVIA
BELGIUM (FRENCH)	LITHUANIA
BULGARIA	NETHERLANDS
CANADA	NEW ZEALAND
COLOMBIA	NORWAY
CYPRUS	PORTUGAL
CZECH REPUBLIC	ROMANIA
DENMARK	RUSSIAN FEDERATION
ENGLAND	SCOTLAND
FRANCE	SINGAPORE
GERMANY	SLOVAK REPUBLIC
GREECE	SLOVENIA
HONG KONG	SOUTH AFRICA
HUNGARY	SPAIN
ICELAND	SWEDEN
IRAN, ISLAMIC REPUBLIC	SWITZERLAND
IRELAND	THAILAND
ISRAEL	UNITED STATES
JAPAN	

TIMSS is an important study for those interested in U.S. education. In 1983, the National Commission on Excellence in Education pointed to our nation's low performance in international studies as evidence that we were A Nation at Risk. In 1989, President Bush and the governors of all 50 states adopted the National Goals for Education, one of which was that "by the year 2000, the U.S. will be first in the world in mathematics and science achievement." Mathematics and science experts have issued major calls for reform in the teaching of their subjects. The National Council of Teachers of Mathematics published Curriculum and Evaluation Standards in 1989, and Professional Standards for Teaching Mathematics in 1991. In 1993 the American Association for the Advancement of Science followed suit with Benchmarks for Science Literacy, and in 1996, the National Academy of Sciences published National Science Education Standards.

TIMSS helps us measure progress toward our national goal of improving our children's academic performance in mathematics and science. But TIMSS is much more than a scorecard for the math and science events in the "educational Olympics." It is a diagnostic tool to help us examine our nation's progress toward improvement of mathematics and science education. It was designed to look behind the scorecard to illuminate how our education policies and practices compare to those of the world community.

TIMSS helps us answer the following questions about our nation's mathematics and science learning:

- Are U.S. curricula and expectations for student learning as demanding as those of other nations?
- Is the level of classroom instruction in the U.S. as high as that in other countries?
- Do U.S. teachers receive as much support in their efforts to teach students as their colleagues in other nations?
- Are U.S. students as focused on their studies as their international counterparts?

This report draws from the many reports and parts of the TIMSS study to summarize the initial findings concerning achievement and schooling in the eighth grade. It is part of the first of three waves of TIMSS reports. It will be followed in the next year by a series of reports focusing on the fourth grade, then by a series focusing on the last year of high school. Additional reports on selected topics will be published over the next several years. Much more will be learned as further analysis of the eighth grade data is carried out and findings from grades four and twelve are added.

TIMSS is a fair and accurate comparison of mathematics and science achievement in the participating nations. It is not a comparison of "all of our students, with other nations' best," a charge which some critics have leveled at previous international comparisons. The students who participated in TIMSS were randomly selected to represent all students in their respective nations. The entire assessment process was scrutinized by international technical review committees to ensure its adherence to established standards. Those nations in which irregularities arose are clearly noted in this and other TIMSS reports.

At each step of its development, TIMSS used careful quality control procedures. An international curriculum analysis was carried out prior to the development of the assessments to ensure that the tests reflect the math and science curricula of the variety of TIMSS countries and do not over-emphasize what is taught in only a few. International monitors carefully checked the test translations and visited many classrooms while the tests were being administered in each of the 41 countries to make sure that the instructions were properly followed. The raw data from each country were scrutinized to be sure that no anomalies existed, and all analyses were double checked. Finally, this report has been written and carefully reviewed to avoid over-generalization and inaccuracy.

STUDY DESIGN

TIMSS is the third comparison of mathematics and science achievement carried out by the International Association for the Evaluation of Educational Achievement (IEA). Previous IEA studies of mathematics and science were conducted for each subject separately at various times during the 1960s, 1970s, and 1980s. This is the first time that IEA has assessed both mathematics and science in the same study. Comparative studies of other subjects, including reading literacy (1992)[1], and computers in education (1993)[2] have also been published by the IEA.

TIMSS was designed to focus on students at three different stages of schooling: midway through elementary school, midway through lower secondary school, and at the end of upper secondary school. Because countries around the world set different ages at which children should begin school, decisions about which students should be tested needed to take both age and grade level into account. The populations tested are listed below. Participation in Population 2 was required of all TIMSS nations, but participation in Populations 1 and 3 was optional.

- Population 1 - those students enrolled in the pair of adjacent grades that contained the most nine-year-olds. (Grades 3 and 4 in the U.S. and most of the world. Grades 2 and 3 in a few nations.)
- Population 2 - those students in the pair of adjacent grades that contained the most thirteen-year-olds at the time of testing. (Grades 7 and 8 in the U.S. and most of the world. Grades 6 and 7 in a few nations.)
- Population 3 - students in their final year of secondary school, whatever their age. (Grade 12 in the U.S. and most nations. Grades 9-13 in some nations.)

In all countries, students in both public and private schools received the TIMSS test. In all but a few of the 41 TIMSS countries, virtually all population 1 and 2 children are enrolled in school and were therefore eligible to take the test. Testing occurred 2 to 3 months before the end of the 1995-96 school year. Students with special needs and disabilities which would make it difficult for them to take the test were excused from the assessment. In each country, the test was translated into the primary language or languages of instruction. All testing in the U.S. was done in the English language.

TIMSS includes five different parts: assessments, questionnaires, curriculum analyses, videotapes of classroom instruction, and case studies of policy topics. The study was designed to bring a variety of different and complementary research methods to bear on important policy questions. The use of multiple methodologies has three major benefits. First, it strengthens the conclusions of the study because researchers are able to cross-check key findings by comparing results based on different research methods. Second, it provides broader information because more different types data are gathered than can be acquired through a single method or instrument. Third, the use of multiple methodologies enriches understanding of the contextual meaning of key findings. Each of the five parts on its own represents an important advance in its field. Taken together, they provide an unprecedented opportunity to understand U.S. mathematics and science education from a new and richer perspective.

At population 2, all 41 TIMSS countries participated in the following three IEA-sponsored parts of the study:

- Math and science assessments - One and a half hours in length, the assessments included both multiple-choice and free-response items. A smaller number of students also completed "hands-on" performance assessments, to be reported later.

- School, teacher, and student questionnaires - Students answered questions about their mathematics and science studies and beliefs. Teachers answered questions on their beliefs about math and science and on teaching practices. School administrators answered questions about school policies and practices.

- Curriculum analysis - This exploratory study compared mathematics and science curriculum guides and textbooks. It studied subject-matter content, sequencing of topics, and expectations for student performance.

In conjunction with these three activities, the United States sponsored two additional parts of TIMSS, which were carried out in Germany, Japan, and the U.S. These three countries are all economic superpowers with close economic and political ties. They also are nations whose educators have learned a great deal from each other in the past, and whose school systems are both similar to and different from each other in important ways. The TIMSS researchers in Germany, Japan, and U.S. collaborated in sharing their assessment and questionnaire data, and in carrying out the following two parts of the study:

- Videotapes of mathematics instruction - In the U.S. and Germany, half of the eighth-grade mathematics classrooms that participated in the main TIMSS study were randomly chosen to be filmed. In Japan, an eighth-grade classroom in a random sample of 50 of the TIMSS schools was chosen to be videotaped. In all three countries teachers were filmed teaching a typical lesson, and these tapes were analyzed to compare teaching techniques and the quality of instruction.

- Ethnographic case studies of key policy topics - A team of 12 bilingual researchers each spent three months in Germany, Japan, or the U.S. observing classrooms and interviewing education authorities, principals, teachers, students, and parents. Topics of study were education standards, methods of dealing with individual differences, the lives and working conditions of teachers, and the role of school in adolescents' lives.

More detail on the findings and methodology of each of these parts of TIMSS can be found in the additional reports listed in Appendix 1.

THE TIMSS RESEARCH TEAM

TIMSS was conducted by the IEA, which is a Netherlands-based organization of ministries of education and research institutions in its member countries. The IEA delegated responsibility for overall coordination and management of the TIMSS study to Professor Albert Beaton at the TIMSS International Study Center, located at Boston College. Each of the 41 IEA member-nations that made the decision to participate in TIMSS paid for and carried out the data collection in its own country according to the international guidelines. The costs of the international coordination were paid by the National Center for Education Statistics of the U.S. Department of Education (NCES), the National Science Foundation (NSF), and the Canadian Government.

TIMSS in the United States was also funded by NCES and NSF. Professor William Schmidt of Michigan State University was the U.S. National Research Coordinator. Policy decisions on the study were made by the U.S. National Coordinating Committee, composed of William Schmidt, Larry Suter of NSF, and Jeanne Griffith, Eugene Owen, and Lois Peak of NCES. Lois Peak monitored the international and U.S. TIMSS data collections. The U.S. data collection was carried out by Westat, a private survey research firm. Trevor Williams and Nancy Caldwell were Westat project co-directors. Professor James Stigler at UCLA managed the TIMSS videotape study of mathematics instruction, and Professor Harold Stevenson at the University of Michigan managed the TIMSS ethnographic case studies. The many advisors to the study are listed in Appendix 2.

The U.S. TIMSS team also includes the nearly 4,000 seventh and 7,000 eighth graders who took the assessment, and their principals and teachers in more than 180 schools nationwide. Their cooperation has made this report possible. Third, fourth, and twelfth graders also took different TIMSS tests, and findings from these parts of the study will be reported during the next year.

ORGANIZATION OF THIS REPORT

This report summarizes early findings from the eighth-grade data based on results from all five parts of the TIMSS study. Both seventh and eighth grade students took the TIMSS test, but this initial report focuses on findings for the eighth grade. Future reports based on a more complete and extensive analysis of the data will provide deeper understanding and investigate relationships between the findings from the different parts of the study. Science teacher questionnaire data used in this report are based on preliminary weights which will be further refined in subsequent reports. Extensive documentation of the data collection methodologies and statistical analyses used in this report are available from NCES, and will be published separately.

This report combines the major findings from each of the five parts of the study into a single story about U.S. eighth-grade mathematics and science achievement in comparative perspective. In some respects, results for mathematics and science are similar. The report focuses more on mathematics for two reasons. First, the way in which the subject is taught makes it easier to compare across countries. Second, TIMSS contains more data about mathematics because the videotapes of classroom instruction were conducted only in this subject. Discussion of findings notes where the results in science differ from those in math. This report describes the U.S. against the backdrop of the 41 TIMSS countries, with a special attention to comparisons with Germany and Japan, because we have more information on these countries.

Chapter 1 draws from the results of the student assessments to describe how U.S. students perform in mathematics and science. Succeeding chapters focus on factors which may have an important influence on achievement, and describe how our nation's schools, teachers, and students compare to those in other countries. Chapter 2 examines educational standards and the curriculum, based on data from the curriculum analysis, case studies, videotape study, and questionnaires. Chapter 3 focuses on how teachers actually teach that curriculum, drawing from results of the videotape study and questionnaires. Chapter 4 examines the working life of teachers, based upon findings from the case studies and questionnaires. Chapter 5 describes the lives of students, both in and out of school, based upon case study and questionnaire data. The Conclusions at the end of the report looks across all of the findings for insights about factors associated with student performance and indicates questions for further study.

CHAPTER 1: ACHIEVEMENT

KEY POINTS:

U.S. eighth graders score below average in mathematics achievement and above average in science achievement, compared to the 41 nations in the TIMSS assessment.

In mathematics, our eighth-grade students' international standing is stronger in Algebra and Fractions than in Geometry and Measurement.

In science, our eighth graders' international standing is stronger in Earth Science, Life Science, and Environmental Issues than in Chemistry and Physics.

The U.S. is one of 11 TIMSS nations in which there is no significant gender gap in eighth-grade math and science achievement.

In the past, the mathematics and science achievement of U.S. students has caused nation-wide cries for improvement. Various international studies of these subjects conducted over the past thirty years have shown that our eighth graders have not performed as well as we expect, in comparison to their peers in other nations. U.S. students are not weak in all subjects, however. In a recent IEA study of reading literacy[3], U.S. eighth graders were among the best in the world. Indeed, TIMSS shows that U.S. eighth grade students also scored better than the average of the 41 participating countries in science. The results in mathematics, however, put our nation below average compared to the other nations.

HOW WELL DO U.S. STUDENTS DO?

Compared to their international counterparts, U.S. students are somewhat below the international average of 41 TIMSS countries in mathematics. In science, our students are somewhat above the international average. Figures 1 and 2 on pages 20 and 21 show how U.S. students perform in these subjects.

Tempting as it may be, it is not correct to report U.S. scores by rank alone, as would be the case if one were to say the U.S. is "number x in mathematics out of the 41 TIMSS countries." This is because the process of estimating each country's score from the sample of students who took the test produces only an estimate of the range within which the country's real score lies. This margin of error is expressed as a "plus or minus" interval around the estimated score. In TIMSS, we can say with 95 percent confidence that comparisons of other countries to the U.S. are accurate plus or minus about 20 points, depending on the size and design of the sample in the other countries. Comparisons of the U.S. to the international average are accurate plus or minus about 10 points. (Appendix 3 contains a list of standard errors). Because the precise score cannot be determined with perfect accuracy, to fairly compare the U.S. to other countries, nations have been grouped into broad bands according to whether their performance is higher than, not significantly different from, or lower than the U.S.

In mathematics, students in 20 countries outperform our eighth graders. Students in 13 countries are not significantly different than ours, and U.S. students outperform their counterparts in 7 nations. In science, students in 9 nations outperform U.S. eighth graders, performance in 16 other nations is not statistically different than ours, and we outperform another 15 nations.

SOME SPECIAL NOTES ON THE TEST SCORES

TIMSS required participating nations to adhere to extremely high technical standards at all stages of participation in the project. Many nations experienced some difficulty in this respect. In two nations, difficulties in meeting the standards were so severe that international monitors decided that their data should not be included in the report, and so findings are reported only for the remaining 41 nations. Of the 41 nations, 25 met or came close to meeting all technical standards for the study. However, 16 nations experienced difficulties of various types. In some countries, these

FIGURE 1:
Nations' Average Mathematics Performance Compared to the U.S.

NATIONS WITH AVERAGE SCORES SIGNIFICANTLY HIGHER THAN THE U.S.

NATION	AVERAGE
SINGAPORE	643
KOREA	607
JAPAN	605
HONG KONG	588
BELGIUM-FLEMISH °	565
CZECH REPUBLIC	564
SLOVAK REPUBLIC	547
SWITZERLAND °	545
(NETHERLANDS)	541
(SLOVENIA)	541
(BULGARIA)	540
(AUSTRIA)	539
FRANCE	538
HUNGARY	537
RUSSIAN FEDERATION	535
(AUSTRALIA)	530
IRELAND	527
CANADA	527
(BELGIUM-FRENCH)	526
SWEDEN	519

International Average = 513

SOURCE: Beaton et al. (1996) Mathematics achievement in the middle school years. Table 1.1. Boston College: Chestnut Hill, MA.

NATIONS WITH AVERAGE SCORES NOT SIGNIFICANTLY DIFFERENT FROM THE U.S.

NATION	AVERAGE
(THAILAND)	522
(ISRAEL) *	522
(GERMANY) * °	509
NEW ZEALAND	508
ENGLAND * °	506
NORWAY	503
(DENMARK)	502
UNITED STATES °	500
(SCOTLAND)	498
LATVIA (LSS) °	493
SPAIN	487
ICELAND	487
(GREECE)	484
(ROMANIA)	482

NATIONS WITH AVERAGE SCORES SIGNIFICANTLY LOWER THAN THE U.S.

NATION	AVERAGE
LITHUANIA *	477
CYPRUS	474
PORTUGAL	454
IRAN, ISLAMIC REPUBLIC	428
(KUWAIT)	392
(COLOMBIA)	385
(SOUTH AFRICA)	354

NOTES:
1. Nations not meeting international guidelines are shown in parentheses.
2. Nations in which more than 10 percent of the population was excluded from testing are shown with a *. Latvia is designated LSS because only Latvian-speaking schools were tested, which represents less than 65 percent of the population.
3. Nations in which a participation rate of 75 percent of the schools and students combined was achieved only after replacements for refusals were substituted, are shown with a °.
4. The international average is the average of the national averages of the 41 nations.
5. The country average for Sweden may appear to be out of place; however, statistically, its placement is correct.

difficulties arose because a large proportion of schools, teachers, or students declined to take the test. In others, the selection of schools or classrooms was not carried out according to international plan. In still others, students were slightly older than the international target age. The names of those nations in which major difficulties arose are shown in parentheses in the figures in this report, and Appendix 4 describes any deviations from international specifica-

(continued on page 23)

FIGURE 2:
Nations' Average Science Performance Compared to the U.S.

NATIONS WITH AVERAGE SCORES SIGNIFICANTLY HIGHER THAN THE U.S.

NATION	AVERAGE
SINGAPORE	607
CZECH REPUBLIC	574
JAPAN	571
KOREA	565
(BULGARIA)	565
(NETHERLANDS)	560
(SLOVENIA)	560
(AUSTRIA)	558
HUNGARY	554

NATIONS WITH AVERAGE SCORES NOT SIGNIFICANTLY DIFFERENT FROM THE U.S.

