1 Are readings ~~could~~ corrected for guessing - see page 22

2 P24 - move up comparison to SIMSS

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PURSUING EXCELLENCE

A Study of U.S. Twelfth-Grade Mathematics and Science Achievement in International Context

Initial Findings from the Third International Mathematics and Science Study

National Center for Education Statistics
Office of Educational Research and Improvement NCES 98-049
U.S. Department of Education

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A Study of U.S. Twelfth-Grade Mathematics and Science Achievement in an International Context

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Initial Findings from the
Third International Mathematics and Science Study

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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 1995, the study assessed the math and science knowledge of a half-million students from 41 nations at five different grade levels.

- The information in this report is about students that were assessed at the end of their senior year in the United States and at the end of secondary education in other countries. It includes three areas of performance: mathematics literacy and science literacy; advanced mathematics; and physics.

- This report on students in the final year of secondary school is the last of a series of three public-audience reports titled *Pursuing Excellence*. The first report presented findings on student achievement at eighth grade. The second report presented findings from the fourth grade.

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

Naming dropout rates in different cultures/nations

- 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 students, a charge which some critics have leveled at previous international comparisons. The students who participated in TIMSS were scientifically selected to accurately represent 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.

- This report consists of three parts: initial findings of mathematics and science literacy assessments for 21 participating countries; initial findings of advanced mathematics and physics assessments for 16 countries which administered the advanced mathematics and physics assessments; and initial findings about school systems and students' lives.

ACHIEVEMENT OF ALL STUDENTS

- A sample of all students at the end of secondary school (twelfth grade in the United States) was assessed in mathematics and science literacy. Mathematics literacy and science literacy are defined as the knowledge of mathematics and of science needed to function effectively in society as adults.

- In mathematics literacy, U.S. twelfth graders performed below the international average and among the lowest of the 21 TIMSS countries. U.S. students were outperformed by those in 14 countries, and outperformed those in 2 countries. Among the 21 TIMSS nations, our students scores were not significantly different from those in 4 countries including Italy and the Russian Federation.

- In science literacy, U.S. twelfth graders also performed below the international average and among the lowest of the 21 TIMSS countries. U.S. students were outperformed by students in 11 countries. U.S. students outperformed students in 2 countries. Our students' scores were not significantly different from those of 7 countries including Italy, Germany, France, and the Russian Federation.

- The international standing of U.S. students was stronger at the eighth grade than at the twelfth grade in both mathematics and science literacy.

- The U.S. international standing on the literacy component of TIMSS was stronger in science than in mathematics. This pattern is similar to the findings at fourth and eighth grades in TIMSS.

- The U.S. was one of three countries which did not have a significant gender gap in mathematics literacy among students at the end of secondary schooling. While there was a gender gap in science literacy in the U.S. as in every other TIMSS nation, the U.S. gender gap was one of the smallest.

ACHIEVEMENT OF ADVANCED STUDENTS

- The advanced mathematics assessment was administered to students who had taken pre-calculus, calculus, or Advanced Placement calculus in the United States and to advanced mathematics students in other countries. The physics assessment was administered to students in the United States who had taken physics or Advanced Placement physics and to advanced science students in other countries.

- Performance of U.S. advanced mathematics and physics students was among the lowest of the 16 countries which administered the advanced mathematics and physics assessments. In advanced mathematics, 11 countries outperformed the U.S. and no countries performed more poorly. In physics, 14 countries outperformed the U.S.; again, no countries performed more poorly.

- In all three content areas of advanced mathematics and in all five content areas of physics, U.S. advanced mathematics and physics students' performance was among the lowest of the TIMSS nations.

- In both advanced mathematics and physics, males outperformed females in the U.S. and most of the other TIMSS countries.

- More countries outperformed the U.S. in physics than on advanced mathematics. This differs from the results for mathematics and science literacy, as well as at grades 4 and 8, where more countries outperformed the U.S. in mathematics than in science.

CONTEXTS OF LEARNING

- It is too early in the process of data analysis to provide strong evidence to suggest factors that may be related to the patterns of performance at the end of secondary schooling described here. No single factor or combination of factors emerges as particularly explanatory.

- The fact that other countries differ in the decisions they have made about the nature of secondary education does not mean it is inappropriate or unfair to compare the performance of U.S. students at the end of secondary school to those in other countries. TIMSS provides an opportunity to examine whether the choices countries have made about the nature of secondary education appear to be related to what students know at the end of their secondary schooling in mathematics and science.

yuck defensive what is point

- While secondary education in the U.S. differs from that in many of the other countries on important dimensions, none of those differences are clearly related to the relatively poor performance of our twelfth graders on the TIMSS assessments.

- The lives of U.S. graduating students do not differ from those of their peers in other countries on many of the factors examined. Where there are differences, few appear to be systematically related to the our performance in twelfth grade compared to the other countries participating in TIMSS.

- In general, preliminary analysis sheds little light on factors that might account for why U.S. twelfth graders ~~did not~~ compare ~~as~~ favorably with their international peers as U.S. eighth and fourth graders did.
  less

CONCLUSIONS

- TIMSS does not suggest any single factor or combination of factors that can explain why our performance at twelfth grade is so low.

- From our preliminary analyses, it also appears that some factors commonly thought to influence individual student performance are not strongly related to performance when comparing average student performance across countries.

- TIMSS provides a rich source of information about student performance in mathematics and science, and about education in other countries. These early findings suggest that to use the study most effectively, we need to continue to pursue the data beyond this initial report, taking the opportunity and time to look at interrelationships among factors in greater depth.

PREFACE

The Third International Mathematics and Science Study (TIMSS) is the largest and most comprehensive comparative international study of education that has ever been undertaken. Coordinated in the United States by the National Center for Education Statistics (NCES) and the National Science Foundation (NSF), the study assessed a half-million students from 41 countries in 30 languages to compare their mathematics and science achievement. This report focuses on the 23 countries that participated in the TIMSS study of students at the end of secondary education.

TIMSS comes at a time when mathematics and science achievement have been designated as an educational priority. One of our eight current National Education Goals, established in 1989, is that "by the year 2000, the U.S. will be first in the world in mathematics and science achievement." In addition, 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*[1] in 1989, and *Professional Standards for Teaching Mathematics*[2] in 1991. In 1993, the American Association for the Advancement of Science followed suit with *Benchmarks for Science Literacy*[3], and in 1996, the National Academy of Sciences published *National Science Education Standards*[4].

This is the last of the three reports in the *Pursuing Excellence* series. The first report presented initial findings on the eighth grade and was released in November, 1996. The second report presented findings on the fourth grade, and was released in June, 1997. This report presents initial findings about the international standing of the United States' twelfth graders relative to students completing secondary school in countries that participated in TIMSS. It is based on the comparative data published by the TIMSS International Study Center at Boston College. Future reports on selected topics will provide a more complete and extensive analysis of the data, and will investigate relationships among the findings.

WHAT IS TIMSS?

TIMSS is the third comparison of mathematics achievement and third comparison of 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. TIMSS is the first IEA study that has assessed both mathematics and science at the same time. Comparative studies of other subjects, including reading literacy[5] (1992) and computers in education[6] (1993) 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. Initial findings for the 41 countries in the lower secondary school component[7] and for the 26 countries that participated in the elementary school component[8] are reported in earlier volumes of the *Pursuing Excellence* series. This report presents initial findings for the 23 countries in the remaining component of TIMSS, students at the end of secondary education. Findings are presented for three broad areas of performance.

1) Mathematics and science literacy for all students in the final year of secondary education.