NATION	AVERAGE
ENGLAND * °	552
BELGIUM-FLEMISH °	550
(AUSTRALIA)	545
SLOVAK REPUBLIC	544
RUSSIAN FEDERATION	538
IRELAND	538
SWEDEN	535
UNITED STATES °	534
(GERMANY) * °	531
CANADA	531
NORWAY	527
NEW ZEALAND	525
(THAILAND)	525
(ISRAEL) *	524
HONG KONG	522
SWITZERLAND °	522
(SCOTLAND)	517

NATIONS WITH AVERAGE SCORES SIGNIFICANTLY LOWER THAN THE U.S.

NATION	AVERAGE
SPAIN	517
FRANCE	498
(GREECE)	497
ICELAND	494
(ROMANIA)	486
LATVIA (LSS) °	485
PORTUGAL	480
(DENMARK)	478
LITHUANIA *	476
(BELGIUM-FRENCH)	471
IRAN, ISLAMIC REPUBLIC	470
CYPRUS	463
(KUWAIT)	430
(COLOMBIA)	411
(SOUTH AFRICA)	326

International Average = 516

SOURCE: Beaton et al. (1996) Science achievement in the middle school years. Table 1.1. Boston College: Chestnut Hill, MA.

NOTES:
1. Nations not meeting international guidelines are shown in parentheses.
2. Nations in which more than 10 percent of the population was excluded from testing are shown with a *. Latvia is designated LSS because only Latvian-speaking schools were tested, which represents less than 65 percent of the population.
3. Nations in which a participation rate of 75 percent of the schools and students combined was achieved only after replacements for refusals were substituted, are shown with a °.
4. The international average is the average of the national averages of the 41 nations.
5. The country average for Scotland (or Spain) may appear to be out of place; however, statistically, its placement is correct.

FIGURE 3:
Average Achievement of Nations Meeting, and Not Meeting, International Guidelines

COUNTRIES COMPLYING WITH SPECIFICATIONS

Nation	Math Average	Science Average
BELGIUM-FLEMISH °	565	550
CANADA	527	531
CYPRUS	474	463
CZECH REPUBLIC	564	574
ENGLAND *°	506	552
FRANCE	538	498
HONG KONG	588	522
HUNGARY	537	554
ICELAND	487	494
IRAN, ISLAMIC REPUBLIC	428	470
IRELAND	527	538
JAPAN	605	571
KOREA	607	565
LATVIA (LSS) °	493	485
LITHUANIA *	477	476
NEW ZEALAND	508	525
NORWAY	503	527
PORTUGAL	454	480
RUSSIAN FEDERATION	535	538
SINGAPORE	643	607
SLOVAK REPUBLIC	547	544
SPAIN	487	517
SWEDEN	519	535
SWITZERLAND °	545	522
UNITED STATES°	**500**	**534**
INTERNATIONAL AVERAGE =	527	527

Notes:

1. Nations in which more than 10 percent of the population was excluded from testing are shown with a *. Latvia is designated LSS because only Latvian-speaking schools were tested, which represents less than 65 percent of the population.
2. Nations in which a participation rate of 75 percent of the schools and students combined was achieved only after replacements for refusals were substituted, are shown with a °.
3. The international average is 527 for both mathematics and science. This is the average of the national averages of the 25 countries meeting international guidelines.
4. The international average based on all 41 countries listed is 513 for mathematics and 516 for science.

COUNTRIES WITH LOW PARTICIPATION RATES

Nation	Math Average	Science Average
AUSTRALIA	530	545
AUSTRIA	539	558
BELGIUM-FRENCH	526	471
BULGARIA	540	565
NETHERLANDS	541	560
SCOTLAND	498	517

COUNTRIES TESTING OLDER-THAN-SPECIFIED STUDENTS

Nation	Math Average	Science Average
COLOMBIA	385	411
GERMANY	509	531
ROMANIA	482	486
SLOVENIA	541	560

COUNTRIES WITH NON-STANDARD SELECTION OF CLASSROOMS

Nation	Math Average	Science Average
DENMARK	502	478
GREECE	484	497
THAILAND	522	525

COUNTRIES WITH NON-STANDARD SELECTION OF CLASSROOMS AND OTHER DEPARTURES FROM GUIDELINES

Nation	Math Average	Science Average
ISRAEL	522	524
KUWAIT	392	430
SOUTH AFRICA	354	326

Source: Beaton et al. (1996) Mathematics achievement in the middle school years. Table 1.1. Boston College: Chestnut Hill, MA., and Beaton et al. (1996) Science achievement in the middle school years. Table 1.1. Boston College: Chestnut Hill, MA.

tions that occurred. It should be kept in mind that we cannot have the same amount of confidence in the scores of the 16 nations in which major difficulties arose.

If the international average is calculated only from the 25 countries in which no major difficulties arose in carrying out the international specifications, the U.S. mathematics score is still below the international average. In science, however, our score is no longer significantly different from the average of the 25 nations. Our comparative position in science becomes lower because many of the countries who are removed from consideration are those that we outperformed. Figure 3 on page 22 shows our mathematics and science standing in comparison to these 25 nations, and the types of anomalies that occurred in the other 16 countries. The difference in U.S. standing between Figure 3 and the previous figures demonstrates that the selection of countries against which the U.S. is compared can change our international standing.

Which comparison should we emphasize as TIMSS' main finding – the comparison to 25 countries, or to 41? NCES has chosen as the primary finding our standing with respect to 41 countries because the international TIMSS reports present the results in terms of all 41 nations.

What do the test scores mean? Due to the complex nature of the TIMSS test design, scoring, and analysis, a score of 600 does not mean either 600 items, or 60 percent correct. One can interpret the scores by considering where they fall along the range of scores from 0 to 1000 of other eighth-grade students who took the test. In mathematics, a score of 656 would put a student in the top 10 percent of all students in the 41 TIMSS countries, and a score of 587 would put a student in the top 25 percent. In mathematics, 509 was the average student score. In science, a score of 655 would put a student in the top 10 percent, a score of 592 would put a student in the top 25 percent, and 522 was the average student score.

WHICH COUNTRIES OUTPERFORM THE U.S. IN BOTH SUBJECTS?

We can say with confidence that five nations outperformed us in both mathematics and science. They are:

- Three Asian nations - Singapore, Korea, and Japan.
- Two Central European nations - Czech Republic and Hungary.

The Netherlands, Austria, Slovenia, and Bulgaria also outperformed us in both subjects, but because these countries did not carry out TIMSS according to strict international standards, we can be less certain about their scores. These nine countries were the only ones that outperformed us in science, and they were also among the 20 countries that outperformed us in mathematics.

WHICH COUNTRIES DOES THE U .S. OUTPERFORM IN BO TH SUBJECTS?

We can say with confidence that the U.S. outperformed four countries in both mathematics and science:

- Three European countries - Lithuania, Cyprus, and Portugal.
- One Middle Eastern country - Iran.

The U.S. also outperformed Kuwait, Colombia, and South Africa in both subjects, but due to deviations in their administration of TIMSS, we have less confidence in their scores. These seven countries were the only ones that we outperformed in mathematics, and they were also among the 15 countries that we outperformed in science.

HOW DO WE COMP ARE TO OUR MAJOR ECONOMIC P ARTNERS?

The "Group of Seven" or G-7 countries are major U.S. economic and political allies. The other six nations in this group are the United Kingdom, France, Germany, Canada, Japan, and Italy. Italy did not administer the TIMSS test, so the U.S. can only be compared to the remaining five. The United Kingdom includes England, Scotland, Northern Ireland, and Wales. Northern Ireland and Wales did not participate in TIMSS, and England and Scotland both have the same international standing in comparison to the U.S. Therefore, in this section, we describe our standing in relation to England.

In mathematics, Japan, France, and Canada outperform the U.S., while our scores are not significantly different from those of England and Germany. In science, we score lower than Japan; were not significantly different than England, Canada, and Germany; and score higher than France. Considering our standing in relation to these five major economic partners, it can be said that the U.S. is in the bottom half in mathematics, and about the middle in science.

Among the G-7 countries, Germany is the only nation which appears in parentheses, indicating problems in the implementation of the international guidelines for carrying out the study. In Germany, the problem was a discrepancy in the age of the students tested. Because German children start school somewhat later than children in other countries, the average age of the German eighth-graders who took the TIMSS test was about four months older than the international target age. Some would say that this means that other nations' eighth graders should be compared with Germany's seventh graders for a better age comparison. However, this provides a less-than-ideal grade comparison.

In a grade-based comparison, there is no significant difference between German and U.S. eighth graders. If we were to approximate an age-based comparison by matching the scores of our eighth graders to those of German seventh graders, our eighth graders do significantly better. Both comparisons are useful because most experts believe that achievement is based partly on cognitive maturation which comes with age, and partly on years of study which come with grade in school.

HOW FAR BEHIND THE TOP COUNTRIES ARE WE?

Particularly in mathematics, our students are far behind Singapore and Japan which are among the top-scoring nations in the world in both math and science. One way to compare two nations' scores is by considering their comparative standing with relation to the international percentiles. In mathematics, the scores of our very best U.S. eighth graders, who perform at the 95th percentile for our nation, are not significantly different than the scores of average eighth graders in Singapore, who perform at their nation's 50th percentile. In comparison to Japan, the scores of our best students, who are at the 95th percentile for our nation, are significantly below the scores of the top quarter of Japanese students, who perform at their nation's 75th percentile.

In science, the gap is not so large. Students at the U.S. 95th percentile are significantly better than students at the 75th percentile in Singapore. In comparison to Japan, there is no significant difference between U.S. and Japanese students at the 95th percentile.

Another way to estimate distance between the U.S. and top scoring countries is to use the difference between our seventh and our eighth graders as a unit of measure. In mathematics, the difference between our seventh and eighth graders' scores was 24 points. The difference between the scores of eighth graders in the U.S. and in Singapore was 143 points. This means that the difference in eighth-grade mathematics performance between the two countries is almost six times the difference between U.S. seventh and eighth graders. The difference between U.S. and Japanese eighth graders' mathematics performance is about four times this difference.

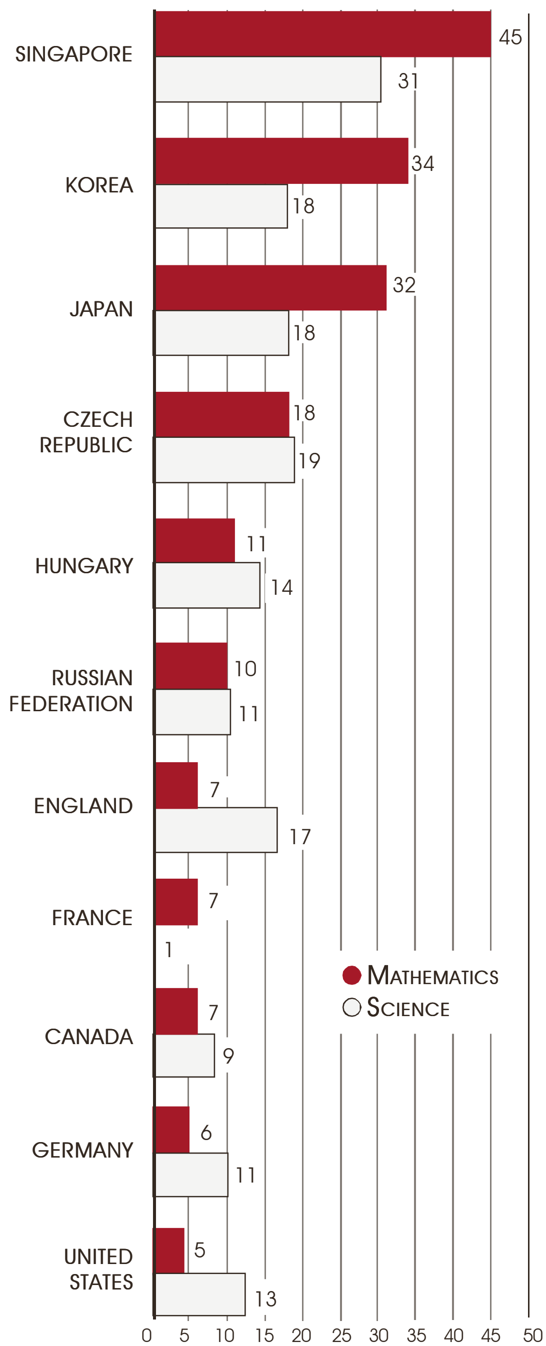
In science, the gap is smaller, but still substantial. The difference between U.S. seventh and U.S. eighth graders' scores is 26 points. The difference between the scores of the U.S. and Singapore was 73 points. The difference in science performance between eighth graders in the U.S. and Singapore is almost three times the difference between our seventh and eighth graders. The difference between U.S. and Japanese eighth graders' science performance is almost one and a half times this difference.

HOW DO OUR BEST STUDENTS COMPARE WITH OTHERS' BEST?

Comparisons of averages tell us how typical students perform, but they do not tell us about the performance of our nation's best students - those who are likely to become the next generation of mathematicians, scientists, doctors, and engineers. If an international talent search were to select the top ten percent of all students in the 41 TIMSS countries combined, what percentage of U.S. students would be included?

In mathematics, 5 percent of U.S. eighth graders would be selected. High-scoring nations would have more of their students represented in the "international top ten percent." Figure 4 on page 26 shows that 45 percent of all Singaporean students and 32 percent of all Japanese students would be chosen in the international talent search in mathematics. In science, 13 percent

FIGURE 4:
Percent of Students from Selected Nations Scoring Among the Top 10 Percent of Eighth Graders in the 41 TIMSS Countries



of U.S. students would be selected, in comparison to 31 percent of Singaporean students and 18 percent of Japanese students.

If the international talent search were to lower its standards considerably to choose the top half of all students in the 41 TIMSS countries, 94 percent of eighth graders in Singapore and 83 percent in Japan would be selected in mathematics, compared to 45 percent of eighth graders in the U.S. In science, 82 percent of the students in Singapore and 71 percent of students in Japan would be selected, compared to 55 percent in the U.S.

HOW DOES THE U.S. MATHEMATICS AND SCIENCE GENDER GAP COMPARE TO OTHER COUNTRIES'?

In the U.S. and in other countries, policy makers have made great efforts to make math and science more accessible to girls, and to encourage gender equity in these subjects. More TIMSS countries have achieved gender equity in their students' scores in mathematics than in science. The U.S. is one of 11 TIMSS nations in which there is no significant gender gap in eighth-grade mathematics and science achievement. The U.S. was one of 33 countries in which there was no statistically significant difference between the performance of eighth-grade boys and

Source: Beaton et al. (1996) Mathematics achievement in the middle school years. Table 1.4. Boston College: Chestnut Hill, MA., and Beaton et al. (1996) Science achievement in the middle school years. Table 1.4. Boston College: Chestnut Hill, MA.

girls in mathematics. In science, we were one of 11 nations with no statistically significant difference. All 11 nations with no significant different in science also demonstrated no difference in mathematics. They are the United States, Singapore, the Russian Federation, Thailand, Australia, Ireland, Romania, Flemish Belgium, Cyprus, Columbia, and South Africa.

HOW DO WE SCORE IN THE DIFFERENT CONTENT AREAS OF MATHEMATICS AND SCIENCE?

Representing student achievement in mathematics and science as a total score is a useful way to summarize achievement. However, mathematics and science contain different content areas, which are emphasized and sequenced differently in curricula around the world. Based on these national priorities, in each country, some content areas have been studied more than others at a particular grade level.

The TIMSS eighth-grade mathematics test included sets of items designed to sample students' ability to do work in the following areas:

- Algebra (patterns, relations, expressions, equations).
- Data Representation, Analysis, and Probability (representation and analysis of data using charts and graphs involving uncertainty and probability).
- Fractions and Number Sense (fractions, decimals, percentages, estimation and rounding).
- Geometry (visualization and properties of geometric figures, including symmetry, congruence, and similarity).
- Measurement (units of length, weight, time, area, volume, and interpretation of measurement scales).
- Proportionality (proportionality and ratios).

Figure 5 on pages 28 and 29 shows that among these content areas, U.S. students' performance is at about the international average in Algebra; Data Representation, Analysis, and Probability; and Fractions and Number Sense. Compared to other countries, we do less well in Geometry; Measurement; and Proportionality. Our weaker performance in these latter three topics may pull the overall U.S. score down to below average.

In science, the TIMSS eighth-grade test sampled students' ability to do work in the following subjects:

- Chemistry (classification of matter, chemical properties and transformations).
- Earth Science (earth features, earth processes, and the earth in the universe).
- Environmental Issues and the Nature of Science (environmental and resource issues, the nature of scientific knowledge, and the interaction of science and technology).

(Continued on page 32)

FIGURE 5:
National Averages in Mathematics Content Areas

FRACTIONS & NUMBER SENSE

Nation	Percent Correct	
SINGAPORE	84	
JAPAN	75	
KOREA	74	
HONG KONG	72	
BELGIUM-FLEMISH °	71	
CZECH REPUBLIC	69	
SWITZERLAND °	67	
SLOVAK REPUBLIC	66	
(AUSTRIA)	66	
IRELAND	65	
HUNGARY	65	
FRANCE	64	
CANADA	64	
(SLOVENIA)	63	
SWEDEN	62	
(BELGIUM-FRENCH)	62	
RUSSIAN FEDERATION	62	
(NETHERLANDS)	62	
(AUSTRALIA)	61	
(ISRAEL) *	60	
(BULGARIA)	60	
(THAILAND)	60	
UNITED STATES °	59	
(GERMANY) *°	58	◀ 58
NORWAY	58	
NEW ZEALAND	57	
ICELAND	54	
ENGLAND *°	54	
(SCOTLAND)	53	
(DENMARK)	53	
(GREECE)	53	
LATVIA (LSS) °	53	
SPAIN	52	
LITHUANIA *	51	
CYPRUS	50	
(ROMANIA)	48	
PORTUGAL	44	
IRAN, ISLAMIC REPUBLIC	39	
(COLOMBIA)	31	
(KUWAIT)	27	
(SOUTH AFRICA)	26	

GEOMETRY

Nation	Percent Correct	
JAPAN	80	
SINGAPORE	76	
KOREA	75	
HONG KONG	73	
CZECH REPUBLIC	66	
FRANCE	66	
(BULGARIA)	65	
BELGIUM-FLEMISH °	64	
RUSSIAN FEDERATION	63	
SLOVAK REPUBLIC	63	
(THAILAND)	62	
(SLOVENIA)	60	
HUNGARY	60	
SWITZERLAND °	60	
(NETHERLANDS)	59	
(BELGIUM-FRENCH)	58	
CANADA	58	
(AUSTRALIA)	57	
(ISRAEL) *	57	
(AUSTRIA)	57	
LATVIA (LSS) °	57	◀ 56
NEW ZEALAND	54	
ENGLAND *°	54	
(DENMARK)	54	
LITHUANIA *	53	
(ROMANIA)	52	
(SCOTLAND)	52	
IRELAND	51	
(GERMANY) *°	51	
ICELAND	51	
NORWAY	51	
(GREECE)	51	
SPAIN	49	
SWEDEN	48	
UNITED STATES °	48	
CYPRUS	47	
PORTUGAL	44	
IRAN, ISLAMIC REPUBLIC	43	
(KUWAIT)	38	
(COLOMBIA)	29	
(SOUTH AFRICA)	24	

ALGEBRA

Nation	Percent Correct	
SINGAPORE	76	
JAPAN	72	
HONG KONG	70	
KOREA	69	
CZECH REPUBLIC	65	
HUNGARY	63	
RUSSIAN FEDERATION	63	
BELGIUM-FLEMISH °	63	
SLOVAK REPUBLIC	62	
(BULGARIA)	62	
(SLOVENIA)	61	
(ISRAEL) *	61	
(AUSTRIA)	59	
(AUSTRALIA)	55	
SPAIN	54	
FRANCE	54	
CANADA	54	
IRELAND	53	
(BELGIUM-FRENCH)	53	
(THAILAND)	53	
SWITZERLAND °	53	
(NETHERLANDS)	53	
(ROMANIA)	52	◀ 52
UNITED STATES °	51	
LATVIA (LSS) °	51	
NEW ZEALAND	49	
ENGLAND *°	49	
(GERMANY) *°	48	
CYPRUS	48	
LITHUANIA *	47	
(SCOTLAND)	46	
(GREECE)	46	
NORWAY	45	
(DENMARK)	45	
SWEDEN	44	
ICELAND	40	
PORTUGAL	40	
IRAN, ISLAMIC REPUBLIC	37	
(KUWAIT)	30	
(COLOMBIA)	28	
(SOUTH AFRICA)	23	

NOTES:
1. Nations not meeting international study guidelines are shown in parentheses.
2. Nations in which more than 10 percent of the population was excluded from testing are shown with a *. Latvia is designated LSS because only Latvian-speaking schools were tested, which represents less than 65 percent of the population.
3. Nations in which a participation rate of 75 percent of the schools and students combined was achieved only after replacements for refusals were substituted, are shown with a °.
4. The international average is the average of the national averages of the 41 nations.

DATA REPRESENTATION, ANALYSIS, & PROBABILITY		
Nation	Percent Correct	
SINGAPORE	79	
KOREA	78	
JAPAN	78	
BELGIUM-FLEMISH ○	73	
SWITZERLAND ○	72	
(NETHERLANDS)	72	
HONG KONG	72	
FRANCE	71	
SWEDEN	70	
IRELAND	69	
CANADA	69	
(AUSTRIA)	68	
CZECH REPUBLIC	68	
(BELGIUM-FRENCH)	68	
(AUSTRALIA)	67	
(DENMARK)	67	
NORWAY	66	
NEW ZEALAND	66	
(SLOVENIA)	66	
ENGLAND *○	66	
HUNGARY	66	
UNITED STATES ○	65	
(SCOTLAND)	65	
(GERMANY) *○	64	
(ISRAEL) *	63	
ICELAND	63	
(THAILAND)	63	
(BULGARIA)	62	◄62
SLOVAK REPUBLIC	62	
RUSSIAN FEDERATION	60	
SPAIN	60	
(GREECE)	56	
LATVIA (LSS) ○	56	
PORTUGAL	54	
CYPRUS	53	
LITHUANIA *	52	
(ROMANIA)	49	
IRAN, ISLAMIC REPUBLIC	41	
(KUWAIT)	38	
(COLOMBIA)	37	
(SOUTH AFRICA)	26	

MEASUREMENT		
Nation	Percent Correct	
SINGAPORE	77	
JAPAN	67	
KOREA	66	
HONG KONG	65	
CZECH REPUBLIC	62	
(AUSTRIA)	62	
SWITZERLAND ○	61	
SLOVAK REPUBLIC	60	
BELGIUM-FLEMISH ○	60	
(SLOVENIA)	59	
(NETHERLANDS)	57	
FRANCE	57	
HUNGARY	56	
RUSSIAN FEDERATION	56	
SWEDEN	56	
(BELGIUM-FRENCH)	56	
(BULGARIA)	54	
(AUSTRALIA)	54	
IRELAND	53	
NORWAY	51	
CANADA	51	◄51
(GERMANY) *○	51	
(THAILAND)	50	
ENGLAND *○	50	
(DENMARK)	49	
NEW ZEALAND	48	
(ISRAEL) *	48	
(SCOTLAND)	48	
(ROMANIA)	48	
LATVIA (LSS) ○	47	
ICELAND	45	
SPAIN	44	
CYPRUS	44	
(GREECE)	43	
LITHUANIA *	43	
UNITED STATES ○	40	
PORTUGAL	39	
IRAN, ISLAMIC REPUBLIC	29	
(COLOMBIA)	25	
(KUWAIT)	23	
(SOUTH AFRICA)	18	

PROPORTIONALITY		
Nation	Percent Correct	
SINGAPORE	75	
HONG KONG	62	
KOREA	62	
JAPAN	61	
BELGIUM-FLEMISH ○	53	
SWITZERLAND ○	52	
CZECH REPUBLIC	52	
(NETHERLANDS)	51	
(THAILAND)	51	
IRELAND	51	
(SLOVENIA)	49	
SLOVAK REPUBLIC	49	
(AUSTRIA)	49	
FRANCE	49	
RUSSIAN FEDERATION	48	
CANADA	48	
(BELGIUM-FRENCH)	48	
HUNGARY	47	
(BULGARIA)	47	
(AUSTRALIA)	47	◄45
SWEDEN	44	
(ISRAEL) *	43	
NEW ZEALAND	42	
UNITED STATES ○	42	
(GERMANY) *○	42	
(ROMANIA)	42	
ENGLAND *○	41	
(DENMARK)	41	
NORWAY	40	
SPAIN	40	
(SCOTLAND)	40	
CYPRUS	40	
(GREECE)	39	
LATVIA (LSS) ○	39	
ICELAND	38	
IRAN, ISLAMIC REPUBLIC	36	
LITHUANIA *○	35	
PORTUGAL	32	
(COLOMBIA)	23	
(SOUTH AFRICA)	21	
(KUWAIT)	21	

SOURCE:
Beaton et al. (1996) Mathematics achievement in the middle school years. Table 2.1. Boston College: Chestnut Hill, MA.

- Percent significantly higher than U.S.
- Percent not significantly different than U.S.
- Percent significantly lower than U.S.
- ◄# International average percent correct, all nations

Figure 6:
National Averages in Science Content Areas

EARTH SCIENCE

Nation	Percent Correct	
Singapore	65	
(Slovenia)	64	
Czech Republic	63	
Korea	63	
Belgium-Flemish °	62	
(Austria)	62	
Sweden	62	
Norway	61	
Ireland	61	
(Netherlands)	61	
Japan	61	
Slovak Republic	60	
Hungary	60	
England *°	59	
Russian Federation	58	
(Bulgaria)	58	
UNITED STATES °	58	
Switzerland °	58	
Canada	58	
(Australia)	57	
(Germany) *°	57	
Spain	57	
(Thailand)	56	
New Zealand	56	
(Israel) *	55	55
France	55	
Hong Kong	54	
(Scotland)	52	
Portugal	50	
(Belgium-French)	50	
Iceland	50	
(Romania)	49	
(Greece)	49	
(Denmark)	49	
Latvia (LSS) °	48	
Lithuania *	46	
Cyprus	46	
Iran, Islamic Republic	45	
(Kuwait)	43	
(Colombia)	37	
(South Africa)	26	

LIFE SCIENCE

Nation	Percent Correct	
Singapore	72	
Japan	71	
Korea	70	
Czech Republic	69	
(Netherlands)	67	
(Thailand)	66	
Hungary	65	
(Austria)	65	
(Slovenia)	65	
(Bulgaria)	64	
England *°	64	
Belgium-Flemish °	64	
(Australia)	63	
(Germany) *°	63	
UNITED STATES °	63	
Sweden	63	
Russian Federation	62	
Canada	62	
Hong Kong	61	
Norway	61	
(Israel) *	61	
New Zealand	60	
Slovak Republic	60	
Ireland	60	
Switzerland °	59	59
Iceland	58	
Spain	58	
(Scotland)	57	
France	56	
(Denmark)	56	
(Romania)	55	
(Belgium-French)	55	
(Greece)	54	
Portugal	53	
Latvia (LSS) °	53	
Lithuania *	52	
Iran, Islamic Republic	49	
Cyprus	49	
(Kuwait)	45	
(Colombia)	44	
(South Africa)	27	

PHYSICS

Nation	Percent Correct	
Singapore	69	
Japan	67	
Korea	65	
Czech Republic	64	
(Netherlands)	63	
(Austria)	62	
England *°	62	
Slovak Republic	61	
(Slovenia)	61	
Belgium-Flemish °	61	
(Bulgaria)	60	
(Australia)	60	
Hungary	60	
Canada	59	
Hong Kong	58	
New Zealand	58	
Switzerland °	58	
Russian Federation	57	
(Germany) *°	57	
Sweden	57	
(Israel) *	57	
(Scotland)	57	
Norway	57	
Ireland	56	
UNITED STATES °	56	
Spain	55	55
France	54	
(Thailand)	54	
Iceland	53	
(Greece)	53	
(Denmark)	53	
(Belgium-French)	51	
Latvia (LSS) °	51	
Lithuania *	51	
(Romania)	49	
Portugal	48	
Iran, Islamic Republic	48	
Cyprus	46	
(Kuwait)	43	
(Colombia)	37	
(South Africa)	27	

CHEMISTRY	
Nation	Percent Correct
Singapore	69
(Bulgaria)	65
Korea	63
Japan	61
Czech Republic	60
Hungary	60
(Austria)	58
Slovak Republic	57
Russian Federation	57
(Slovenia)	56
Sweden	56
England *°	55
Hong Kong	55
(Germany) *°	54
Ireland	54
(Australia)	54
(Israel) *	53
UNITED STATES °	53
New Zealand	53
(Netherlands)	52
Iran, Islamic Republic	52
Canada	52
Spain	51
(Greece)	51
Belgium-Flemish °	51
(Scotland)	51
Portugal	50
Switzerland °	50
Norway	49
Latvia (LSS) °	48
Lithuania *	48
France	47
(Romania)	46
Cyprus	45
(Thailand)	43
Iceland	42
(Belgium-French)	41
(Denmark)	41
(Kuwait)	40
(Colombia)	32
(South Africa)	26

International average: 51

ENVIRONMENTAL ISSUES & THE NATURE OF SCIENCE	
Nation	Percent Correct
Singapore	74
(Netherlands)	65
England *°	65
Korea	64
(Australia)	62
(Thailand)	62
UNITED STATES °	61
Canada	61
Ireland	60
Japan	60
(Bulgaria)	59
Czech Republic	59
New Zealand	59
(Slovenia)	59
Belgium-Flemish °	58
(Scotland)	57
Norway	55
Hong Kong	55
(Austria)	55
Slovak Republic	53
Hungary	53
France	53
Spain	53
(Israel) *	52
Sweden	52
(Germany) *°	51
Switzerland °	51
(Greece)	51
Russian Federation	50
Iceland	49
(Denmark)	47
Latvia (LSS) °	47
Cyprus	46
(Belgium-French)	46
Portugal	45
(Romania)	42
(Colombia)	40
Lithuania *	40
(Kuwait)	39
Iran, Islamic Republic	39
(South Africa)	26

International average: 53

NOTES:

1. Nations not meeting international study guidelines are shown in parentheses.
2. Nations in which more than 10 percent of the population was excluded from testing are shown with a *. Latvia is designated LSS because only Latvian-speaking schools were tested, which represents less than 65 percent of the population.
3. Nations in which a participation rate of 75 percent of the schools and students combined was achieved only after replacements for refusals were substituted, are shown with a °.
4. The international average is the average of the national averages of the 41 nations.

SOURCE:

Beaton et al. (1996) Science achievement in the middle school years. Table 2.1. Boston College: Chestnut Hill, MA.

- Percent significantly higher than U.S.
- Percent not significantly different from U.S.
- Percent significantly lower than U.S.
- (#) International average percent correct

- Life Science (structure, diversity, classification, processes, cycles, and interactions of plants and animals).

- Physics (energy forms, physical transformations, force and motion, and physical properties of matter).

Figure 6 on pages 30 and 31 shows our comparative standing in these content areas. The U.S. is among the top countries in the world in Environmental Issues and the Nature of Science, and we are also above the international average in Earth Science and Life Science. In Chemistry and Physics, our performance is not significantly different from the international average. Our better-than-average scores in Environmental Issues, Earth Science, and Life Science may pull our overall science score up to above average.

WHAT DID PRIOR STUDIES SHOW ABOUT HOW U .S. STATES COMPARE TO OTHER COUNTRIES?

Comparison of U.S. states with other nations reminds us that not all U.S. school systems are alike, and that wide differences in achievement exist within our own nation. Some would say that comparisons of U.S. states and other nations are fair for two reasons. First, most U.S. states are larger either in size or population than many countries in the TIMSS study. For example, California is larger in size than Japan, Germany, or England. New Jersey has a larger population than Austria, Denmark, or Switzerland. A second reason that such comparisons are fair is that each U.S. state is responsible for its own education system, similar to the way in which most other TIMSS national governments are responsible for their own education system.

Future analyses may make possible such comparisons between U.S. states and the TIMSS nations. Efforts are now underway to create an experimental linkage between the TIMSS study and the mathematics and science portions of the National Assessment of Educational Progress (NAEP). This linkage will allow an estimation of how states would have performed on TIMSS if their students had taken the test. The results for eighth-grade mathematics and science will be announced in 1997.

Until those findings are released, however, we can look at the results of a similar linkage which was performed in 1991 for eighth-grade mathematics students' scores on NAEP and on the International Assessment of Educational Progress[4]. In that comparison, the mathematics scores of Iowa, North Dakota, and Minnesota were similar to top-scoring Taiwan and Korea. In contrast, Alabama, Louisiana, and Mississippi scored about the same as lowest-scoring Jordan. These findings underscore the considerable variation in achievement that exists among states within our own nation.

HAS U.S. INTERNATIONAL STANDING IMPROVED OVER TIME?

Results from the National Assessment of Education Progress show that our eighth-grade students' scores in math and science have improved somewhat in comparison to our own performance during the past decades. If our domestic performance over time is improving, how does this affect our international standing? It is possible that only U.S. achievement has improved over time, while achievement in other countries has not. Of course, it is also possible that improvements in the U.S. have been matched or exceeded by improvements in other countries.

International comparisons over time are difficult. The first international studies of math and science achievement were conducted in the 1960s, and there have been three previous assessments in each subject since that time. However, each assessment has been done differently. A different set of nations participated, different topics in math and science were included in the tests, the age and type of students sampled in each country changed slightly, and indeed even the borders and names of some of the nations have changed. Furthermore, the field of assessment has matured greatly over the past thirty years, rendering the methods of the then-revolutionary early studies crude by today's standards. These and other factors complicate comparisons over time, and require that any conclusions that are drawn be necessarily tentative.

In TIMSS mathematics, we have seen that our eighth-graders scored below the international average. This is basically the same relative international standing reported for U.S. thirteen-year-olds in the IEA First and Second International Mathematics Studies in the 1960s and 1980s, and the mathematics portion of the International Assessment of Educational Progress in the early 1990s[5]. Relative to their international counterparts, it is not likely that U.S. eighth-graders' standing in mathematics has improved significantly.

In the three previous international science assessments in the 1960s, 1980s, and early 1990s, the U.S. performed below the international average of thirteen or fourteen-year-olds. However in TIMSS, our students scored at or above the international average. Because comparisons over time are difficult, caution should be exercised in assuming there has been significant improvement in our international standing in science, but it is a possibility.