2) Advanced mathematics for students in the final year of secondary education who have taken advanced course work in mathematics.

3) Physics for students in the final year of secondary education who have taken physics.

The first two components of TIMSS defined eligible students primarily on the basis of age. The elementary school group included students enrolled in the pair of adjacent grades that contained the most 9 year-olds, grades 3 and 4 in the U.S. and most other countries. The lower secondary school students were in the pair of grades that contained the most 13 year-olds, grades 7 and 8 in the U.S. and most other countries.

A major goal of this component of TIMSS was to measure the "yield" of the secondary school system. Because countries have different structures for secondary education, the final grade for secondary education may be as low as 9 and as high as 14, depending on the country and program in which the student is enrolled. For the United States, the final year of secondary education is Grade 12, and twelfth grade students were selected for the study. All twelfth graders were eligible for the mathematics and science literacy portion of the study. Advanced mathematics students in the U.S. were defined as twelfth graders who had taken or were taking a full year of a high school course that included the word "Calculus" in the title. Physics students were twelfth graders who had taken or were taking at least one full year of high school physics. Appendix 1 provides information about how other countries identified students to participate in the study.

Students in both public and private schools were administered the literacy assessment, which was about one and one-half hours in length, and included both multiple-choice and free-response items. In each country, the items were translated into the primary languages of instruction. In the U.S. all assessments were administered in English. Testing occurred 2 to 3 months before the end of the 1994-95 school year. Students with special needs and disabilities that would make it difficult for them to take the assessment were excused.

Like the other components of TIMSS, participating countries collected data beyond the student assessments. Students completed questionnaires about their mathematics and science studies and beliefs. School administrators completed questionnaires about school policies and practices. And an exploratory curriculum analysis compared mathematics and science curriculum guides and textbooks. It studied subject-matter content, sequencing of topics, and expectations for student performance. Teacher questionnaires were not administered, as some of the graduating students who participated in the study were no longer enrolled in mathematics and science.

TIMSS is the most fair and accurate international comparison of students which has ever been undertaken. The students who participated in TIMSS were to be randomly selected to represent all students in their respective nations, using guidelines developed by international committees. An international curriculum analysis was carried out prior to the development of the assessments to ensure that the items would reflect the mathematics and science curricula in the TIMSS countries. To further ensure that the assessment measured knowledge that the world community considers important for students to know, the items were developed by international committees. International monitors carefully checked the translations and visited many classrooms while the assessments were being administered in each of the participating countries to make sure that the instructions were properly followed.

Maintaining quality standards for sampling provided challenges for most of the countries. Most of the 23 countries who participated in this portion of TIMSS—including the United States—experienced difficulties of various types. Areas of difficulty included minimizing the extent to which students were excluded from the population eligible for the sample and gaining participation of schools and students after they were selected for the sample. All countries in which difficulties arose are shown in parentheses in the figures and tables in this report. The U.S. is in parenthesis because its combined participation rate (the product of the percent of sampled schools and the percent of sampled students who agreed to participate, allowing replacements for initial refusals) was 64 percent, below the standard of 75 percent. Appendix 1 provides information about sampling and adherence to sampling and other standards in all the countries.

Full documentation of the data collection methodologies and statistical analyses used in all participating countries is available in technical reports[9] and quality control reports[10] published by the TIMSS International Study Center at Boston College. A complete list of all TIMSS reports published to date is contained in Appendix 7.

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 Mullis at the TIMSS International Study Center, located at Boston College. Each of the 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 cost of the international coordination was paid by the National Center for Education Statistics (NCES) of the U.S. Department of Education, the National Science Foundation (NSF), and the Canadian Government.

The United States portion of TIMSS was also funded by NCES and NSF. Professor William Schmidt of Michigan State University was U.S. National Research Coordinator. Policy decisions on the study were made by the U.S. National Coordinating Committee. NCES monitored the international and U.S. TIMSS projects. 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. The many advisors to the study are listed in Appendix 6.

The U.S. TIMSS team also includes the approximately 11,000 twelfth-grade students who took the assessment, and their principals in 210 schools nationwide. Their cooperation has made this report possible.

What Questions Does This Report Answer?

This report answers three basic questions:

- How does the mathematical and scientific literacy of U.S. twelfth graders compare to that of students completing secondary school in other nations?
- How do our U.S. high school seniors enrolled in advanced mathematics and physics perform in these subjects in comparison to their counterparts in other nations?
- What factors might contribute to the U.S. relative performance in mathematics and science at the end of secondary school?

Chapter 1 answers the first question. This question is important because it measures the "yield" of our school system in comparison to that of other nations. The findings in this chapter reveal how well our students have been prepared by 12 years of formal schooling for their future as workers and citizens in a world that increasingly relies on mathematics, science, and technology.

Chapter 2 answers the second question. Advanced students have taken additional specialized mathematics and science courses in high school, such as calculus and physics. Many are likely to become our nation's future physicians, engineers, and research scientists, and to enter mathematical and scientific professions.

Chapter 3 answers the third question. It examines a variety of factors related to schooling and students' lives to see if any of them shed some insight into why U.S. students perform as they do relative to students in other countries at the end of secondary school.

CHAPTER I: ACHIEVEMENT OF ALL STUDENTS

KEY POINTS:

U.S. twelfth graders scored below the international average, and among the lowest of the 21 TIMSS nations in both mathematics and science literacy in the final year of secondary school.

U.S. students' international standing was stronger at the eighth grade than at the twelfth grade in both mathematics and science.

The U.S. was one of three countries which did not have a significant gender gap in mathematics literacy at the end of secondary schooling. While there was a gender gap in science literacy in the U.S. as in all other TIMSS countries, the U.S. gender gap is one of the smallest.

The U.S. international standing on the literacy component of TIMSS was stronger in science than in mathematics. This pattern is similar to the findings at fourth and eighth grades in TIMSS.

MATHEMATICS AND SCIENCE LITERACY

How well do young people understand the basic mathematics and science needed to function effectively in society? To answer this question, TIMSS developed a mathematics and science literacy assessment. This assessment was designed to determine students' general level of knowledge of fundamental scientific and mathematical concepts upon the completion of secondary school. This assessment was given to a random sample of all students completing their final year of secondary education, at whatever grade or age their nation or program of studies set as the end of their schooling.

Because the assessment was designed for all students completing secondary school, whether or not they were currently taking mathematics or science at the time of the study, the kinds of questions asked of the students were not tied to any one particular program or course of study. However, it was designed to examine how well students had acquired the mathematical and scientific skills and knowledge judged by an international committee of experts to be necessary for all citizens in their daily life. The results, obtained through an assessment of students' knowledge of mathematical and scientific concepts, reasoning, and practical or "real world" applications, provide a glimpse of how well prepared the graduates of the education system in the various TIMSS nations are for higher education and the world of work.

Tempting though it may be, it is not correct to report U.S. scores by rank alone. This is because the score reported for each country was based on a sample of students in each country, and is therefore an estimate of the "true" score that would have been achieved had all the eligible students participated in the assessment. While many steps were taken to ensure that the samples were representative of the total population, each estimated score has a margin of error associated with it. The margin of error is expressed as a "plus or minus" interval around the estimated score, creating a range of scores within which the true score is likely to fall. Thus, while one score may be higher than another, if the difference between the two is small enough, it may not be statistically significant because of the margins of error. Because precise scores 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 significantly higher than, not significantly different from, or significantly lower than the U.S.

In TIMSS, we can say with 95 percent confidence that comparisons of other countries' scores to those of the U.S. are accurate plus or minus about 10 to 20 points, depending on the design of sample in other countries. Comparisons of the U.S. to the international average are accurate plus or minus about 7 points. (Appendix 2 contains a list of national averages and standard errors.)