We have now examined what TIMSS tells us about what eighth-grade students have learned. Learning, of course, is closely related to what students are taught. Next we turn to an examination of how the U.S. mathematics and science curricula compare with those of other nations.

CHAPTER 2: CURRICULUM

KEY POINTS:

The content taught in U.S. eighth-grade mathematics classrooms is at a seventh-grade level in comparison to other countries.

Topic coverage in U.S. eighth-grade mathematics classes is not as focused as in Germany and Japan.

In science, the degree of topic focus in the eighth-grade curriculum may be similar to that of other countries.

Our nation is atypical among TIMSS countries in its lack of a nationally-defined curriculum.

U.S. eighth graders spend more hours per year in math and science classes than German and Japanese students.

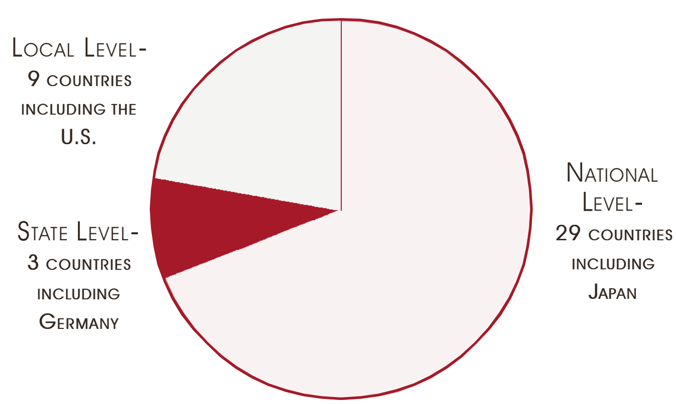
U.S. policy makers are concerned about whether standards for our students are high enough, and, in particular, whether they are as challenging as those of our foreign economic partners. There is a widespread belief that our nation's economic productivity is related to our students' performance in mathematics and science, and that this in turn is related to the expectations that are set for student performance.

However, the relationship between standards, teaching, and learning is not a simple one. Formal and informal decisions at many levels affect what students are taught. National, state, and local authorities as well as publishers set forth the officially intended curriculum in both curriculum guidelines and textbooks. Teachers also make decisions about what should be taught. Depending on the country, their decisions are based more or less closely on the officially intended curriculum. What teachers actually teach their students is sometimes called the "implemented curriculum." Both the officially intended curriculum and the implemented curriculum must be considered when discussing a nation's goals for student learning.

WHO SETS CURRICULUM STANDARDS?

In most TIMSS countries, the curriculum is determined by national authorities. Figure 7 shows that curriculum is determined at the national level in 29 of the TIMSS countries, at the state or region in 3 countries, and at the local or district level in 9 countries. Germany, Japan, and the U.S. differ in this respect, which makes comparisons among the three countries interesting. Which authority sets a country's official curriculum standards makes a difference in whether or not there is a single

FIGURE 7
Number of TIMSS Countries Determining Curriculum at Various Levels



SOURCE:
Beaton et al. (1996) Mathematics achievement in the middle school years. Figure 1. Boston College: Chestnut Hill, MA.

official core curriculum for the entire nation, or whether there are as many official curricula as there are states or districts in the country.

Japan is one of the countries that determines curriculum at the national level. The National Ministry of Education specifies one set of curriculum guidelines that details the topics of study and the number of instructional hours required in every accredited elementary and junior high school. For these schooling levels, it also approves textbooks published by six commercial publishers. Textbooks resemble each other in content because they must be based closely on the national guidelines. Local school boards make only minor modifications to the national guidelines, and choose textbooks from among the approved list. However, the Ministry itself does not monitor whether or not the standards are adhered to, leaving the issue of oversight to the local boards of education. Teachers of each subject in a school work together closely to be sure that they cover the material in the textbooks at approximately the same depth and rate. This is partly due to the oversight of local authorities, and partly due to teachers' desire that their students score well on the high-school entrance examination, which is based directly on the national curriculum.

In Germany, each of the 16 states sets its own curriculum standards for students. To encourage some degree of similarity across states, the national Conference of Ministers of Education discusses various issues related to standards and adopts broad recommended guidelines concerning curriculum, hours of instruction, and examination guidelines. State curriculum standards vary widely in their level of specificity, and the degree to which schools and teachers are held accountable for following them. Teachers in states where curriculum guidelines are not highly specific, and where schools and districts are allowed to develop their own secondary school exit examinations, have considerable flexibility in determining what and how they teach.

In the U.S., most of the nearly16,000 districts design their own curriculum or standards, usually within broad guidelines issued by each of the 50 states. There are many different commercially published textbooks. Because most textbooks are designed with an eye to sales in as many districts as possible, they include the content specified by the guidelines from a number of different states. As a result, textbooks usually contain much more material than a teacher can cover fully in a year. Each of the many different textbooks includes somewhat different topics from which teachers in various districts can choose. Few states or districts closely monitor or enforce compliance with state or district standards, and U.S. teachers usually have the latitude to design the content and pace of their courses to suit their perception of their students' needs.

IS CURRICULUM IN THE U.S. AS FOCUSED AS IN OTHER COUNTRIES?

Evidence from a variety of sources in TIMSS shows us that the U.S. mathematics curriculum is less focused than that of other countries. The U.S. science curriculum more closely resembles international practices.

The TIMSS curriculum analysis studied the officially intended curriculum by asking U.S. curriculum experts to judge which topics were recommended to be taught at each grade level. Their judgments were compared with those of experts in the other TIMSS countries. This effort revealed that the number of topics recommended to be covered in the U.S. was greater than the international average at each of grades 1 through 8 for mathematics.

Textbooks are another aspect of the officially intended curriculum. Videotapes of mathematics classes in Germany, Japan, and the U.S. showed that textbooks were used during class in almost half of U.S. lessons and a third of German lessons, but in only 2 percent of Japanese lessons. Teacher-developed worksheets were common in U.S. and Japanese lessons. In Japan, students also use supplementary practice books which are usually purchased from the school for use in home study.

The TIMSS curriculum analysis compared the most commonly used textbooks in the various countries. For the U.S. portion of this analysis, mathematics experts were asked to recommend the most commonly-used U.S. eighth-grade textbooks in these subjects. The TIMSS questionnaire surveys of teachers found that these chosen texts were indeed among the most widely used books in the U.S, although they accounted for the textbooks used by only 28 percent of the students. This finding that the five recommended textbooks covered a fairly small proportion of students is an indication of the great diversity of textbooks in our country. In Japan, close to 90 percent of the students used one of the five most common textbooks. Analysis found that the set of 5 U.S. eighth-grade texts included more different topics across all the texts than the set of texts in Japan and Germany.

Of course, not all teachers cover every topic recommended by curriculum experts, or included in textbooks. Therefore, TIMSS also studied the implemented curriculum—what teachers actually cover in their classrooms. Using the same definitions of mathematics topics that the curriculum analysis used, the videotape study of eighth-grade mathematics lessons in Germany, Japan, and the U.S. revealed that U.S. lessons include a greater number of topics. On average, U.S. teachers taught 1.9 topics per lesson, compared with 1.6 in Germany and 1.3 in Japan. The variety of topics was much wider in the U.S., too.

In science, the officially intended curriculum as reflected by U.S. curriculum experts' recommendations about topics to be taught was close to the international average for grades 3 through 8. Science experts in each country chose the three most common textbooks used in their classrooms, which were found to be used by 16 percent of students in the U.S., and 84 percent of students in Japan.

Thus, the evidence from a variety of TIMSS sources reinforces the finding that our eighth-grade mathematics curriculum is less focused than the curricula of other nations, if focus is defined as number and variety of topics in the intended and implemented curriculum. Although less information is available for science, U.S. curricular focus may be more similar to the average of the TIMSS countries in this subject.

IS CURRICULUM IN THE U.S. AS ADVANCED AS IN OTHER COUNTRIES?

The U.S. mathematics curriculum is not as advanced as in Germany and Japan. Concerning the intended curriculum, analysis of textbooks found that Geometry occupied more space in the German and Japanese books than in the U.S. texts. The Japanese textbooks also devoted more space to algebra than did the books studied by the majority of U.S. eighth graders, who are in non-algebra tracks.

The implemented curriculum in the U.S. is also less advanced than that of Germany and Japan. In the videotapes studied, 40 percent of U.S. eighth-grade mathematics lessons included arithmetic topics such as whole number operations, fractions, and decimals, whereas these topics were much less common in Germany and Japan. In contrast, German and Japanese eighth-grade lessons were more likely to cover algebra and geometry.

The topics being taught in U.S. mathematics classrooms were at a seventh-grade level in comparison to other countries, while the topics observed in the German and Japanese classrooms were at a high eighth-grade or even ninth-grade level. This was discovered based on a comparison of the TIMSS curriculum analysis and videotape studies. The curriculum analysis asked experts in each of the TIMSS countries to report the grade level at which their country focused on various topics. These findings were compared to the topics which the TIMSS videotape study observed eighth-grade teachers in Japan, Germany, and the U.S. to be actually teaching.

TIMSS does not have data to judge whether the U.S. curriculum in science is as advanced as that of other countries because the videotape study was conducted only in mathematics.

HOW MUCH TIME IS SPENT IN CLASS?

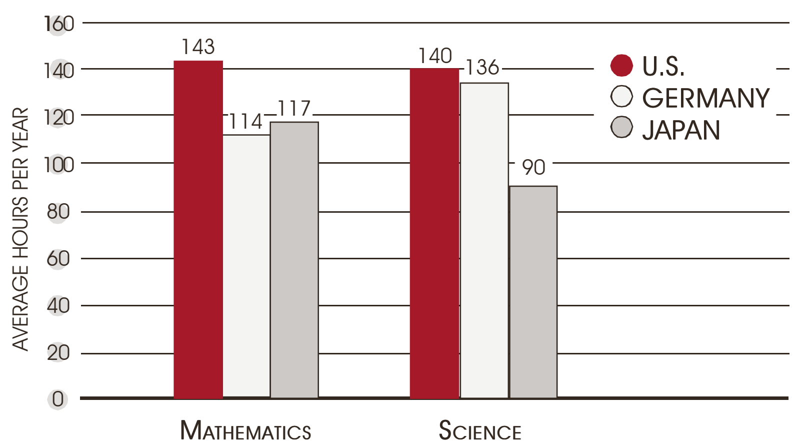
Lengthening the school year or school day has often been proposed as a measure to improve U.S. students' achievement, as it has been thought that U.S. students spend less time at school than their international counterparts. TIMSS compared the amount of time that teachers report U.S. students spend in mathematics and science classes with the amount of time reported for students in Germany and Japan. In contrast to previous analyses, TIMSS carefully took into account differences between countries in the length of the school year, school week, and class period, as well as differences between the amount of time required for students in high and low tracks. On this basis, the average number of hours per year that a student in each country spends in mathematics and science class was calculated.

U.S. eighth-graders spend considerably more hours per year in mathematics classes than their Japanese and German counterparts. U.S. students also spend much more time in science classes than students in Japan. Figure 8 on page 39 shows the amount of time that students in the different countries spend in math and science classes per year. U.S. students' instructional time is both longer and more compressed, because it takes place within a school year of approximately 180 days, as compared to 188 in Germany and 220 in Japan. Of course, time spent in homework, after-school classes, and out-of-school study is also an important factor in learning, and findings concerning these topics will be examined in Chapter 5.

Taken together, TIMSS curriculum-related findings show that lack of sufficient class time is not the easy answer to the question of why U.S. students are below the international average in mathematics. Instead, findings suggest that our students receive a less-advanced curriculum, which is also less focused. Next we will consider how this curriculum is taught by examining the findings concerning classroom teaching.

FIGURE 8

HOURS OF MATHEMATICS AND SCIENCE INSTRUCTIONAL TIME PER YEAR FOR EIGHTH-GRADERS



SOURCE:
Third International Mathematics and Science Study; unpublished tabulations, U.S., German, and Japanese school and teacher surveys; Westat, Inc., 1996.

CHAPTER 3: TEACHING

KEY POINTS:

The content of U.S. mathematics classes requires less high-level thought than classes in Germany and Japan.

U.S. mathematics teachers' typical goal is to teach students how to do something, while Japanese teachers' goal is to help them understand mathematical concepts.

Japanese teachers widely practice what the U.S. mathematics reform recommends, while U.S. teachers do so less frequently.

Although most U.S. math teachers report familiarity with reform recommendations, only a few apply the key points in their classrooms.

During the past several years, mathematics professional organizations, concerned about the quality of instruction in U.S. classrooms, have issued calls for reform. In 1989, the National Council of Teachers of Mathematics (NCTM) set forth Curriculum and Evaluation Standards, followed in 1991 by Professional Standards for Teaching Mathematics, and in 1995 by Assessment Standards. The essence of the recommendations in these reform documents is that instruction should be more than mere mastery of facts and routine skills. It should require students to understand and apply mathematical concepts in new situations.

Publication and discussion of documents such as these, however, do not change the behavior of all of America's hundreds of thousands of mathematics teachers within a few years. Recommendations for major changes in other areas of American life, such as improving health through regular exercise and proper diet, have required decades of sustained effort by public health organizations at all levels to assist individual citizens in changing ingrained personal habits and attitudes. Indeed, the campaign still continues. Changing our nation's habits of teaching and public attitudes toward mathematics and science may also require a similarly long and concerted effort by many committed people.

TIMSS was not designed as an evaluation of the U.S. mathematics reform efforts described in the documents listed above. There are three reasons why TIMSS is unsuitable as such an evaluation. First, because it is an international study, it was designed to measure those aspects of mathematics and science knowledge and practice considered important by the majority of TIMSS nations, rather than those specifically recommended by the U.S. reform community. Second, TIMSS tested U.S. students in the spring of 1995, which was too soon after the publication of the reform documents for states and districts to have designed their own reform programs, retrained teachers in the new practices, and nurtured a generation of students according to the new approach. Third, a proper evaluation requires matching "before and after" measurements between which progress can be judged, and we have no prior measurement which matches TIMSS. For these reasons, TIMSS is not suitable as an evaluation. It should be studied as a baseline measurement against which future progress can be gauged.

Until TIMSS, no large nationally-representative study had observed U.S. classrooms to watch how teachers actually teach. To overcome this lack, and to understand how U.S. classroom teaching compares to that of other countries, NCES added an innovative new research methodology to the TIMSS project— videotaping and quantitative coding of a national sample of eighth-grade mathematics classes in Germany, Japan, and the U.S.

In the U.S. and Germany, half of the eighth-grade mathematics classrooms in which students were scheduled to take the TIMSS test were randomly chosen to be filmed. In Japan, 50 classrooms from the schools in which the TIMSS test was administered were chosen by the principal and officials at the National Institute for Educational Research. Teachers whose classrooms were chosen and who agreed to participate were videotaped teaching a typical lesson. In this way, videotapes of 230 lessons were collected in the three countries combined. The videotapes were then coded and analyzed to compare the teaching techniques and lesson content typical of the three countries. Teachers also completed a questionnaire concerning the lesson that was videotaped. The findings can be considered representative of the type of instruction received by German, Japanese, and U.S. eighth-grade mathematics students. The results provide a window on actual teaching in U.S. classrooms, and also show how U.S. mathematics classes compare to those in Germany and Japan.

HOW DO MATHEMATICS TEACHERS STRUCTURE AND DELIVER THEIR LESSONS?

When studying what teachers do in their classrooms, we should first understand what they mean to do. Therefore, the videotape study asked teachers about their goals for the lesson. In contrast to expert recommendation that well-taught lessons focus on having students think about and come to understand mathematical concepts, U.S. and German eighth-grade mathematics teachers usually explained that the goal of their lesson was to have students acquire particular skills, i.e. to learn how to do something. Learning a skill, such as being able to solve a certain type of problem, or using a standard formula, was listed as the goal by about 60 percent of the U.S. and German teachers, compared with 27 percent of the Japanese teachers. Japanese teachers' goals were more likely to resemble the recommendations of U.S. reform experts. Mathematical thinking, such as exploring, developing, and understanding concepts, or discovering multiple solutions to the same problems, was described as the goal of the lesson by 71 percent of the Japanese teachers,

FIGURE 9:
COMPARISON OF THE STEPS TYPICAL OF EIGHTH-GRADE MATHEMATICS LESSONS IN JAPAN, THE U.S., AND GERMANY

The emphasis on understanding is evident in the steps typical of Japanese eighth-grade mathematics lessons:
■ Teacher poses a complex thought-provoking problem. ■ Students struggle with the problem. ■ Various students present ideas or solutions to the class. ■ Class discusses the various solution methods. ■ The teacher summarizes the class' conclusions. ■ Students practice similar problems.
In contrast, the emphasis on skill acquisition is evident in the steps common to most U.S. and German math lessons:
■ Teacher instructs students in a concept or skill. ■ Teacher solves example problems with class. ■ Students practice on their own while the teacher assists individual students.

SOURCE:
Third International Mathematics and Science Study; unpublished tabulations, Videotape Classroom Study, UCLA, 1996.

compared with 29 percent of German and 24 percent of U.S. teachers. This difference in goals is played out in the typical sequences of activities, or cultural scripts, which characterize mathematics lessons in the three countries. Figure 9 on page 42 describes the steps typical of these cultural scripts.