MATHEMATICS LITERACY ASSESSMENT

The mathematics literacy assessment consists of about 80 percent multiple choice items and 20 percent free response items. Based on each country's curriculum, the mathematics literacy assessment was found to be at about a seventh grade difficulty for most TIMSS nations. In the case of the U.S., the assessment was most equivalent to the ninth grade curriculum, reflecting the late appearance of algebra and many geometry topics in curriculum in the U.S.

HOW WELL DO U.S. TWELFTH GRADERS DO ON THE MATHEMATICS LITERACY ASSESSMENT?

On the mathematics portion of the literacy assessment, U.S. students scored below the international average, and among the lowest of the twenty-one countries. Only two countries were significantly below those of the U.S. Figure 1-1 shows how U.S. students performed on the mathematics literacy assessment.

Figure 1-1:
Mathematics Literacy Achievement

NATIONS WITH AVERAGE SCORES SIGNIFICANTLY HIGHER THAN THE US

NATION	AVERAGE
(NETHERLANDS)	560
SWEDEN	552
(DENMARK)	547
SWITZERLAND	540
(ICELAND)	534
(NORWAY)	528
(FRANCE)	523
NEW ZEALAND	522
(AUSTRALIA)	522
(CANADA)	519
(AUSTRIA)	518
(SLOVENIA)	512
(GERMANY)	495
HUNGARY	483

NATIONS WITH AVERAGE SCORES NOT SIGNIFICANTLY DIFFERENT FROM THE US

NATION	AVERAGE
(ITALY)	476
(RUSSIAN FEDERATION)	471
(LITHUANIA)	469
CZECH REPUBLIC	466
(UNITED STATES)	461

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

NATION	AVERAGE
(CYPRUS)	446
(SOUTH AFRICA)	356

INTERNATIONAL AVERAGE = 500

NOTE: Nations not meeting international sampling and other guidelines are shown in parentheses.

SOURCE: Mullis et al. (1998) *Mathematics and Science Achievement in the Final Year of Secondary School.* Table 2.1. Boston College: Chestnut Hill, MA.

In mathematics literacy, students in the final year of secondary school in 14 countries scored significantly above our twelfth graders (The Netherlands, Sweden, Switzerland, Norway, France, New Zealand, Australia, Canada, Denmark, Iceland, Slovenia, Hungary, Germany, and Austria). Students in four countries were not significantly different from ours (Italy, the

Russian Federation, Lithuania and the Czech Republic). Students in two countries (Cyprus and South Africa) performed significantly below the students in the U.S.

WHAT ARE STUDENTS ASKED TO DO ON THE MATHEMATICS LITERACY ASSESSMENT?

Mathematics literacy assessment items are designed to measure general knowledge and skills judged by an international committee of experts to be necessary for citizens in their daily life. The following are three examples of mathematics literacy assessment items. Appendix 3 shows the percentage of students responding correctly to each example item in every country.

The item shown in Figure 1-2 requires an understanding of basic concepts of measurement. This item was easy for students in the most TIMSS countries: the international average was 83 percent. Sixty-two percent of U.S. twelfth graders responded correctly on this item. Most U.S. students who responded incorrectly chose "A" which is the largest number of the paces, not recognizing that someone with the longest pace would cover the same distance in the least number of paces, "D."

FIGURE 1-2: EXAMPLE OF MATHEMATICS LITERACY ITEM

Four children measured the width of a room by counting how many paces it took them to cross it. The chart below shows their measurements. Who had the longest pace?

Name	Number of Paces
Stephen	10
Erlane	8
Ana	9
Carlos	7

A. Stephen
B. Erlane
C. Ana
D. Carlos

Is this a reading problem not a math problem?

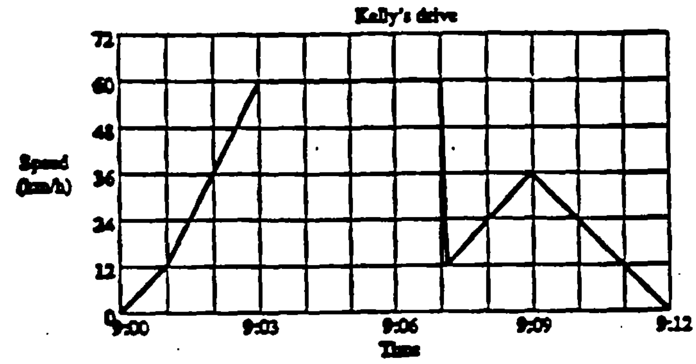
Answer: D U.S. Average: 62 percent International Average: 83 percent

Figure 1-3 is an item on which U.S. students did well. This item requires students to interpret the information in a travel graph and to provide their response in an open-ended format. Students needed to be able to read the line graph and use the labeled information on the vertical axis to provide the answer of 60 km/hour as the car's maximum speed. About 85 percent of our students responded correctly on this item which is 11 percentage points above the international average.

FIGURE 1-3: EXAMPLE OF MATHEMATICS LITERACY ITEM

Kelly went for a drive in her car. During the drive, a cat ran in front of the car. Kelly slammed on the brakes and missed the cat.

Slightly shaken, Kelly decided to return home by a shorter route. The graph below is a record of the car's speed during the drive.



major issue

What was the maximum speed, in kilometers per hour, of the car during the drive?

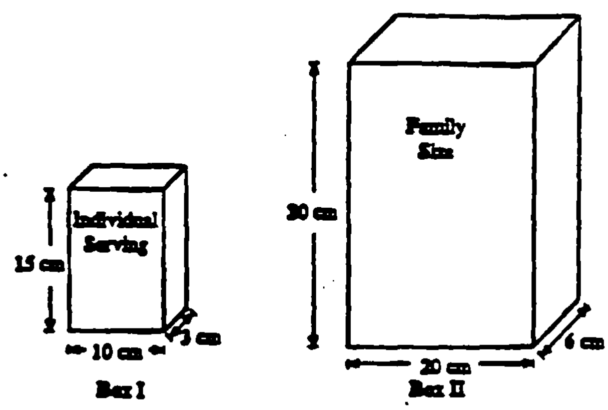
Answer: 60 km/hour U.S. Average: 85 percent International Average: 74 percent

less than half

The item shown in the Figure 1-4 requires students to use information and to solve a problem. Twenty-four percent of our students responded correctly to this item, while the international average was 49 percent. The majority of U.S. twelfth graders, 61 percent, chose "A", 160 grams. Students choosing "A" might have observed the width, height, and depth of Box I and Box II separately and found that the width, and height, and depth of Box II are twice those of Box I. They then incorrectly doubled the weight. The correct answer was "D", which is eight times the original weight.

FIGURE 1-4: EXAMPLE OF MATHEMATICS LITERACY ITEM

The two cereal boxes shown below are similar in shape and are full of cereal. Box I holds 80 grams of cereal.



How many grams of the same cereal does Box II hold?

A. 160
B. 320
C. 480
D. 640

Answer: D U.S. Average: 25 percent International Average: 49 percent

How Do U.S. Students In Twelfth Grade Do In Mathematics Achievement Compared To Those In Eighth Grade?

Twenty countries participated TIMSS at both the eighth grade and the final year of secondary school. Figure 1-5 shows the mathematics performance of 20 nations at eighth grade and the final year of secondary school compared to the international average.

FIGURE 1-5: Mathematics Performance at the Eighth Grade and the Final Year of Secondary School Compared With the International Average

	Final year of secondary school: above the international average	Final year of secondary school: same as the international average	Final year of secondary school: below the international average
Eighth grade: Above the international average	Switzerland, (Netherlands), (Austria), (France), (Canada)	(Slovenia), (Australia), Czech Republic	Hungary, (Russian Federation)
Eighth Grade: Same as the international average	Sweden, New Zealand, (Denmark)	(Germany)	(U.S.)
Eighth Grade: below the international average	(Norway), (Iceland)		(Lithuania), (Cyprus), (South Africa)

NOTE: Nations not meeting international sampling and other guidelines are shown in parentheses.

SOURCE: Mullis et al. (1998) *Mathematics and Science Achievement in the Final Year of Secondary School.* Figure 2.3. Boston College: Chestnut Hill, MA.

Students in five countries seem to maintain their international standing above the international average at both the eighth and the final year of secondary school (Austria, Canada, France, Netherlands, and Switzerland).

The three dark shaded cells on the upper right side in figure 1-5 show six countries, including the U.S., that had a lower relative international standing in mathematics achievement in the final year of secondary school than in the eighth grade. The difference in relative international standing between eighth grade and the final year of secondary school was rather moderate for the U.S.; going from "same as" the international average at the eighth grade to "below" the international average at the twelfth grade. In Hungary and the Russian Federation, their relative international standings in mathematics achievement went from "above" the international average at eighth grade to "below" the international average at the end of secondary school.

The three lightly shaded cells on lower left side in the same figure show five countries that had a higher relative international standing of the mathematics achievement in the final year of secondary school than in the eighth grade. Iceland and Norway showed a great difference in their relative international standings in mathematics achievement between two grades: "below" the international average at eighth grade and "above" the international average at the final year of secondary school.

It is noteworthy that except for the U.S. and Australia, the countries that had a lower relative international standing in mathematics achievement in the final year of secondary school than in the eighth grade are the countries that belong to the former Eastern Block (the Russian Federation, Hungary, Slovenia, the Czech Republic). In contrast, countries that had a higher relative international standing in the final year of secondary school than in the eighth grade are Nórdic countries (Sweden, Denmark, Norway, and Iceland) with New Zealand as the exception.

IS THERE A GENDER GAP IN MATHEMATICS LITERACY AT THE TWELFTH GRADE?

In the U.S. and other countries, policy makers have made great efforts to make mathematics and science more accessible to young women, and to encourage gender equity in these subjects. Despite these efforts, students in the final year of secondary school in most TIMSS nations demonstrated a significant gender gap in the mathematics portions of the literacy assessment, with young men performing better than young women. **In the U.S., the gender gap was not significant.** The U.S. was one of three countries (South Africa and Hungary) among the TIMSS nations which did not have a significant gender gap in the mathematics literacy.

HAS THE RELATIVE INTERNATIONAL STANDING IN MATHEMATICS AT THE END OF SECONDARY SCHOOL IN THE U.S. CHANGED OVER TIME?

International comparisons over time are difficult. The first international studies of mathematics and science achievement were conducted in the 1960s, and there have been three assessments since that time. However, each assessment has been done differently. A different set of nations participated, different topics in mathematics and science were included in the assessments, 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 are necessarily tentative.

We have seen that U.S. twelfth graders scored below the international average, and among the lowest of all TIMSS nations. This international standing was similar to the one reported for U.S. twelfth graders in the IEA First and Second International Mathematics Studies conducted in the 1960s and 1980s. Relative to their international counterparts completing secondary school, it is not likely that U.S. twelfth graders' standing has changed significantly in mathematics achievement.

SCIENCE LITERACY ASSESSMENT

The science portion of the literacy assessment consisted of about 60 percent multiple choice items and 40 percent free response items. (Based on each country's curriculum, the science literacy assessment was found to be at a ninth grade level for most TIMSS nations. In the case of the U.S., the assessment is most equivalent to what eleventh grade students are exposed to in their curricula, reflecting the relatively late appearance of physics and chemistry in U.S.)

HOW WELL DO U.S. TWELFTH GRADERS DO ON THE SCIENCE LITERACY ASSESSMENT?

On the science portion of the literacy assessment, U.S. students also scored below the international average, and among the lowest of the twenty-one countries. Only two countries were significantly below the U.S. Figure 1-6 show how U.S. students perform in science literacy assessment.

FIGURE 1-6: Science Literacy Achievement

NATIONS WITH AVERAGE SCORES SIGNIFICANTLY HIGHER THAN THE U.S.	
NATION	AVERAGE
SWEDEN	559
(NETHERLANDS)	558
(ICELAND)	549
(NORWAY)	544
(CANADA)	532
NEW ZEALAND	529
(AUSTRALIA)	527
SWITZERLAND	523
(AUSTRIA)	520
(SLOVENIA)	517
(DENMARK)	509

NATIONS WITH AVERAGE SCORES NOT SIGNIFICANTLY DIFFERENT FROM THE U.S.	
NATION	AVERAGE
(GERMANY)	497
(FRANCE)	487
CZECH REPUBLIC	487
(RUSSIAN FEDERATION)	481
(UNITED STATES)	**480**
(ITALY)	475
HUNGARY	471
(LITHUANIA)	461

NATIONS WITH AVERAGE SCORES SIGNIFICANTLY LOWER THAN THE U.S.	
NATION	AVERAGE
(CYPRUS)	448
(SOUTH AFRICA)	349

NOTE: Nations not meeting international sampling and other guidelines are shown in parentheses.

SOURCE: Mullis et al. (1998) *Mathematics and Science Achievement in the Final Year of Secondary School.* Table 2.2. Boston College: Chestnut Hill, MA.

In science literacy, students at the end of secondary school in 11 countries (Sweden, the Netherlands, Norway, New Zealand, Canada, Australia, Switzerland, Slovenia, Iceland, Austria and Denmark) outperformed U.S. twelfth graders. Students in seven countries were not significantly different from those in the U.S. (the Czech Republic, the Russian

Federation, Italy, Hungary, Germany, France, and Lithuania). Students in Cyprus and South Africa performed below students in the U.S.

WHAT WERE STUDENT ASKED TO DO IN THE SCIENCE LITERACY ASSESSMENT?

The following are three examples of the science literacy assessment items. Appendix 3 shows the percentage of students in every country responding correctly to each item.

The item shown in Figure 1-7 requires students to apply scientific principles to develop explanations. Forty-two percent of our students responded at least partially correctly to this item, which was among the lowest percentage of the 21 nations. This item was not considered to be particularly difficult, as the international average was 61 percent. Partial credit was given to answers such as those students who misused the term "mass" instead of "force" or "weight" but displayed correct thinking, e.g., "the mass is distributed over a smaller area".

FIGURE 1-7: EXAMPLE OF SCIENCE LITERACY ITEM

> Some high heeled shoes are claimed to damage floors. The base diameter of these very high heels is about 0.5 cm and of ordinary heels about three cm. Briefly explain why the very high heels may cause damage to floors.
>
> correct
>
> *Answer Examples:*
> - *The pressure from the heel is greater because the area is smaller*
> - *Because of the narrow diameter of very high heels, all the body weight is spread over a smaller area. There is greater pressure exerted on the floor with the higher heels because it is all placed on a small area. The pressure is less on a wider heel because the weight is distributed over a greater area causing less damage.*
>
> U.S. Average: **42 percent** International Average: **61 percent**

metric

The item shown in Figure 1-8 requires knowledge of simple information about human biology. Our students performed relatively well on this item. Seventy-five percent of U.S. twelfth graders responded correctly, whereas the international average was 58 percent. In three other countries, Australia, Canada, and Iceland, over 70 percent of students also responded correctly to this item.