The U.S. and German emphasis on skills rather than understanding is also carried over into the type of mathematical work that students are assigned to do at their desks during class. Students were coded as practicing routine procedures if their seatwork required them to carry out a previously-learned solution method or procedure on a routine problem. In the U.S., 96 percent of seatwork time was spent on routine procedures, in comparison to 89 percent in Germany, and 41 percent in Japan. Students were assigned to invent new solutions, proofs, or procedures on their own which require them to think and reason in 44 percent of Japanese, 4 percent of German lessons, and less than 1 percent of U.S. lessons. Clearly, Japanese students much more often engage in the type of mathematical thinking recommended by experts and the U.S. reform movement.

When a lesson included a mathematical concept, it was usually simply stated in U.S. classrooms, whereas it was developed in Japanese and German ones. For example, consider a lesson on the Pythagorean theorem. When the concept is merely stated, the teacher or a student might simply say "we find the length of the hypotenuse of a right triangle by using $a^2+ b^2= c^2$." In contrast, a concept was coded as having been developed if it was proven, derived, or explained in some detail.

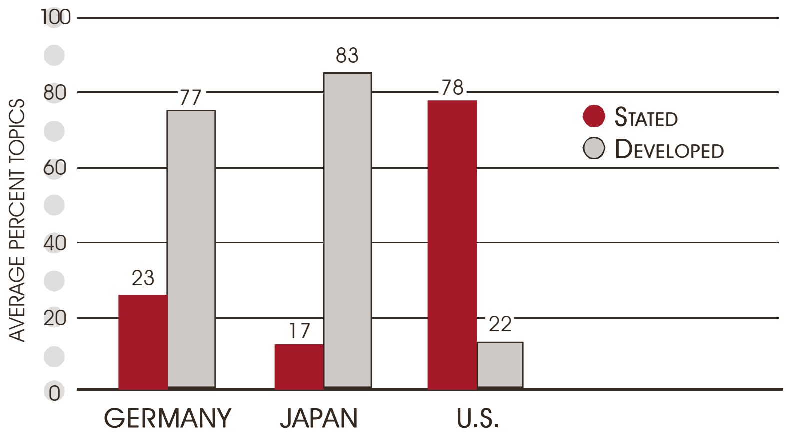
Figure 10 on page 44 shows that U.S. teachers rarely developed concepts, in contrast to German and Japanese teachers, who usually did. In Germany, the teacher usually did the mental work in developing the concept, while the students listened or answered short questions designed to add to the flow of the teacher's explanation. Japanese teachers, however, designed the lesson in such a way that the students themselves derived the concept from their own struggle with the problem.

These findings from the videotape study are corroborated by the TIMSS questionnaire findings. Teachers were asked to choose activities that were characteristic of their teaching from among those listed on the questionnaire. U.S. math teachers were more likely to report asking students to practice computational skills, in most or every class than were their German and Japanese colleagues. Similarly, Japanese teachers were more likely to report they ask students to analyze relationships, write equations, explain their reasoning, and solve problems with no obvious solution in most or every class than teachers in the U.S. and Germany.

Linking concepts used in one part of the lesson to ideas or activities in another part of the lesson is believed by experts to improve students' ability to learn and understand a subject in an integrated way. The videotape study found that 96 percent of Japanese lessons included such explicit linkages in comparison to about 40 percent of U.S. and German lessons. Talking about such relationships may help make lessons more coherent

FIGURE 10

AVERAGE PERCENTAGE OF TOPICS IN EIGHTH-GRADE MATHEMATICS LESSONS THAT ARE STATED OR DEVELOPED



SOURCE:
Third International Mathematics and Science Study; unpublished tabulations, Videotape Classroom Study, UCLA, 1996.

for students by showing them the relationships between ideas and activities used in different parts of the lesson.

Interruptions present a threat to the coherence of lesson activities. The study found that the flow of mathematics lessons was more frequently interrupted than in Germany and Japan. One U.S. math lesson in four was temporarily halted by an outside interruption, typically a loudspeaker announcement, or a visitor at the door. In contrast, interruptions in German lessons were much less common, and the Japanese lessons observed in the study never experienced outside interruptions. Interruptions coming from within the classroom were also more common in U.S. mathematics lessons, such as substantial discussion of non-mathematical subjects like recent sports events, or extended disciplinary incidents. In the U.S., 23 percent of lessons were broken up in this way, compared to 9 percent in Japan, and 4 percent in Germany.

Taken together, these findings suggest that Japanese rather than U.S. or German lessons more often resembled the recommendations of experts and the U.S. reform movement. U.S. lessons typically focused on acquiring mathematical skills rather than conceptual understanding, and were less coherently presented.

IS THE MATHEMATICAL CONTENT OF U.S. LESSONS AS RICH AS THAT IN GERMANY AND JAPAN?

As noted earlier, the U.S. eighth-grade mathematics curriculum focuses more on arithmetic, while the German and Japanese curricula focus more on geometry and algebra. Furthermore, U.S. eighth graders are studying topics usually learned at the seventh grade in most other TIMSS countries.

How does the quality of the mathematical reasoning used in U.S. classrooms compare with that in

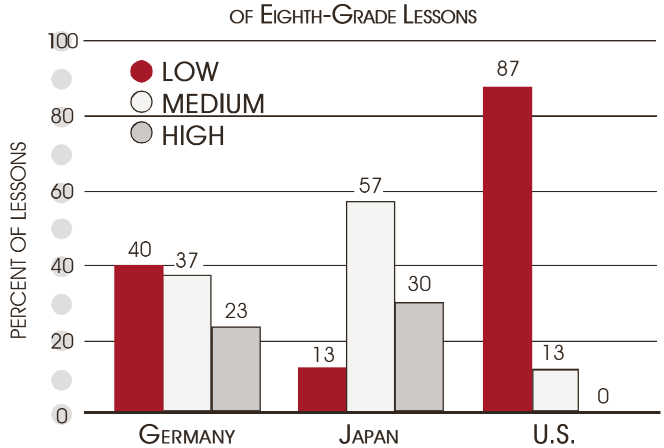
Germany and Japan? Videotape researchers requested the assistance of 3 mathematics professors and one professor of mathematics education in evaluating the quality of the mathematics contained in the videotaped lessons. This group of four experts was asked to judge the quality of the "story" formed by the sequence of mathematical ideas in a random sample of 90 of the lessons divided evenly among each of the three countries. They studied such factors as the coherence of the sequencing, the type of reasoning required of students, the increase in cognitive complexity between the beginning and end of the lesson, and the way in which the problems and examples contributed to the lesson's central concept.

To ensure that the experts were not unconsciously biased toward any country, they were not allowed to actually see the videotapes. Instead, they were provided with a written summary of each lesson's sequence of mathematical statements and equations, as well as how these were embedded in learning activities. The summaries were carefully reviewed to disguise any words such as "yen," or "football," or other hints which might indicate the country in which the lesson was taught. Each expert first independently rated the overall quality of the mathematical content of each lesson as either low, medium, or high. After comparing their ratings, they found high agreement among their judgments. Figure 11 below shows their judgments.

None of the U.S. lessons was considered to contain a high-quality sequence of mathematical ideas, compared to 30 percent of the Japanese, and 23 percent of the German lessons. Instead, the lowest rating was assigned to the mathematical reasoning used in 87 percent of the U.S. lessons, in comparison to 40 percent of the German and 13 percent of Japanese lessons. This finding does not mean that there are no lessons with high-quality mathematical reasoning anywhere in the U.S. However, it does indicate that they are probably a rare phenomenon.

FIGURE 11

EXPERT JUDGEMENTS OF THE QUALITY OF THE MATHEMATICAL CONTENT OF EIGHTH-GRADE LESSONS



SOURCE:
Third International Mathematics and Science Study; unpublished tabulations, Videotape Classroom Study, UCLA, 1996.

These findings that our nation's eighth-grade mathematics classes are based on less challenging material, and lack mathematically rich content suggest that our students have less opportunity to learn challenging mathematics than their counterparts in Germany and Japan.

TO WHAT EXTENT ARE THE RECOMMENDATIONS OF THE MATHEMATICS REFORM MOVEMENT BEING IMPLEMENTED?

A great deal of effort has been invested in the reform of mathematics teaching in the U.S. in recent years. There is considerable agreement among experts about what good instruction should look like. The main goal of the reform is to create classrooms in which students are challenged to think deeply about mathematics and science, by discovering, understanding and applying concepts in new situations. For many years, Japanese mathematics educators have closely studied U.S. education reform recommendations, and attempted to implement these and other ideas in their own country.

Has the message about mathematics reform penetrated to U.S. classrooms? TIMSS data suggest that it is beginning to, but still only in limited ways. Ninety-five percent of U.S. teachers stated that they were either "very aware" or "somewhat aware" of current ideas about teaching and learning mathematics. When asked to list titles of books they read to stay informed about current ideas, one third of U.S. teachers wrote down the names of two important documents by the National Council of Teachers of Mathematics, Curriculum and Evaluation Standards and Professional Teaching Standards.

U.S. teachers believe that their lessons are already implementing the reform recommendations, but the findings described so far in this chapter suggest that their lessons are not. When asked to evaluate to what degree the videotaped lesson was in accord with current ideas about teaching and learning mathematics, almost 75 percent of the teachers respond either "a lot" or "a fair amount." This discrepancy between teachers' beliefs and the TIMSS findings leads us to wonder how teachers themselves understand the key goals of the reform movement, and apply them in the classroom.

Teachers in the study were asked to describe which aspects of the videotaped lesson exemplified current ideas about teaching and learning mathematics. Most U.S. teachers' answers fall into one of three categories:

- Hands-on, real-world math - 38 percent of the teachers mentioned lesson activities that apply math to daily life, such as temperature in Alaska, or that use a physical representation of a mathematical concept, such as geometric blocks.
- Cooperative learning - 31 percent of the teachers mentioned the use of peer tutoring, "study buddies," or math discussion groups.
- Focus on thinking - 19 percent of the teachers mentioned focusing on conceptual thinking about math in preference to computational skills, or mention focusing on problem solving.

Over 80 percent of the teachers in the study referred to something other than a focus on thinking, which is the central message of the mathematics reform movement. The majority of the teachers cited examples of hands-on math or cooperative learning, which are techniques included among the reform recommendations. However, these techniques can be used either with or without engaging students in real mathematical thinking. In fact, the videotape study observed many examples of these techniques being conducted in the absence of high-quality mathematical content.

These findings suggest that the instructional habits and attitudes of U.S. mathematics teachers are only beginning to change in the direction of implementation of mathematics reform recommendations. Teachers' implementation of the reform still concentrates on isolated techniques rather than the central message, which is to focus lessons on high-level mathematical thought. The finding that almost 20 percent of the teachers believed that they had implemented this focus on mathematical thinking, despite experts' judgments that a high-quality sequence of mathematical ideas was virtually absent in their lessons, suggests that teachers may not yet understand what the reform movement means by this term.

The videotape study found that, in many ways, Japanese teaching resembled the recommendations of the U.S. reform movement more closely than did American teaching. Japan also scored among the top nations in the world on the TIMSS test. However, until more studies of other high-scoring nations are carried out, we cannot be sure that there is a relationship between Japan's high scores and its style of teaching.

WHAT DO INITIAL FINDINGS SHOW ABOUT SCIENCE TEACHING?

TIMSS provides less data about science teaching than about mathematics teaching, because the videotape study was conducted only in mathematics. However, the TIMSS teacher and student questionnaires included some items about instructional practices which help us understand something about the teaching of science in Germany, Japan, and the U.S.. The questionnaire data has only begun to be analyzed, and more analyses will soon be completed. Preliminary analyses suggest that U.S. science teaching may resemble mathematics teaching in some respects, and differ in others. Therefore, one should not assume that the videotape findings in mathematics apply to science or to other subjects.

Taken together, the data suggest that the instruction in typical U.S. mathematics classes is not of as high a quality as that in other countries. Next, we turn to the TIMSS findings concerning the teachers themselves. Do the daily working lives of U.S. teachers provide as much support for their instructional activities as those of other countries?

CHAPTER 4: TEACHERS' LIVES

KEY POINTS:

Unlike new U.S. teachers, new Japanese and German teachers receive long-term structured apprenticeships in their profession.

Japanese teachers have more opportunities to discuss teaching-related issues than do U.S. teachers.

U.S. teachers have more college education than their colleagues in all but a few TIMSS countries.

Student diversity and poor discipline are challenges not only for U.S. teachers, but for their German colleagues as well.

Hoping to improve U.S. classroom instruction, many policy makers have recommended improvements in various aspects of the U.S. teacher education system. Experts agree that both the quality of the college preparation prospective teachers receive as well as the quality of the in-service training existing teachers receive are important. However, each year, the percentage of newly-hired teachers is comparatively small in relation to the size of the existing teaching force. Therefore, many experts agree that, in the short run, the quickest way to improve students' learning opportunities is to improve the instruction provided by existing teachers.

To better understand how the characteristics of teachers' daily lives may or may not contribute to high-quality teaching, a team of twelve bilingual researchers each spent three months in German, Japanese, or U.S. schools, observing and interviewing teachers, principals, and students. This activity was carried out as a supplement to the U.S. TIMSS effort. As this chapter will describe, researchers found important differences between U.S. teachers' opportunities for professional learning and improvement of their teaching, and the opportunities of their Japanese and German counterparts.

WHO TEACHES MATHEMATICS AND SCIENCE?

U.S. teachers report that they have spent more years in college than teachers in all but a few of the 41 TIMSS countries. Nearly half of the teachers of U.S. eighth-graders had a masters' degree, a proportion which was exceeded by only four other TIMSS countries. In Japan, few teachers had more than a Bachelors' degree with teacher training. In Germany, teachers complete 13 years of primary and secondary school, followed by about six years of study at the university, after which they write a thesis and pass an examination to receive a degree considered equivalent to a U.S. masters' degree.

Spending many years in college, however, does not necessarily result in teachers who are experts in their fields. Many U.S. policy makers consider it important for mathematics and science teachers to have a strong college background in those subjects. TIMSS, however, was unable to collect information on this topic due to the great variety of ways in which university training in mathematics and science is organized in the participating countries.

Japanese and German teachers enjoy the security of the benefits and tenure which come from their status as civil servants. As civil servants, their jobs are highly protected, and they are comparatively free from concerns about labor-force downsizing or termination for incompetence.

The typical teacher of U.S. eighth-grade math and science students was a woman in her forties, with about 15 years of prior teaching experience. Forties was the norm for most of the other TIMSS countries. The typical teacher of German students was a man nearly fifty, who had been teaching for about 19 years; and the typical teacher of Japanese students was a man in his late thirties, who had been teaching for 14 years.

HOW DO TEACHERS SPEND THEIR TIME?

Teachers of the U.S. and German eighth-grade students teach more classes per week than Japanese teachers. Questionnaires asked teachers to report the number of periods they teach each week. Mathematics teachers in the U.S. most commonly reported teaching 26 periods per week. German teachers reported teaching 24, and Japanese teachers reported teaching 16 periods. Science teachers in the U.S. and Germany most often reported teaching 25 periods per week, and Japanese science teachers 18. Most mathematics teachers in all three countries taught few periods outside of their subject, and the same was true of science teachers.

In addition to teaching, U.S. and Japanese teachers are formally scheduled to perform considerable additional duties during the school day. In the U.S., teachers reported that these additional responsibilities are primarily in student supervision and lesson planning. In Japan, the time was roughly balanced between student counseling, administrative duties, and lesson planning. Most German teachers were scheduled for very few hours of non-teaching tasks at school, and they did their lesson planning at home.

Eighth-grade math and science class sizes in the U.S. and Germany were about the same, averaging 24 to 25 students per class. Japanese math and science classes were much larger, averaging 37 students.

The rhythm of U.S. and Japanese teachers' daily school life was more similar than for their German colleagues. Observations of U.S. teachers showed that they usually were at school around eight hours a day. They were expected to be in the building during school hours, although many came earlier, or stayed later. Japanese teachers were usually at school around nine hours a day. They were expected to be at school from the time it started in the morning until about 4:00 or 5:00, when student club activities end. Many worked later on some evenings. Japanese schools also were in session for a half day two Saturdays per month.

German teachers of eighth-grade students spent the shortest amount of time at school. The hours during which they were in the building usually varied from day to day, depending on their teaching schedule. During periods when they were not scheduled to teach, teachers often were not at school and felt free to come and go from the school much as college professors do in the United States. Most returned home when school was over around 1:30, ate their lunch at home, and planned lessons and reviewed student work during the afternoon and evening.

U.S. and German teachers do not have the rich informal opportunities to learn from each other and to share questions about teaching-related issues that are enjoyed by their Japanese colleagues. Japanese schools are designed with one very large teachers' room, in which all teachers have their main desks, and the seating is arranged so that all teachers from a particular grade or subject sit near each other. When they were not actually instructing classes, teachers spent most of their time in this large room with their colleagues, providing many casual opportunities each day to share advice, ideas and teaching materials. Japanese cultural norms expect junior teachers to query their older colleagues for teaching tips and rely on their advice.