FIGURE 1-8: EXAMPLE OF SCIENCE LITERACY ITEM

> The most important function of the white blood cells is to
>
> A. transport oxygen to the cells of the body.
> B. remove carbon dioxide from the blood.
> C. prevent excessive bleeding from a wound.
> D. dissolve large food molecules
> E. aid the body in fighting infection.
>
> *Answer: E* U.S. Average: **75 percent** International Average: **58 percent**

The item shown in Figure 1-9 requires students to theorize, analyze and solve a problem. This was a difficult item for most students, as the international average was 35 percent. About 23 percent of our students received at least partial credit, given for answers such as those who failed to mention temperature, e.g., "the water will boil more rapidly and will evaporate faster".

FIGURE 1-9: EXAMPLE OF SCIENCE LITERACY ITEM

A kettle of boiling water is on a stove. If the burner under the kettle is turned up, what will happen to the temperature of the water in the kettle? Explain your answer.

Correct

Answer examples:

- *Same, because it has reached the temperature level (boiling point/100° C point) where water turns to steam.*
- *The temperature of the boiling water will stay the same. Once water is boiling, the temperature cannot reach a higher boiling point.*

U.S. Average: 23 percent International Average: 35 percent

HOW DO U.S. STUDENTS IN TWELFTH GRADE COMPARE TO THOSE IN EIGHTH GRADE IN SCIENCE ACHIEVEMENT?

In science, the U.S. is one of three countries that scored above the international average in eighth grade, and scored below the international average in the final year of secondary school. Figure 1-10 shows relative international standing in science achievement at eighth grade and the final year of secondary school compared with the international average.

Figure 1-10 Science Performance at the Eighth Grade and the Final Year of Secondary School Compared With the International Average

	Final year of secondary school: above the international average	Final year of secondary school: same as the international average	Final year of secondary school: below the international average
Eighth grade: Above the international average	(Netherlands), Sweden, (Norway), (Austria), (Canada)	(Slovenia), (Australia), Czech Republic, (Germany)	(U.S.), Hungary, (Russian Federation)
Eighth Grade: Same as the international average	Switzerland, New Zealand		
Eighth Grade: below the international average	(Iceland)	(France), (Denmark)	(Lithuania), (Cyprus), (South Africa),

NOTE: Nations not meeting international sampling and other guidelines are shown in parentheses.

SOURCE: Mullis et al. (1998) *Mathematics and Science Achievement in the Final Year of Secondary School.* Figure 2.4. Boston College: Chestnut Hill, MA.

For five countries, the relative international standing in science achievement was above the international average at both the eighth grade and the final year of secondary school (Austria, Canada, Netherlands, Norway, and Sweden).

The three dark shaded cells on the upper right side in the Figure 1-10 show seven countries that had a lower relative international standing in science achievement in the final year of secondary school than in the eighth grade. In three countries, including the U.S., the relative international standing differed greatly between two grades: "above" the international average at the eighth grade and "below" the international average at the end of secondary school.

The three lightly shaded cells on lower left side in the same figure show five countries that had a higher relative international standing in science achievement in eighth grade than in the final year of secondary school. Iceland is the only country that scored "below" the international average at eighth grade and "above" the international average at the final year of secondary school.

The pattern for changes in countries in the relative international standing in science achievement is not as clear as it is in mathematics. The former Eastern Block countries (Hungary, the Russian Federation, Slovenia, and the Czech Republic) had a lower relative international standing in science achievement in the final year of secondary school than in the eighth grade. However, countries that have a higher relative international standing in the final year of secondary school than in eighth grade include two of the participating Nordic countries, as well as Switzerland, New Zealand, and France.

IS THERE A GENDER GAP IN SCIENCE LITERACY AT THE TWELFTH GRADE?

In the U.S., there is a gender gap on the science portion of the literacy assessment. Excluding South Africa, in all other TIMSS nations, including the U.S., young men performed significantly better than young women on the science literacy portion of the assessment. However, among those countries the U.S. gender gap was one of the smallest.

how much? does it? data?

HAS THE RELATIVE INTERNATIONAL STANDING OF THE U.S. CHANGED OVER TIME?

We have seen that U.S. twelfth graders scored below the international average, and among the lowest of all TIMSS nations. This is basically the same relative international standing reported for U.S. twelfth graders in the IEA First and Second International Science Studies in the 1960s and 1980s. Relative to their international counterparts in the final year of secondary school, it is not likely that U.S. twelfth graders' standing has improved significantly in science.

HOW DOES THE PERFORMANCE OF THE U.S. TWELFTH GRADERS IN SCIENCE COMPARE TO THEIR PERFORMANCE IN MATHEMATICS?

Although U.S. students scored below the international average and among the lowest of TIMSS nations on both portions of the literacy assessment from the one point of view, our international standing on the literacy assessment was stronger in science than it was in mathematics. Fourteen countries were significantly higher than U.S. in the mathematics literacy assessments, while students in 11 countries outperformed ours in science literacy. This pattern is similar to the findings of fourth- and eighth-grade TIMSS results, in which the U.S. relative international standing was stronger in science than it was in mathematics.

We have now examined what TIMSS tells us about all students in the final year of secondary school. Next, we turn to an examination of how the advanced students in U.S. who were taking or have taken advanced courses in mathematics and science compare to their counterparts in other TIMSS nations.

CHAPTER TWO: ACHIEVEMENT OF ADVANCED STUDENTS

KEY POINTS:

Performance of the U.S. advanced mathematics and physics students was among the lowest of the 16 countries which administered the advanced mathematics and physics assessments.

In all three content areas of advanced mathematics and in all five content areas of physics, U.S. advanced math and physics students' performances were among the lowest of the TIMSS nations.

In both advanced mathematics and physics, males outperformed females in the U.S. This was also true for 5 of the 6 content areas in physics, but only one (geometry) of the content areas in mathematics.

More countries outperformed U.S. students in physics than on advanced mathematics. This differs from the results for the mathematics and science literacy, where more countries outperformed the U.S. in mathematics than in science.

to such subjects but that most people view as advanced math.

EMBARGOED until FEBRUARY 24, 1998 AT 11:00 A.M. EDT

Chapter One has shown us how U.S. twelfth graders perform in mathematics and science literacy in comparison to young people graduating from secondary school in other countries. It shows us the level of general mathematics and scientific knowledge of the entire student population. But because advances in science and technology are playing a greater role in shaping the future of our nation and our world, it is useful to look beyond the general levels of scientific and mathematics literacy among typical people and focus on the advanced levels of knowledge of those who are likely to become our next generation of scientists, engineers, and mathematicians.

Therefore, in addition to the TIMSS assessment of science and mathematics literacy, other assessments were created to compare the achievement of students taking advanced science and mathematics courses. Physics was selected for the advanced science assessment because it is the branch of science most closely associated with mathematics and because it was viewed as most closely embodying the essential elements of natural science.

w/in countries? btwn countries?

The variability of scores tends to be greater in the advanced mathematics and physics assessments than it was in the mathematics and literacy assessment. Thus, an estimate of a country's average score in the advanced mathematics and physics assessment includes a bigger margin of error than it does in the mathematics and science literacy assessment. We can say with 95 percent of confidence that comparisons of other countries scores to those of the U.S. are accurate plus or minus about 35 points. Comparisons of the U.S. with the international average are accurate plus or minus about 12 points. (Appendix 2 contains a list of national average scores and standard errors.)

ADVANCED MATHEMATICS ASSESSMENT

only about one-quarter of

An assessment of advanced mathematics was given to a sample of students taking advanced course work in mathematics. In the U.S., these were students who had completed or were completing a full year of a high school course that included the word "Calculus" in the title. This included Calculus, Pre-calculus, Advanced Placement Calculus, and Calculus and Analytic Geometry. Considering this, it should be noted that the advanced mathematics assessment was ~~not primarily~~ a calculus assessment. Five content areas were included: Numbers, Equations, and Functions; Calculus; Validation and Structure; Probability and Statistics; and Geometry. Sub-scales were created for the Geometry; Calculus; and Numbers, Equations and Function content areas. The number of items in the other two categories was too small to obtain reliable scores so separate sub-scales were not developed for them. The advanced mathematics items consisted of three-quarters multiple choice items and one-quarter free-response items.

27% calculus

This section focuses on the advanced mathematics achievement of students in their final year of secondary school who have taken advanced mathematics. Fewer countries participated in the advanced mathematics assessments. Among the 21 countries which participated in the mathematics and science literacy assessments, six countries (Hungary, Iceland, Netherlands, New Zealand, Norway, and South Africa) did not administer the advanced mathematics assessments. Greece, which did not participate in the mathematics and science literacy assessment, did participate in both advanced mathematics and physics assessments. As a result, 16 countries participated in the advanced mathematics assessment.

Previous international studies have been criticized for comparing relatively large percentages of U.S. students to other countries' elites. This is not true of the TIMSS advanced mathematics assessment. To identify students for the assessment, countries were asked to identify advanced mathematics students according to their own definitions. For most countries, these students represented about 10 to 20 percent of their age cohort. For the United States, this figure was 14 percent. The only exceptions to this pattern were the Russian Federation and Lithuania, where advanced mathematics students constituted less than 10 percent of the age cohort, and in Austria and Slovenia. The data were not available for Germany.

where was greater than 20% ?

HOW DO OUR TWELFTH GRADERS WITH ADVANCED MATHEMATICS TRAINING COMPARE TO ADVANCED MATHEMATICS STUDENTS IN OTHER COUNTRIES?

The performance of U.S. advanced mathematics students was among the lowest of the 16 TIMSS nations who administered the assessment. Figure 2-1 shows that 11 nations outperformed the U.S., while our scores were not significantly different from those of four other nations. **No countries scored below the U.S. on the assessment of advanced mathematics.**

Figure 2-1:
Nations' Average Performance on Advanced Mathematics Compared with the U.S.

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

NATION	AVERAGE
FRANCE	557
(RUSSIAN FEDERATION)	542
SWITZERLAND	533
(AUSTRALIA)	525
(DENMARK)	522
(CYPRUS)	518
(LITHUANIA)	516
GREECE	513
SWEDEN	512
(CANADA)	509
(SLOVENIA)	475

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

NATION	AVERAGE
(ITALY)	474
CZECH REPUBLIC	469
(GERMANY)	465
(UNITED STATES)	442
(AUSTRIA)	436

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

NATION	AVERAGE
NONE	

INTERNATIONAL AVERAGE = 501

NOTE: Nations not meeting international sampling and other guidelines are shown in parentheses.

SOURCE: Mullis et al. (1998) *Mathematics and Science Achievement in the Final Year of Secondary School.* Table 5.1. Boston College: Chestnut Hill, MA.

U.S. advanced mathematics students included those who had completed or were completing Pre-calculus, Calculus, Calculus and Analytic Geometry, or Advanced Placement Calculus, representing about 14 percent of the school-leaving age cohort in the U.S. If we were to compare only those who completed Calculus or Advanced Placement Calculus against all the advanced mathematics students in other countries, how would our calculus students perform?

HOW DO U.S. TWELFTH GRADERS WITH CALCULUS OR ADVANCED PLACEMENT CALCULUS COMPARE TO ALL ADVANCED MATHEMATICS STUDENTS IN OTHER COUNTRIES?

U.S. twelfth graders with Calculus or Advanced Placement Calculus training represents about seven percent of the cohort at the school-leaving age. Not surprisingly, these students performed better in the assessment than the larger group which included students whose highest course was Pre-calculus. **Advanced mathematics students in six countries (France, Russian Federation, Switzerland, Denmark, Cyprus, and Lithuania) outperformed calculus students in the U.S.** Figure 2-2 shows that the performance of U.S. twelfth graders with Calculus or Advanced Placement Calculus training is not significantly different from seven of the 16 TIMSS nations who administered the assessment to their advanced mathematics students. Our scores were significantly higher than those of two other nations (Germany and Austria).

Figure 2-2:
Nations' Average Advanced Mathematics Performance of Advanced Mathematics Students Compared with U.S. Calculus and AP Calculus Students

NATIONS WITH AVERAGE SCORES SIGNIFICANTLY HIGHER THAN THE U.S.	
NATION	**AVERAGE**
FRANCE	557
(RUSSIAN FEDERATION)	542
SWITZERLAND	533
(DENMARK)	522
(CYPRUS)	518
(LITHUANIA)	516

NATIONS WITH AVERAGE SCORES NOT SIGNIFICANTLY DIFFERENT THAN THE U.S.	
NATION	**AVERAGE**
(AUSTRALIA)	525
GREECE	513
SWEDEN	512
(CANADA)	509
(UNITED STATES)	492
(SLOVENIA)	475
(ITALY)	474
CZECH REPUBLIC	469

NATIONS WITH AVERAGE SCORES SIGNIFICANTLY LOWER THAN THE U.S.	
NATION	**AVERAGE**
(GERMANY)	465
(AUSTRIA)	436

INTERNATIONAL AVERAGE = 504

NOTE: Nations not meeting international sampling and other guidelines are shown in parentheses. The Placement of Australia may appear out of place; however, statistically its placement is correct.

SOURCE: Mullis et al. (1998) *Mathematics and Science Achievement in the Final Year of Secondary School.* Table 5.1. Boston College: Chestnut Hill, MA.

7, The performance ~~of U.S.~~ twelfth graders with Advanced Placement Calculus training, who represent about five percent of the cohort at the school-leaving age, was significantly higher than the performance ~~of advanced~~ mathematics students in five other countries, and above the international average. Figure 2-3 shows that one nation (France) outperformed the U.S., while our scores are not significantly different from nine other countries. Thus, the most advanced mathematics students in the U.S., about 5 percent of total age group, performed similarly to 10 to 20 percent of the age cohort in most of the other countries.

Figure 2-3:
Nations' Average Advanced Mathematics Performance of Advanced Mathematics Students Compared with the U.S. AP Calculus Students

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

NATION	AVERAGE
FRANCE	557

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

NATION	AVERAGE
(RUSSIAN FEDERATION)	542
SWITZERLAND	533
(AUSTRALIA)	525
(DENMARK)	522
(CYPRUS)	518
(LITHUANIA)	516
GREECE	513
(UNITED STATES)	513
SWEDEN	512
(CANADA)	509

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

NATION	AVERAGE
(SLOVENIA)	475
(ITALY)	474
CZECH REPUBLIC	469
(GERMANY)	465
(AUSTRIA)	436

INTERNATIONAL AVERAGE = 505

NOTE: Nations not meeting international sampling and other guidelines are shown in parentheses.

SOURCE: Mullis et al. (1998) *Mathematics and Science Achievement in the Final Year of Secondary School.* Table 5.1. Boston College: Chestnut Hill, MA.

How Do We Score In The Different Content Areas Of Advanced Mathematics?