Formal discussions between teachers were more frequent in Japan, as well. When asked how often they meet to discuss curriculum, 76 percent of the teachers of the Japanese TIMSS students reported "at least once a month," compared to 60 percent of the U.S. and 44 percent of the German teachers.

HOW DO TEACHERS LEARN TO TEACH?

U.S. teachers lack the long and carefully mentored introduction to teaching that Japanese and German teachers receive. In Germany this period of intensive training comes before being hired as a teacher. In Japan, it comes during the first year on the job. In all three countries, prospective teachers first take a mixture of courses in education and in academic subject areas leading to graduation from college. After this, however, their experiences diverge sharply.

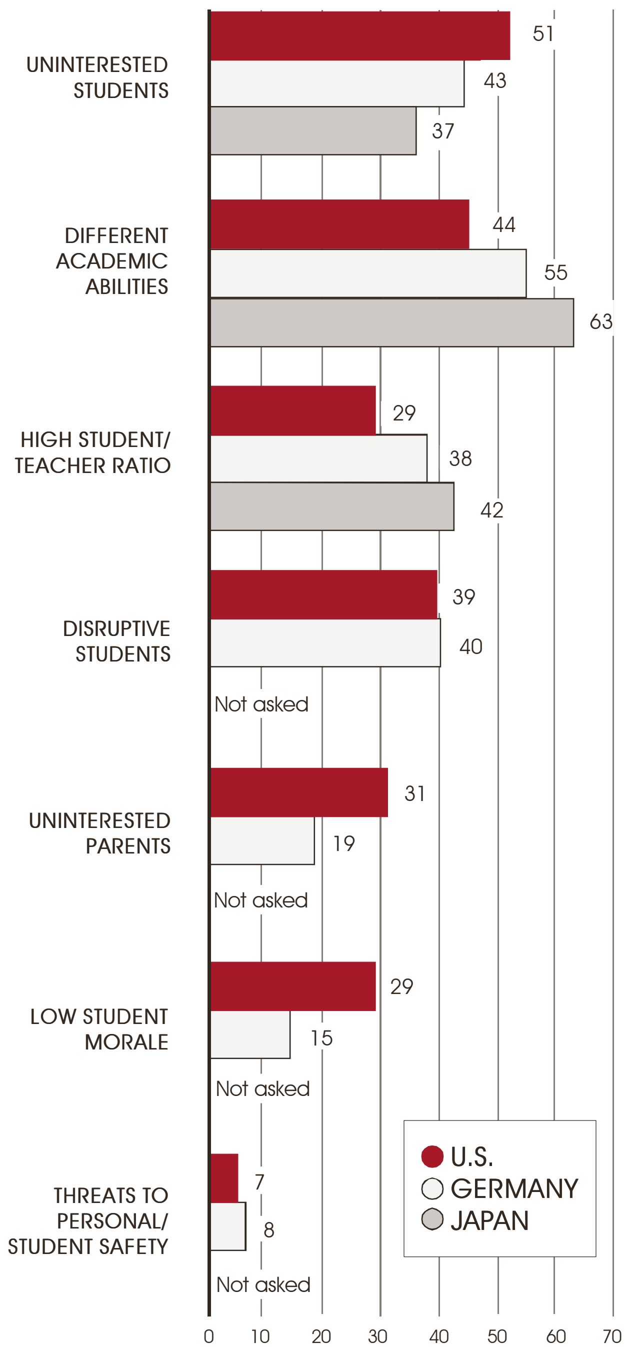
In Germany, after passing a state examination at the end of college, prospective teachers spend two years in student teaching in a program resembling a traditional apprenticeship. During the two years, prospective teachers have a reduced teaching load that begins with classroom observation, then progresses to assisted teaching, and finally to unassisted teaching under the close direction of a mentor teacher. They also attend seminars in their subjects once or twice a week, and their seminar instructor joins the mentor in observing and evaluating the prospective teacher. At the end of the second year, candidates take another state examination and apply for jobs. Placement is not guaranteed.

In Japan, after passing the teacher certification and employment selection examinations, successful candidates are hired by various prefectures, which are similar to U.S. states. New teachers then undergo intensive mentoring and training during their first year on the job. New teachers' first year includes at least 60 days of closely mentored teaching and 30 days of further training at resource centers run by the local and prefectural boards of education. Their teaching load is reduced to allow time for these activities. As is typical of Japanese society, mentoring and assistance between junior and senior teachers continues throughout teachers' working lives.

In comparison to the intensive on-the-job training that German and Japanese teachers receive, U.S. teachers' induction is less structured and comprehensive. Prospective U.S. teachers typically spend 12 weeks or less in student teaching near the end of their undergraduate training. After meeting state licensing requirements and being hired by a school district, the nature of the induction program varies by district, and may include some type of in-service training, and some mentoring by a more experienced teacher.

FIGURE 12

Percentage of Eighth-Grade Mathematics Teachers Reporting That Various Circumstances Limit Their Teaching "Quite a Lot" or "A Great Deal"



SOURCE: Third International Mathematics and Science Study: Unpublished Tabulations, U.S., German, and Japanese teacher surveys, Westat, 1996.

WHAT CHALLENGES DO TEACHERS FACE?

Although teaching students is their job, dealing with students can be teachers' greatest challenge. **During interviews, teachers in all three countries frequently described student diversity as a challenge.** Diversity takes different forms in each country, however. U.S. teachers referred primarily to differences in American students' social, economic, or ethnic background, or to the challenges of dealing with non-English-speaking students. German teachers referred to differences in ethnic background, language, and national origin between the children of German citizens and their country's foreign workers. Japanese teachers referred to the wide differences in academic ability within each classroom, which arise from their nation's policy of not separating students by ability in any way until high school, and not retaining low-performing students in grade.

What circumstances do teachers in the three countries believe limit their effectiveness? TIMSS questionnaires asked teachers to rate the extent to which various factors limited their ability to teach. Figure 12 on page 52 shows the results.

Uninterested students and a wide range of academic abilities challenge teachers in all three countries. Over a third of U.S. and German eighth-grade teachers also felt that disruptive students limited their effectiveness as teachers. The Japanese chose not to include any questionnaire items relating to discipline or morale problems in their schools.

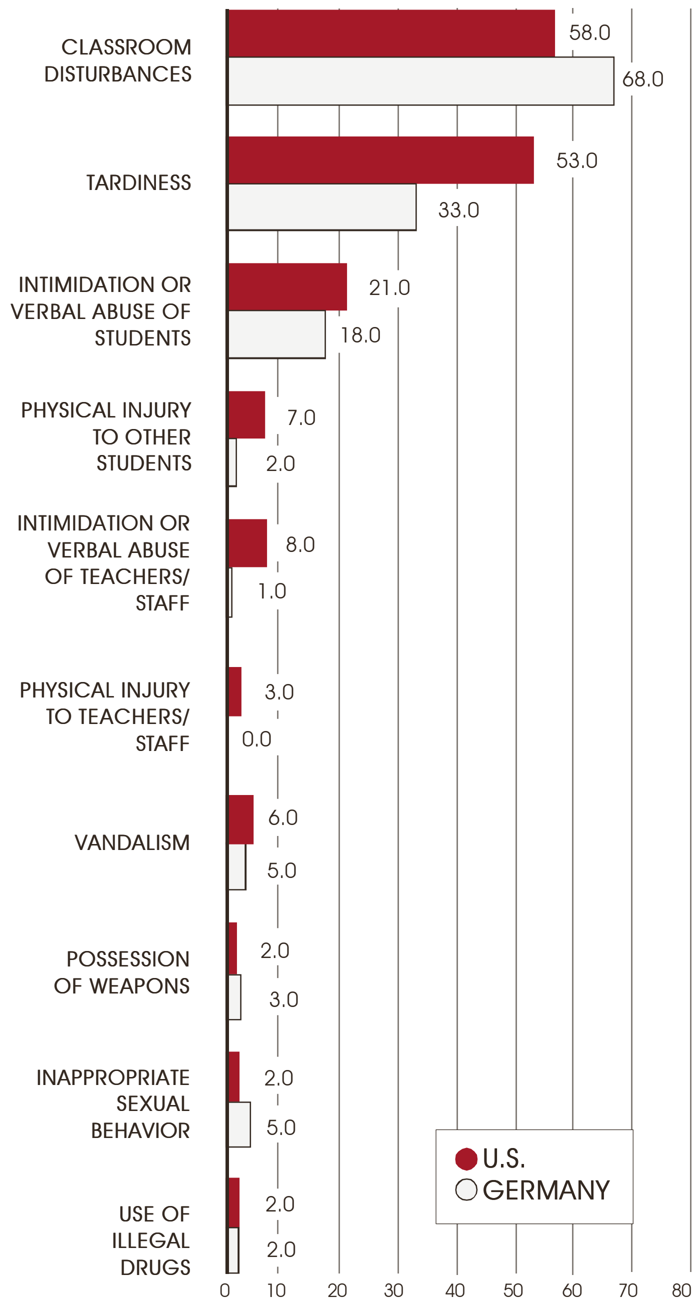
Severe discipline problems and threats to student and teacher safety are neither widespread nor unique to the U.S., despite stories in the popular media that sometimes give the impression that these problems do not exist in other countries. An approximately equal and small number of German and U.S. eighth-grade teachers reported feeling that threats to themselves or their students' safety limited their effectiveness as teachers. Most teachers, however, never experience such serious problems. Seventy-six percent of the U.S. and 65 percent of German teachers reported that threats to their own or students' safety did not limit their effectiveness at all. TIMSS researchers who observed and interviewed teachers in their schools reported that, in both countries, the schools with such serious problems were generally in poorer areas of the city.

Science teachers in all three countries reported hindrances similar to those of their mathematics colleagues, except that they added shortages of demonstration and instructional equipment to the circumstances which limit the effectiveness of their teaching.

Students themselves reported somewhat more discipline problems than their teachers, possibly because children often do not report all incidents to school authorities. About 25 percent of the eighth-graders in both Germany and the U.S. reported on the questionniares that, during the past month, they had been afraid that another student might hurt them. About 40 percent in each country said that one of their friends had been hurt by another student. Theft was

FIGURE 13

Discipline Problems Eighth-Grade Principals Deal with on a Daily Basis



SOURCE:
Third International Mathematics and Science Study; unpublished tabulations, U.S., German, and Japanese School Surveys; Westat, 1996.

more common in the U.S. than Germany. Fifty-eight percent of U.S. students but only 32 percent of German students said that one of their friends had something stolen during the past month. Skipping classes was more common in Germany, with 66 percent of German students reporting that one of their friends had skipped class during the past month, compared with 50 percent in the U.S.

Figure 13 on page 54 shows the percentage of U.S. and German principals who reported that they dealt with various kinds of discipline problems on a daily basis. Principals in both countries responded that their most common discipline problems were classroom disturbances, tardiness, and intimidation or verbal abuse of students by other students. More serious problems such as physical injury of students, teachers, or staff were rare. Use of illegal drugs and possession of weapons was reported as a daily problem by only about 2 percent of the U.S. and German principals. Over 90 percent of principals reported that they and their staff dealt with these problems rarely or never.

Teachers in all three countries found dealing with student diversity to be a challenge to their effectiveness. Many German teachers also experienced problems with student misbehavior. Many teachers in all three countries believed their effectiveness was limited by the range of student abilities represented in their classes, and also by disruptive and disinterested students. The next chapter turns to the questions of how nations deal with student ability differences, as well as the supports and incentives offered to students in their academic endeavors.

CHAPTER 5: STUDENTS' LIVES

KEY POINTS:

Eighth-grade students of different abilities are typically divided into different classrooms in the U.S., and different schools in Germany. In Japan, no ability grouping is practiced.

In the U.S. students in higher-level mathematics classes study different material than students in lower-level classes. In Germany and Japan, all students study the same material, although in Germany, lower-level classes study it less deeply and rigorously.

Japanese eighth-graders are preparing for a high-stakes examination to enter high school at the end of ninth grade.

U.S. teachers assign more homework and spend more class time discussing it than teachers in Germany and Japan. U.S. students report about the same amount of out-of-school math and science study as their Japanese and German counterparts.

Heavy TV watching is as common among U.S. eighth graders as it is among their Japanese counterparts.

On the surface, the lives of eighth graders in most TIMSS countries are fairly similar. School and family occupy the biggest portions, with friends, TV, homework, clubs, and fun added around the side. Yet below the surface, the way in which societies choose to structure the schooling process gives rise to different opportunities and expectations for young people. The motivators, supports, and obstacles to study in each country are outgrowths of the choices provided by society and schools. In each country, the expectations which adult society sets for young people form a framework within which students organize their lives.

WHAT DOES THE SYSTEM REQUIRE OF STUDENTS?

Some U.S. education policy makers have looked admiringly at other nations which use periodic gateway examinations to control student access to the next level of education. Such high-stakes tests are believed to encourage students to study hard. The German and Japanese systems are frequently cited as examples by the proponents of such practices. TIMSS allows us to compare the pathways through schooling in these two countries to those of our own, to understand how the expectations built into the system motivate students of different ability levels.

JAPAN

Japanese public schools offer a single curriculum for all students through the end of 9th grade. Students in elementary and junior high schools are virtually never tracked or grouped by academic ability. There is a widespread belief that, to be fair to all students, the nine years of compulsory education must offer the same nationally determined curriculum to all, regardless of individual differences in motivation or ability. Until the end of ninth grade, there are no gateway exams, and all students are promoted whether or not they understand the material. Students who are overly or insufficiently challenged by classroom assignments may receive extra help after school from a teacher, or their parents may pay to enroll them in a juku, which is a private after-school class. In Japan, a substantial amount of remedial and enrichment instruction is provided by the private sector.

In mathematics, all eighth-grade Japanese students receive a curriculum heavily focused on algebra and geometry. Review of arithmetic is not included in the official curriculum goals and textbooks. TIMSS observers noted that there are differences in students' ability to keep up with the curriculum within each classroom, and also between schools where students come from families with predominantly high or low economic backgrounds. However, the Japanese system is designed such that teachers throughout the country strive to meet similar standards for presentation of content, while allowing almost unlimited variation in the standards of performance attained by students.

At the end of ninth grade, virtually all Japanese students continue on to high school. Before they do, however, all must take the high school entrance exam. This examination covers the five core subjects, including mathematics and science. Scores on the examination serve as a gateway which divides students into high, medium, and low-level high schools on the basis of each student's scores on the exam and prior academic performance. The best of the graduating ninth-graders are accepted at the best academic high schools in each city, which prepare students for application to the best universities. The slowest students are accepted only by the lesser-ranked commercial or vocational high schools, which prepare graduates to enter the labor force. Students and parents clearly understand the consequence of this examination at the end of ninth grade for future career and life choices. Japanese students say that the examination motivates them to study harder during their junior high school years. For the majority of Japanese students, this is the only high-stakes exam they will experience.

Once Japanese students enter high school, they are again promoted each year, until they graduate. Most students then enter the labor force or vocational training. Approximately one third of the high school graduates decide to apply to a university or two-year college, most of which require an entrance examination. Competition on the entrance examinations for prestigious universities is intense, although some lower-ranked colleges will accept most high-school graduates who apply.

Germany

Various exceptions and experiments notwithstanding, the German school system basically sorts students into one of three types of schools at the end of the fourth grade of elementary school. This is accomplished through a system of gateway examinations and ability grouping which differs considerably from the Japanese. Most German students attend one of three types of schools:

- Gymnasium, which provides a demanding, academic curriculum through grade 13 and leads to the Abitur exit examination and university study.
- Realschule which provides a moderately-paced curriculum ending at grade 10 and leads to a school-leaving certificate and vocational training or further study at a Gymnasium.
- Hauptschule, which provides practically-oriented instruction ending at grade 9 and leads to a school leaving certificate and vocational training or employment. Immigrant and non-German students are over-represented in the Hauptschule.

The gateway into one of these schools is controlled by teacher recommendations at the end of fourth grade. Parents can, and frequently do, override teacher recommendations if they believe that their child deserves to be placed in a higher track. If the student is unable to keep up with his classmates, however, he or she will be retained in grade and after repeated failure will be returned to the next lower level of schooling. Most German parents and teachers are relatively comfortable with the fairness of this system, because they believe that it allows each child an education best suited to his or her abilities, interests and future career. However, there is a substantial current of opinion within Germany which would prefer to delay the sorting of students into different school types until later in the student's life, and to make it easier for students to change upward to a higher school type. Most recent policy reforms have made small changes to modify the system in this direction.

Classes in grades 5-9 basically cover the same content in all three types of German schools, although there is considerable difference in the depth and rigor of instruction between the three school types. Typically, Gymnasium students receive a theoretical approach, and Hauptschule students receive a practical approach to the same content. In eighth-grade mathematics, the German curriculum focuses mostly on Geometry and Algebra for all three types of schools, with some mixture of other topics.

Within most schools, eighth graders all follow the same course of study in math and science, regardless of their ability level. Seventy-five percent of the schools reported that they provide only one course of study in mathematics, and 90 percent provide only one course in science. Generally speaking, the German system separates students into different ability levels primarily between, rather than within, schools.

In Germany, students who have not learned the material may be required to repeat the grade, or may be moved to a less demanding school type. Principals reported that 5 percent of students were required to repeat grade eight. Most students finishing the Hauptschule at the end of grade 9, or Realschule at the end of grade 10 receive a diploma, and most states do not require an exit exam. About 10 percent of the students receive only a school-leaving certificate instead of a diploma. Approximately one-third of German students are enrolled in a Gymnasium, and about a quarter of these end their studies before taking the Abitur examination at the end of 13th grade. Very few students who sit for the Abitur fail it, although those with a lower score may not be able to enter their chosen university or field of study.

United States

It is more difficult to generalize about the United States, because practices differ among the thousands of school districts in the country. Generally speaking, however, within-class grouping or individuation of instruction is fairly common in elementary schools in the subjects of reading and mathematics. In middle schools and high schools, students are frequently grouped by ability into different mathematics classes. In the U.S., 80 percent of principals of eighth graders reported that they provided different ability-based classes in mathematics, but only 17 percent reported this in science. Course content and textbooks usually differ between the higher and lower-level classes. In the eighth grade, lower-level classes typically focus on a review of arithmetic and other basic skills with a small amount of algebra. Higher-level classes focus more heavily on algebra, with a small amount of geometry.

In the U.S., educational expectations and teaching standards can also differ substantially between communities, based on a neighborhood's economic status and parental expectations for their children's futures. Minority students are over-represented in lower-level classes and in schools in poorer areas.

There are various procedures for dealing with students who teachers judge have not learned the course material. They may be promoted anyway, retained in grade, moved to a lower-tracked class, or given remedial assistance. Principals reported that 4 percent of the students in their schools were required to repeat grade eight.

Generally speaking, the U.S. system does not have high-stakes gateway examinations which regulate entrance to further schooling before the end of twelfth grade. Seventeen states currently have an exit examination as a requirement for high-school graduation. In most cases, this is a minimum-competency test. Students may take the test several times if necessary, and few students repeatedly fail. Scores on college entrance examinations such as the SAT and ACT are given considerable weight by most selective universities, although non-selective schools may not require them at all.

This section has examined the learning expectations embedded in the school systems in the three countries. Japan is the only one of the three countries which requires a high-stakes entrance examination for all students. Mathematics and science are included on this examination, and Japanese eighth-graders are therefore likely to be studying these subjects harder than usual in preparation. Methods of sorting students by ability into schools and classes differ among the three countries, but both Germany and Japan teach algebra and geometry to all of their eighth-grade students, although the level of rigor may differ by track. In contrast, in the U.S. a heavy focus on algebra is usually reserved for students in the higher tracks, and few U.S. eighth-graders in any track study much geometry.

In all three countries, the standards of performance for students at each grade level are set in such a way that almost all students are passed from one grade to the next, and all who complete secondary education can obtain some type of secondary school diploma, regardless of their level of academic ability.

HOW DO STUDENTS SPEND THEIR TIME DURING SCHOOL?

United States

U.S. students attend school approximately 180 days per year, five days per week. Each day, school usually runs from about 8:00 in the morning until mid-afternoon, with a lunch break and five to seven-minute breaks between classes.

Schools vary in how they organize students. Middle schools commonly include either grades 7-9, or 6-8, although variations exist. In some schools, the student body is subdivided into "houses" or "blocks" which include several classes of students and a single group of teachers, to strengthen continuity in student-teacher and student-student relationships. In other schools, students change teachers and classmates at the end of each period.

Most U.S. schools offer a variety of teacher-led after-school activities, including sports, music, art, theater, and academic clubs. The range of after-school activities varies by school and often reflects the district's and school's resources and socioeconomic status. Participation in clubs is voluntary, and students can participate in more than one activity, as some are seasonal or do not meet every day. Ten percent of U.S. students said that they participate in some type of math or science club each week.

Germany

German students attend school approximately 188 days per year. School usually starts around 7:45 in the morning, and ends around 1:15, with 10 to 25 minute breaks between classes. There is no lunch period, and most students return home for lunch. Gymnasium usually include students from grades 5-13, Realschule grades 5-10, and Hauptschule grades 5-9. Eighth-grade students remain together throughout the day, with teachers changing classrooms. Classes are usually kept together for several years and develop a strong sense of unity.

Most German schools offer few extracurricular activities. Schools visited by TIMSS observers offered mostly sports, arts, and student government. Student participation was low, and some clubs rarely met. Six percent of German students said that they participate in a math or science club each week. Over half of all German students under the age of 15 are involved in organized sports, but these are sponsored by a national organization's local sports clubs rather than the school.

Japan

Japanese schools are in session 220 days per year, five days per week, and two Saturday mornings per month. School usually starts at 8:00 in the morning and ends in the middle of the afternoon, with a lunch break, 5 to 15 minute breaks between various periods, and a homeroom meeting at the beginning and end of each day. The number of classes per day is frequently reduced for special seasonal events, school-wide meetings, and other activities. Junior high schools include grades 7-9. Students in a given class remain together throughout the day, and a different teacher for each subject comes to the students' classroom.

Extracurricular or "club" activities are a very important part of Japanese eighth-graders' lives, and well over half of all students participate. Clubs meet daily throughout the year from the time that classes are over until about 5:00 or 6:00. Four percent of Japanese students reported participating in a math or science club.

In contrast to their German and U.S. counterparts, Japanese junior-high school students are required to wear uniforms to school, and must follow a strict dress code. Regular uniform inspections chastise such deviations as non-regulation belts, shoes, hairstyles, jewelry, and non-regulation book bags. The students themselves play a major role in the enforcement of school rules and discipline. Between students, there is a complicated senior-junior system of deference and behavior training. Younger students speak to students in upper grades using the respectful term *sempai* (upper-class man/woman). Particularly within the clubs, upper-class students are in charge of overseeing the younger students.

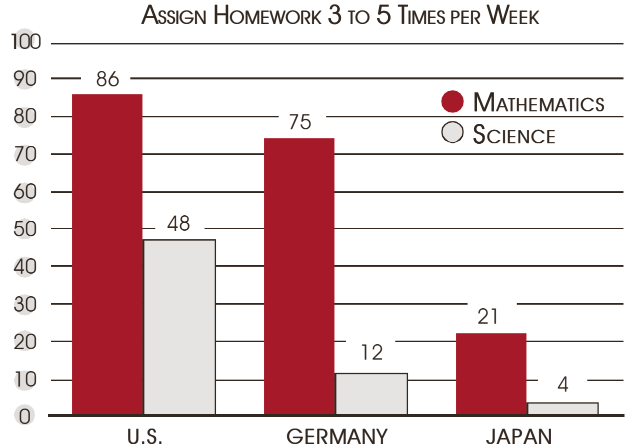
HOW MUCH STUDY DO STUDENTS DO AFTER SCHOOL?

Study at home is not the same as homework. Ideally, students would be self-motivated to study mathematics and science more than the minimum required by homework assignments. The degree to which this actually happens depends on the individual student, and the degree to which the culture encourages or requires eighth-graders to take responsibility for their own learning.

Interviews with students about their daily lives found that, in all three countries, most students tended to put in extra non-assigned study before examinations and relax after they were finished. In Germany and the U.S., the only tests

FIGURE 14

PERCENT OF MATHEMATICS AND SCIENCE TEACHERS WHO ASSIGN HOMEWORK 3 TO 5 TIMES PER WEEK



SOURCE:
Third International Mathematics and Science Study; unpublished tabulations, U.S., German, and Japanese National Surveys; Westat, 1996.

with some consequences for students' academic lives were periodic teacher-prepared in-class examinations. There were broad similarities across countries in students' strategies of study for these examinations. High-achieving students described doing extra hours of non-assigned review and preparation, while this was much less common among low achievers. In Japan, consciousness about the examinations at the end of ninth grade caused all eighth graders to be mindful of the need for extra personal study and preparation, although high achievers were more likely to translate this into substantial home study.

Most Americans believe that homework is an important part of the learning process. Some have recommended assignment of more homework as a means of improving mathematics achievement. It is frequently assumed that teachers in high-achieving countries assign more homework than do U.S. teachers.

However, TIMSS found that Japanese teachers actually assigned less homework than U.S. and German teachers. The teacher questionnaire results and videotapes of classroom practices both agree on this finding. Figure 14 on page 62 shows that 86 percent of U.S. mathematics and 75 percent of German teachers assigned homework 3 to 5 times per week, in comparison to 21 percent of Japanese teachers. When asked about the amount of homework they assign, U.S. and German math teachers' most common response was about thirty minutes or less, three or more times per week. Japanese teachers typically assigned the same amount, but once or twice per week.

U.S. and German teachers not only assign more homework than Japanese, but they also spent more class time talking about or doing it. Time spent on assigning, working on, or sharing homework occupied 11 percent of U.S. and 8 percent of German lessons, in comparison to 2 percent of Japanese lessons. Furthermore, most U.S. teachers reported that they counted homework toward student grades, whereas this practice was not common in Germany and Japan. It was only in the U.S. that some teachers allocated class time for students to begin their homework in class.

The picture changes, however, when students themselves were asked how much time they spend studying math and science. On average, Japanese, German, and U.S. students reported that they spent about the same amount of time each day — between 30 minutes and an hour — studying mathematics outside of school, and about the same amount studying science. These questionnaire findings are in line with what interviewers found when they spoke with eighth graders in each country about their study habits.

Between 30 minutes and an hour of after-school study per night is an average in each country. Of course there were wide differences between students everywhere in how willing they were to complete assignments or go beyond them in extra personal study. Some German, Japanese, and U.S. teachers noted that low-achieving students, particularly those from troubled family backgrounds were less likely to complete assignments, either because they lacked the motivation, or did not have a family environment which was conducive to home study. In contrast, some high-achieving students in each country engaged in extra study beyond what was assigned.

If Japanese teachers assigned less homework than German and U.S. teachers, but Japanese students reported that they studied about as much as their counterparts in these countries, how were typical Japanese students motivated and supported in this extra study? Researchers who observed and interviewed in Japanese schools and homes reported that parents, teachers, and friends encouraged students to study hard during their eighth and ninth grade years in preparation for the high school entrance examinations. Students are believed to have considerable personal responsibility for this process. Some popular teen magazines even run articles on how to devise a personal study and review plan. Japanese students described a combination of peer support and competition that encouraged them to study harder during these years. For students who enter a commercial or vocational high school, however, extra study tends to fall off again after entrance to high school.

Another important source of outside assistance for Japanese students is the juku, which are private after-school classes offered in a variety of subjects to help slower students catch up, or faster students study in more depth to prepare for entrance examinations. Parents must pay to send their children to these private classes, which are run by companies or neighborhood tutors. Researchers reported that some mothers take an extra job to provide the tuition. Although the purpose of juku is academic, students enjoy attending them, because they are able to spend time with their friends walking or riding subway trains to and from the classes. Sixty-four percent of Japanese eighth graders reported attending weekly extra lessons in math, and 41 percent in science. Most students attend juku one or two hours per week. Attendance drops off substantially once high school entrance examinations are completed. Other types of non-academic after-school classes, such as music or marital arts, were also popular among Japanese students.

Japanese experts report that instruction in mathematics juku focuses more on review and practice of basic skills than is typical of Japanese classrooms. This assists slower students who need review of prior material, and provides all students extra practice with concepts learned but not drilled upon in class. Although more systematic study of juku instruction is needed, the hypothesis might be entertained that Japanese students benefit from the different but complementary nature of juku and classroom instruction.

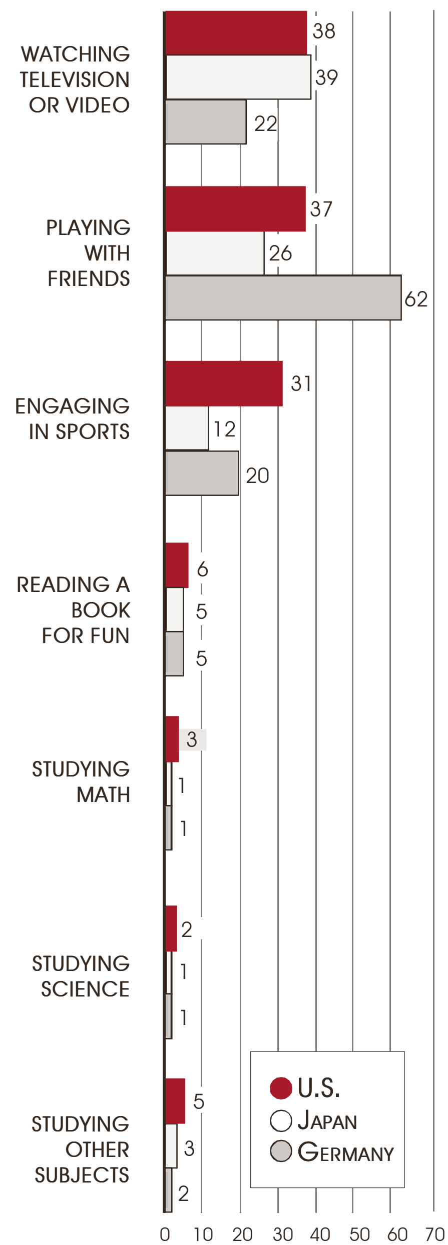
WHAT DO STUDENTS THINK ABOUT MATHEMATICS AND SCIENCE?

At least half the students in Germany, Japan, and the U.S. reported that they like math and science. In the U.S., boys and girls were equally positive, but German and Japanese girls were less positive than boys in those countries.

How much students like math and science is a different question. Students in all three countries were more inclined to agree that that it was important to have time to have fun than that to do well in mathematics and science. More students in the U.S. also agreed that it was important to do well in sports than to do well in math and science. In Germany and Japan, however, fewer students considered it important to do well in sports than in mathematics.

Japanese policy makers are currently discussing an emerging social phenomenon they term risu kirai, or "dislike of mathematics and science." Although much discussed among Japanese experts, it is not clear how widespread this phenomenon is in Japan. About 10 percent of Japanese students reported that they disliked mathematics "a lot," which was comparable to the number of U.S. students who reported strongly disliking the subject. Interviews with Japanese students who disliked the subject suggest that they disliked it because they saw it as difficult and uninteresting. Japanese teachers speculated that many of these students may have fallen behind in earlier grades and never caught up. The teachers thought that the demanding pace of

FIGURE 15
PERCENT OF EIGHTH-GRADERS SPENDING 3 OR MORE HOURS IN VARIOUS AFTER-SCHOOL ACTIVITIES ON A NORMAL SCHOOL DAY



SOURCE:
Third International Mathematics and Science Study: Unpublished Tabulations, U.S., German, and Japanese Surveys, Westat, 1996.

the curriculum and the need to keep instruction focused on the material which will be covered on the high school entrance examination caused students to fall behind.

Most Japanese students experience mathematics and science as difficult. Eighty-seven percent disagreed with the statement "math is an easy subject," and 85 percent disagreed with a similar statement in science. About half of U.S. students on the other hand, reported that math and science are easy. Given the findings reported in Chapter 3 that the U.S. mathematics curriculum focuses on easier topics, and that classroom activities are based mostly on routine procedures rather than conceptual thinking, the hypothesis might be entertained that U.S. students' classroom experiences, at least in mathematics, lead them to believe that these subjects are easy.

WHAT DO STUDENTS DO AFTER SCHOOL BESIDES STUDY?

What other choices and opportunities do societies offer their eighth-graders besides focus on school and study? The way in which societies structure the choices available to young people shows something about the priority assigned to schooling and the society's investment in education.

Figure 15 on page 65 shows that eighth-graders in all three countries were more likely to spend extended periods after school watching television or videos, playing with friends, or engaging in sports than taking part in more academically-related activities. Students who watched a lot of television each day after school were fairly common in all three countries, especially the U.S. and Japan. After-school sports were more popular in the U.S than in Germany or Japan. Almost one third of U.S. eighth-graders reported spending three hours per day engaged in sports activities. In Germany, friends were more popular than television. Two-thirds of German students spent at least three hours per day playing with friends, possibly because German schools finish before lunch, and students have more time to spend with their friends in the afternoon. Very few students in any of the three countries spent extended periods of time reading books for fun or studying school subjects.

The priorities that nations assign to schooling are evident in the opportunities provided for students outside of school. Japan tries to encourage eighth-graders to focus primarily on school, family, and study. In contrast to U.S. and German schools, Japanese schools set and enforce policies for behavior off school grounds. Examples include policies regarding curfews; clothing to be worn in public; use of bicycle helmets: and prohibitions against entering game arcades, dating, employment, smoking, and alcohol. In some towns, teachers and parents check shopping malls, parks, and other areas where students are likely to congregate to monitor student compliance with the rules. These policies may contribute to Japanese students' reports that they spent less time with their friends than German and U.S. teenagers.

In the U.S. and Germany, working at a paid job was not uncommon even for eighth graders. About a quarter of all students in these countries reported that they worked at a paid job before or after school at least an hour per week. In Japan, this percentage was 4 percent.

In summary, eighth-graders' lives in Germany, Japan, and the U.S. share broad similarities in their focus on school, friends, TV, and sports. However, the way in which each society has designed its schooling process, and the expectations that it sets for students provide different motivators, supports, and distractions from study. Considering the choices that other nations have made in this regard may help us to better understand our own.

CONCLUSIONS

KEY POINTS:

No single factor can be considered to influence student performance in isolation from other factors. There are no single answers to complex questions.

The content of U.S. eighth-grade mathematics classes is not as challenging as that of other countries, and topic coverage is not as focused.