Representing student achievement in advanced mathematics as a total score is a useful way to summarize achievement. However, the advanced mathematics assessments contained different content areas, which are emphasized and sequenced differently in curricula around the world.

Based on these national priorities, some content areas have been studied more than others in different countries by the time these students are ready to graduate from secondary school.

The TIMSS advanced mathematics assessment included sets of items designed to sample students' ability to do work in the following areas:

Numbers and Equations:	Complex numbers and their properties; permutations and combinations; equations and formulas; and patterns, relations and functions.
Calculus:	Infinite processes; and change.
Geometry:	Basic geometry; coordinate geometry; polygons and circles; and three-dimensional geometry.

Figure 2-4 shows that **in all of the content areas of advanced mathematics, U.S. students' performance was among the lowest of the TIMSS nations.** Among the content areas, our students performance was relatively weakest in Geometry: no country scored similar to or below the U.S. In Numbers, Equations, and Functions, and in Calculus fewer countries (11 countries) scored above U.S.

Figure 2-4:
National Averages in Advanced Mathematics Content Areas

Numbers & Equations

Nation	Average
(RUSSIAN FEDERATION)	555
FRANCE	548
(LITHUANIA)	547
GREECE	539
SWEDEN	523
(AUSTRALIA)	517
SWITZERLAND	514
(CANADA)	512
(CYPRUS)	510
(DENMARK)	504
(SLOVENIA)	491
CZECH REPUBLIC	460
(ITALY)	460
(UNITED STATES)	459
(GERMANY)	457
(AUSTRIA)	412

INTERNATIONAL AVERAGE = 501

Calculus

Nation	Average
(CYPRUS)	561
FRANCE	560
GREECE	538
(RUSSIAN FEDERATION)	537
(AUSTRALIA)	530
(ITALY)	520
SWITZERLAND	512
(DENMARK)	508
(CANADA)	503
(LITHUANIA)	498
SWEDEN	480
(SLOVENIA)	471
(GERMANY)	454
(UNITED STATES)	450
CZECH REPUBLIC	446
(AUSTRIA)	439

INTERNATIONAL AVERAGE = 501

Geometry

Nation	Average
(RUSSIAN FEDERATION)	548
SWITZERLAND	547
FRANCE	544
(DENMARK)	527
(CYPRUS)	517
(LITHUANIA)	515
(CANADA)	499
GREECE	498
(AUSTRALIA)	496
CZECH REPUBLIC	494
SWEDEN	492
(GERMANY)	487
(ITALY)	480
(SLOVENIA)	476
(AUSTRIA)	462
(UNITED STATES)	424

INTERNATIONAL AVERAGE = 500

Key:

- Average significantly higher than U.S.
- Average not significantly different from U.S.
- Average significantly lower than U.S.

NOTE: Nations not meeting international sampling and other guidelines are shown in parentheses.

SOURCE: Mullis et al. (1998) *Mathematics and Science Achievement in the Final Year of Secondary School.* Table 5.1. Boston College: Chestnut Hill, MA.

WHAT WERE STUDENTS ASKED TO DO IN THE ADVANCED MATHEMATICS ASSESSMENT?

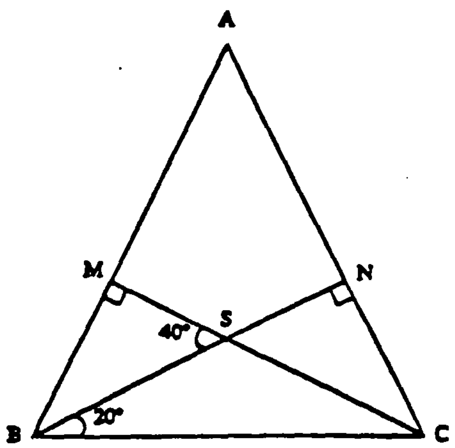
One example of a geometry item is shown in Figure 2-5. This item requires students to utilize knowledge of congruence and similarity of triangles, and to prove and justify the statement. The international average for this item was 48 percent. While this item was not easy, it was particularly difficult for our students. Nineteen percent of our students responded at least partially correctly, which was among the lowest of the 16 nations participating. Over one-third of our students got this item incorrect due to incorrect argumentation and/or including more than one incorrect geometric fact, step or reason.

FIGURE 2-5: EXAMPLE OF GEOMETRY ITEM

In the ΔABC, shown below, the altitudes BN and CM intersect at point S. The measure of the $\angle MSB$ is 40° and the measure of $\angle SBC$ is 20°. Write a PROOF of the following statement:

"ΔABC is isosceles."

Give geometric reasons for statements in your proof.



Answer Examples

Correct proof. Proves that $\angle B \cong \angle C$ using the following facts:

- *the sum of angles in any triangle is 180°.*
- *if two angles of a triangle are equal, the triangle is isosceles and possibly also uses:*
  - *—vertically opposite angles are equal;*
  - *—supplementary angles add to 180°.*

U.S. Average: **19 percent** International Average: **48 percent**

Figure 2-6 is an example of a Probability and Statistics item. The percentage of our students responding correctly was 12 percentage points above the international average.

FIGURE 2-6: EXAMPLE OF PROBABILITY AND STATISTICS ITEM

A set of 24 cards is numbered with the positive integers from 1 to 24. If the cards are shuffled and if only one is selected at random, what is the probability that the number on the card is divisible by four or six?

A $\frac{1}{6}$

B $\frac{5}{24}$

C $\frac{1}{4}$

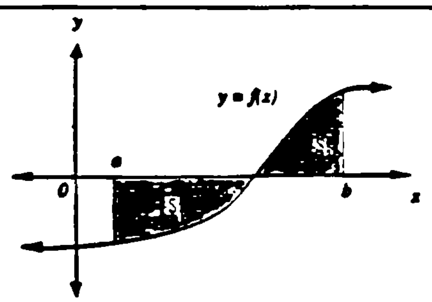
D $\frac{1}{3}$

E $\frac{5}{12}$

Answer: D U.S. Average: **62 percent** International Average: **50 percent**

The item shown in 2-7 which requires students to demonstrate their understanding of integrals, proved to be a difficult item for most students, and for U.S. students. Twenty-seven percent of U.S. students responded correctly to this item, and the international average was 35 percent. To understand the item correctly, students needed to understand that if a curve lies above the x-axis, the integral represents the area under the curve, and if the curve lies below the x-axis, the integral represents the negative of the area between the curve and the x-axis.

FIGURE 2-7: EXAMPLE OF CALCULUS ITEM



The figure above shows the graph of $y = f(x)$.
S_1 is the area enclosed by the x- axis, $x = a$, and $y = f(x)$;
S_2 is the area enclosed by the x- axis, $x = b$, and $y = f(x)$;
where $a < b$ and $0 < S_2 < S_1$.

The value of $\int_a^b f(x)\,dx$ is

A. $S_1 + S_2$

B. $S_1 - S_2$

C. $S_2 - S_1$

D. $|S_1 - S_2|$

E. $\frac{1}{2}(S_1 + S_2)$

Answer: C U.S. Average: **27 percent** International Average: **35 percent**

Is There A Gender Gap In Advanced Mathematics At The Twelfth Grade?

In the U.S., twelfth grade young men outperformed twelfth grade young women in advanced mathematics. The U.S. is one of the 11 TIMSS nations in which a gender gap existed. No significant gender gap existed in the other five countries. **For the U.S. there was a significant gender gap existing in geometry but not in the other two content areas, calculus and numbers, equations, and functions.** On average, males outperformed females in all three

castles by guide

content areas of the advanced mathematics assessment. About one-half of the countries had a significant gender gap in the content areas of Calculus and Geometry and about one-third in the content area of Numbers, Equations, and Functions.