Most U.S. mathematics teachers report familiarity with reform recommendations, although only a few apply the key points in their classrooms.

Evidence suggests that U.S. teachers do not receive as much practical training and daily support as their German and Japanese colleagues.

This report has presented highlights from initial analyses of U.S. eighth-graders in international perspective. These findings lightly sketch only a corner of the entire picture of U.S. performance in mathematics and science which will be painted over the next years as further analysis of the eighth-grade data is carried out and findings from grades four and twelve are added.

This section looks across the findings presented in the previous pages for insights into the key questions with which the study started: How do our eighth-graders compare to their international counterparts? What have we learned about mathematics achievement and the factors that may be associated with it? What have we learned about science? What have we learned about how our education system as a whole compares to that of other countries?

Looking for insights into factors associated with student performance is complicated because achievement after eight years of schooling and thirteen years of life is the product of many different influences. Furthermore, education in our country is a vast system with many interrelated parts. No single factor can be properly considered in isolation from others. Realizing that there are no single answers to complex questions, let us review the data.

WHERE DO WE STAND?

The U.S. is far from being among the top nations of the world in mathematics and science. We are far from this goal. Singapore, Korea, Japan, the Czech Republic, and Hungary outperform us in both subjects. Particularly in mathematics, our students lag far behind top-ranking countries. Compared to our goal of excellence among nations, we are not where we aim to be.

However, we are on a par with many of our international trading partners. Our students stand not far from the international average: somewhat below in mathematics, and somewhat above in science. Our math scores are not significantly different than those of Germany and England. Our science scores are not significantly different than those of Germany, England, Canada, and Russia. We rank near the middle of the 41 TIMSS countries, among other nations to whom we frequently compare ourselves.

WHAT HAVE WE LEARNED ABOUT MATHEMATICS?

Our eighth graders score below the international average in mathematics. Although international comparisons over time are difficult, there does not appear to have been much improvement during the past three decades in U.S. students' international standing in this subject. The following factors may be associated with this performance:

- **The content of U.S. eighth-grade mathematics classes is not as challenging as that of other countries.**

  U.S. eighth-grade curriculum and instruction both appear to be less chal lenging than those in other countries. Concerning curriculum, topics covered in U.S. mathematics classrooms are at a seventh-grade level in comparison to other countries. Virtually all German and Japanese students study algebra and geometry in the eighth grade, while in the U.S., only students in higher-level classes receive significant exposure to algebra, and few students study geometry.

Concerning instruction, the content of U.S. classes requires less high-level thought than classes in Germany and Japan. The sequence of mathematical ideas used in lessons was judged to be of low quality in a majority of U.S. classrooms, while this was less frequently the case in the other two countries.

- **Topic coverage is not as focused in U.S. eighth-grade mathematics classes as in the classrooms of other countries.**

  In the U.S., curriculum is determined at the state and local level, which is atypical among TIMSS countries, most of whom determine curriculum nationally. In all grades 1-8, the U.S. mathematics curriculum recommends coverage of more topics than the international average. U.S. mathematics lessons also include a greater number of topics and activities than those in Germany and Japan.

- **Most U.S. eighth-grade math teachers report familiarity with reform recommendations, although only a few apply the key points in their classrooms.**

  Ninety-five percent of U.S. eighth-grade mathematics teachers say that they are aware of current ideas about teaching and learning mathematics. Most believe that the lessons they teach exemplify elements of the recommendations. However, the way in which U.S. teachers understand and implement these recommendations suggests that they are focusing on isolated techniques rather than the central message that teaching and learning should involve high-level mathematical thought. Our mathematics teachers' typical goal is to teach students how to do something, rather than how to think about and understand mathematical concepts. In a variety of respects, Japanese mathematics teaching more closely resembles the recommendations of the U.S. reform movement.

WHAT HAVE WE LEARNED ABOUT SCIENCE?

U.S. eighth graders score above the international average in science. In the three previous international science assessments, the U.S. scored below the international average. Because comparisons of different international assessments over time are difficult, caution should be exercised in assuming that there has been significant improvement in our international standing in science, but it is a possibility.

This initial report contains less information about science than about mathematics because the questionnaire data have not yet been fully analyzed, and the videotape study of classroom instruction was conducted only in mathematics. Furthermore, because we are unable to use multiple research methods to verify the science findings from different perspectives, our findings are more tentative than for mathematics.

Fuller description of eighth-grade science teachers' instructional practices must await further questionnaire analysis.

WHAT HAVE WE LEARNED ABOUT U.S. EDUCATION AS A WHOLE?

TIMSS provides several insights about U.S. eighth-grade teachers and students, which are true of both mathematics and science education.

- **Evidence suggests that U.S. teachers do not receive as much practical training and daily support as their German and Japanese colleagues.**

  In contrast to new German and Japanese teachers, new U.S. teachers do not receive a long-term structured apprenticeship in their profession. Once on the job, they have fewer formal and informal opportunities to discuss and share teaching-related issues and questions. Schools are managed in such a way that lessons are frequently interrupted by loudspeaker announcements or visitors at the door.

- **Our eighth-graders spend at least as much time studying mathematics and science as students in Germany and Japan.**

  During school, our eighth graders spend more hours in mathematics and science classes per year than students in Germany and Japan. U.S. teachers assign more homework, and spend more class time discussing it than teachers in those countries. Outside of school, our students report doing about as much math and science-related homework and other study as German and Japanese students, although most Japanese eighth graders also attend after-school classes in mathematics for an hour or two per week in preparation for the entrance exams to high school.

QUESTIONS FOR FURTHER STUDY

The initial findings described in this report raise many important questions for further study. Some of these may be answered through continued analysis of the eighth-grade data. Others must await the design of future international studies. For this reason, TIMSS is an important national resource for secondary analysis and further research. Some examples are:

- **Why is our international standing lower in mathematics than in science?**

  Deeper analysis of the TIMSS data will help us to compare the curriculum and instructional practices used in mathematics with those in science, to better understand the similarities and differences.

- **How is student achievement related to curriculum coverage?**

  Comparison of the curriculum analysis with achievement scores in the various content areas can illuminate the degree to which our students' performance in algebra, earth science, and other content areas is related to curricular emphasis in these areas.

- **Does mathematics teaching in high performing countries resemble the reform movement's recommendations?**

  The videotape study found that in many ways, Japanese mathematics teaching resembles the recommendations of the U.S. reform movement more closely than does U.S. and German teaching. Is this an important factor in understanding why Japan also scores among the top nations of the world in mathematics? Undertaking similar videotape observational studies of other high-performing nations and further analysis of the TIMSS teacher questionnaire data could provide insight into this question.

TIMSS' LONG TERM UTILITY TO THE NATION

TIMSS is not an answer book, but a mirror through which we can see our own education system in international perspective. It helps us view with new eyes those aspects of our system which we may take for granted. Its findings make us think more deeply about the cultural assumptions and unconscious choices which form the underpinnings of our society's approach to schooling. We come to understand our own system better by comparing it to others. Careful study of our country's reflection in the mirror of international comparisons can provide information to assist educators, business leaders, teachers, and parents as they guide our nation in the pursuit of excellence.

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APPENDIX 1
ADDITIONAL TIMSS REPORTS

For more information visit the TIMSS website at: http://www.ed.gov/NCES/timss.

REPORTS PUBLISHED ON OR BEFORE NOVEMBER 20, 1996

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FORTHCOMING REPORTS

Many Visions, Many Aims: A Cross-National Investigation of Curricular Intentions in School Mathematics.

Many Visions, Many Aims: A Cross-National Investigation of Curricular Intentions in School Science.

A Splintered Vision: An Investigation of U.S. Science and Mathematics Education.

U.S. TIMSS: Mathematics and Science in the Eighth Grade.

U.S. TIMSS: Compendium of Statistics; 7th and 8th Grades.

U.S. TIMSS: Technical Report.

The TIMSS Videotape Classroom Study: Methods and Preliminary Findings. Stigler, James et al.

The Education System in Germany: Case Study Findings.

The Education System in the U.S.: Case

Study Findings.

The Education System in Japan: Case Study Findings.

Case Study Literature Review of Education Policy Topics in Germany, Japan, and the United States.

TIMSS - NAEP Link for Eighth-Grade Mathematics in 41 Nations and 43 States.

TIMSS - NAEP Link for Eighth-Grade Science in 41 Nations and 43 States.

Various International and U.S. Reports Based on 4^{th} Grade TIMSS Data.

Various International and U.S. Reports Based on 12^{th} Grade TIMSS Data.

APPENDIX 2
ADVISORS TO THE U.S. TIMSS STUDY

U.S. TIMSS STEERING COMMITTEE

William Schmidt - Chair
U.S. TIMSS National Research Coordinator, Michigan State University College of Education

Gordon Ambach
Council of Chief State School Officers

Deborah Ball
University of Michigan

Audrey Champagne
SUNY University at Albany

David Cohen
University of Michigan

John Dossey
Illinois State University

Emerson Elliott
National Council for Accreditation of Teacher Education

Sheldon Glashow
Harvard University

Larry Hedges
University of Chicago

Henry Heikkinen
University of Northern Colorado

Jeremy Kilpatrick
University of Georgia

Mary Lindquist
Columbus College

Marcia Linn
University of California at Berkeley

Robert Linn
University of Colorado

Paul Sally
The University of Chicago

Richard Shavelson
Stanford University

Bruce Spencer
Northwestern University

Elizabeth Stage
University of California

James Taylor
Global M

Kenneth Travers
University of Illinois

Paul Williams
University of Wisconsin

John Dossey
Illinois State University

VIDEOTAPE AND CASE STUDY CONSULTANT ROUNDTABLE MEMBERS

Robert LeVine - Chair
Harvard University

Philip Altbach
Boston College

Jim Hiebert
University of Delaware

Eugenia Kemble
American Federation of Teachers

Dan Levine
Westat

Mary Lindquist
Columbus College

Francisco Ramirez
Stanford University

Paul Salley,
University of Chicago

Rainer Silbereisen
University of Jena, Germany

Floraline Stevens
Floraline I. Stevens and Associates

David Stevenson
U.S. Department of Education

ADVISORS TO DEVELOPMENT OF THIS REPORT

Joe Crosswhite
Ohio State University

Henry Heikkinen
University of Northern Colorado

Ross Brewer
Exemplars

Eugenia Kemble
American Federation of Teachers

APPENDIX 3

National Average Scores and Standard Errors

The 95 percent "plus or minus" confidence interval around each nation's score is two times the standard error.

Country	Mathematics Average	Mathematics Standard Error	Science Average	Science Standard Error
(AUSTRALIA)	530	4.0	545	3.9
(AUSTRIA)	539	3.0	558	3.7
BELGIUM-FLEMISH °	565	5.7	550	4.2
(BELGIUM-FRENCH)	526	3.4	471	2.8
(BULGARIA)	540	6.3	565	5.3
CANADA	527	2.4	531	2.6
(COLOMBIA)	385	3.4	411	4.1
CYPRUS	474	1.9	463	1.9
CZECH REPUBLIC	564	4.9	574	4.3
(DENMARK)	502	2.8	478	3.1
ENGLAND *°	506	2.6	552	3.3
FRANCE	538	2.9	498	2.5
(GERMANY) *°	509	4.5	531	4.8
(GREECE)	484	3.1	497	2.2
HONG KONG	588	6.5	522	4.7
HUNGARY	537	3.2	554	2.8
ICELAND	487	4.5	494	4.0
IRAN, ISLAMIC REPUBLIC	428	2.2	470	2.4
IRELAND	527	5.1	538	4.5
(ISRAEL) *	522	6.2	524	5.7
JAPAN	605	1.9	571	1.6
KOREA	607	2.4	565	1.9
(KUWAIT)	392	2.5	430	3.7
LATVIA (LSS) °	493	3.1	485	2.7
LITHUANIA *	477	3.5	476	3.4
(NETHERLANDS)	541	6.7	560	5.0
NEW ZEALAND	508	4.5	525	4.4
NORWAY	503	2.2	527	1.9
PORTUGAL	454	2.5	480	2.3
(ROMANIA)	482	4.0	486	4.7
RUSSIAN FEDERATION	535	5.3	538	4.0
(SCOTLAND)	498	5.5	517	5.1
SINGAPORE	643	4.9	607	5.5
SLOVAK REPUBLIC	547	3.3	544	3.2
(SLOVENIA)	541	3.1	560	2.5
(SOUTH AFRICA)	354	4.4	326	6.6
SPAIN	487	2.0	517	1.7
SWEDEN	519	3.0	535	3.0
SWITZERLAND °	545	2.8	522	2.5
(THAILAND)	522	5.7	525	3.7
UNITED STATES °	500	4.6	534	4.7
INTERNATIONAL AVERAGE	513		516	

NOTES:

1. Nations not meeting international guidelines are shown in parentheses.
2. Nations in which more than 10 percent of the population was excluded from testing are shown with a *. Latvia is designated LSS because only Latvian-speaking schools were tested, which represents less than 65 percent of the population.
3. Nations in which a participation rate of 75 percent of the schools and students combined was achieved only after replacements for refusals were substituted, are shown with a °.
4. The international average is the average of the national averages of the 41 nations. It has no standard error.

SOURCE:

Beaton et al. (1996) Mathematics achievement in the middle school years. Table 1.1. Boston College: Chestnut Hill, MA.,
Beaton et al. (1996) Science achievement in the middle school years. Table 1.1. Boston College: Chestnut Hill, MA.

APPENDIX 4
SUMMARY OF NATIONAL DEVIATIONS FROM INTERNATIONAL STUDY GUIDELINES

Twenty-two of the 41 TIMSS countries experienced a more or less serious deviation from international guidelines for execution of the study. In 16 countries, the TIMSS International Study Center considered the deviations to be sufficiently serious to raise questions about the confidence to be placed in their scores. These 16 nations with major difficulties are noted with an asterisk in this appendix, and with parentheses in Figures 1, 2, 3, 5, and 6 in this report.

*Australia - Participation rate did not meet the international criterion of 75 percent of schools and students combined. Participation rate was 70 percent after replacements for refusals were substituted.

*Austria - Participation rate did not meet the international criterion of at least 50 percent participation by schools before replacement. The initial participation rate was 41 percent before replacement. Participation rate was 80 percent after replacements for refusals were substituted.

*Belgium (Flemish) - Participation rate of 75 percent of schools and students combined was achieved only after replacements for refusals were substituted.

Belgium (French) - Participation rate did not meet the international criterion of 75 percent of schools and students combined. Participation rate was 72 percent after replacements for refusals were substituted.

*Bulgaria - Participation rate did not meet the international criterion of 75 percent of schools and students combined. Participation rate was 63 percent after replacements for refusals were substituted.

*Colombia - The pair of grades tested was one grade higher than the international target. Average age of students in the upper grade was 15.7.

*Denmark - International guidelines requiring random selection of the classrooms to receive the assessment were not followed.

England - More than the international criterion of ten percent of schools and students were excused from the test for various reasons with resulting coverage of 89 percent of the desired population. Participation rate of 75 percent of schools and students combined was achieved only after replacements for refusals were substituted.

*Germany - The pair of grades tested was one grade higher than the international target. Average student age of students in the upper grade was 14.8. One of sixteen regions (Baden-Wuerttemberg) did not participate in the study, with resulting coverage of 88 percent of the desired population. Participation rate of 75 percent of schools and students combined was achieved only after replacements for refusals were substituted.

*Greece - International guidelines requiring random selection of the classrooms to receive the assessment were not followed.

*Israel - Test administered only in the Hebrew-speaking public school system, with resulting coverage of 74 percent of the desired population. International guidelines requiring random selection of the classrooms to receive the assessment were not followed. Participation rate did not meet the international criterion of at least 50 percent participation by schools in the sample before replacement. The participation rate before replacement was 45 percent.

*Kuwait - In contrast to other nations, which tested two adjacent grades, Kuwait tested only one grade; the ninth grade. This grade was higher than either of the grades which should have been the international target. Average student age was 15.3.

Latvia (LSS) - Test administered only in Latvian-speaking schools, with resulting coverage of 51 percent of the desired population. Because coverage falls below the international 65 percent population-coverage criterion, Latvia is designated (LSS) for Latvian Speaking Schools.

Lithuania - Test administered only in Lithuanian-speaking schools, with resulting coverage of 84 percent of the desired population.

*Netherlands - Participation rate did not meet the international criterion of at least 50 percent participation by schools before replacement. The initial participation rate before replacement was 24 percent.

*Romania - The pair of grades tested was one grade higher than the international target. Average student age in the upper grade was 14.6.

*Scotland - Participation rate did not meet the international criterion of 75 percent of schools and students combined. Participation rate was 73 percent after replacements for refusals were substituted.

*Slovenia - The pair of grades tested was one grade higher than the international target. Average student age was 14.8.

*South Africa - International guidelines requiring random selection of the classrooms to receive the assessment were not followed. Participation rate did not meet the international criterion of 75 percent of schools and students combined. Participation rate was 62 percent after replacements for refusals were substituted.

Switzerland - Test administered in 22 of 26 cantons, with resulting coverage of 86 percent of the desired population.

*Thailand - International guidelines requiring random selection of the classrooms to receive the assessment were not followed.

United States - Participation rate of 75 percent of schools and students combined was achieved only after replacements for refusals were substituted.