PHYSICS ASSESSMENT

Physics students in TIMSS countries took a physics assessment, which included questions about Mechanics; Electricity and Magnetism; Particle, Quantum and other types of Modern Physics; Heat; and Wave Phenomena. In the U.S., the population which took the assessment were twelfth graders who had completed or were completing at least a year-long course in physics. This included Physics I, Physics II, Advanced Physics, and Advanced Placement Physics.

This section focuses on the physics achievement of students in their final year of secondary school who have taken physics courses. Fewer countries participated in the physics assessment. Among the 21 countries which participated in the mathematics and science literacy assessments, seven countries (Hungary, Iceland, Italy, Lithuania, Netherlands, New Zealand, and South Africa) did not administer the physics assessment. Greece and Latvia, which did not participate in the literacy assessment, did participate in the physics assessment. As a result, 16 countries participated in the physics assessment.

Previous international studies have been criticized for comparing relatively large percentages of U.S. students to other countries' elites. This is not true of the TIMSS physics assessment. For 10 countries, these students represented about 10 to 20 percent of the entire population at the school-leaving age. In the U.S., they represented about 14 percent of the age cohort. The only exceptions to this pattern were Denmark, Latvia, and the Russian Federation, where the students represented less than 10 percent of the cohort at the school-leaving age, and Austria and Slovenia where the students represented more than 20 percent of the age cohort. Data for Germany were not available.

HOW DO OUR TWELFTH-GRADERS WHO HAVE TAKEN PHYSICS COMPARE TO SIMILAR STUDENTS IN OTHER COUNTRIES?

The performance of U.S. twelfth-grade physics students was among the lowest of the 16 TIMSS nations which administered the assessment to a comparable population of their physics students. Figure 2-8 shows that fourteen nations outperformed the U.S., while our scores were not significantly different from those of one other nation. **No countries scored below the U.S. on the physics assessment.**

Figure 2-8:
Nation's Average Physics Performance of Physics Students Compared with the U.S.

NATIONS WITH AVERAGE SCORES SIGNIFICANTLY HIGHER THAN THE US	
NATION	AVERAGE
NORWAY	581
SWEDEN	573
(RUSSIAN FEDERATION)	545
(DENMARK)	534
(SLOVENIA)	523
(GERMANY)	522
(AUSTRALIA)	518
(CYPRUS)	494
(LATVIA)	488
SWITZERLAND	488
GREECE	486
(CANADA)	485
FRANCE	466
CZECH REPUBLIC	451

NATIONS WITH AVERAGE SCORES NOT SIGNIFICANTLY DIFFERENT FROM THE U.S.	
NATION	AVERAGE
(AUSTRIA)	435
(UNITED STATES)	423

NATIONS WITH AVERAGE SCORES SIGNIFICANTLY LOWER THAN THE U.S.	
NATION	AVERAGE
NONE	

NOTE: Nations not meeting international sampling and other guidelines are shown in parentheses.

SOURCE: Mullis et al. (1998) *Mathematics and Science Achievement in the Final Year of Secondary School.* Table 8.1. Boston College: Chestnut Hill, MA.

In the U.S. the population which took the assessment were twelfth graders who had completed or were completing Physics I, Physics II, Advanced Physics, or Advanced Placement Physics, representing about 14 percent of the school leaving age cohort. If we were to compare our most advanced students in physics who had completed or were completing Advanced Placement Physics with physics students in other countries, how would our most advanced students perform?

How Do Our Twelfth Graders With Advanced Placement Physics Training Compare To Physics Students In Other Countries?

Our twelfth graders with Advanced Placement physics represented about 1 percent of the school-leaving age cohort in the U.S. Physics students in fewer countries outperformed our students who had taken Advanced Placement physics. Figure 2-9 shows that six nations outperformed the U.S., while our scores were significantly higher than two other nations. The performance of U.S. twelfth graders with Advanced Placement physics was no different from the international average or from seven of the 16 TIMSS nations who administered the assessment to their physics students. However, U.S. A.P. physics students represented a smaller proportion of the age cohort than the physics students in many of the other countries. ?

? prob all, Denmark
Latvia
f Phys.
less than
1%

Figure 2-9:
Nation's Average Physics Performance of Physics Students Compared with the U.S. AP Physics Students

NATIONS WITH AVERAGE SCORES SIGNIFICANTLY HIGHER THAN THE US	
NATION	AVERAGE
NORWAY	581
SWEDEN	573
(RUSSIAN FEDERATION)	545
(DENMARK)	534
(GERMANY)	522
(AUSTRALIA)	518

NATIONS WITH AVERAGE SCORES NOT SIGNIFICANTLY DIFFERENT FROM THE U.S.	
NATION	AVERAGE
(SLOVENIA)	523
(CYPRUS)	494
(LATVIA)	488
SWITZERLAND	488
GREECE	486
(CANADA)	485
(UNITED STATES)	474
FRANCE	466

NATIONS WITH AVERAGE SCORES SIGNIFICANTLY LOWER THAN THE U.S.	
NATION	AVERAGE
(AUSTRIA)	435
CZECH REPUBLIC	451

INTERNATIONAL AVERAGE = 504

NOTE: Nations not meeting international sampling and other guidelines are shown in parentheses.

SOURCE: Mullis et al. (1998) *Mathematics and Science Achievement in the Final Year of Secondary School.* Table 8.1. Boston College: Chestnut Hill, MA.

How Do We Score In The Different Content Areas Of Physics?

Representing student achievement in physics as a total score is a useful way to summarize achievement. However, the physics assessment contained different content areas, which are emphasized and sequenced differently in curricula around the world. Based on these national priorities, and sequencing of physics training for advanced students at the secondary level, some content areas have been studied more than others in various countries by the time these students graduate from secondary school.

The TIMSS physics assessment included sets of items designed to sample students' ability to do work in the following areas:

Mechanics:	Dynamics of motion; time, space and motion; types of forces; and fluid behavior.
Electricity/Magnetism:	Electricity; and magnetism.
Heat:	Physical changes; energy types, sources and conversions; heat and temperature; and kinetic theory.
Wave Phenomena:	Sound and vibration; light; and wave phenomena.
Modern Physics:	Nuclear chemistry; quantum theory and fundamental particles; beyond the solar system; subatomic particles; and relativity theory.

Figure 2-10 on page x shows that **in all physics content areas, U.S. students' performance was among the lowest of the TIMSS nations.** In only two content areas did a nation score below the U.S.: Students in Austria scored below students in the U.S. in the content area of Heat and students in Cyprus scored below our students in Modern Physics. Among the content areas, U.S. students performed least poorly in the content area of Heat, and the poorest in the content area of Mechanics, in terms of the number of countries outperforming the U.S.

Figure 2-10:
Achievement in Physics Content Areas for Physics Specialists

Mechanics

Nation	Average
NORWAY	572
SWEDEN	563
(SLOVENIA)	552
(RUSSIAN FEDERATION)	537
(CYPRUS)	530
(DENMARK)	529
GREECE	514
(AUSTRALIA)	507
(GERMANY)	495
(LATVIA)	[illegible]
SWITZERLAND	482
(CANADA)	473
CZECH REPUBLIC	[illegible]
FRANCE	457
(AUSTRIA)	420
(UNITED STATES)	420
NONE	

INTERNATIONAL AVERAGE = 501

Electricity/ Magnetism

Nation	Average
SWEDEN	570
NORWAY	565
(RUSSIAN FEDERATION)	549
GREECE	520
(DENMARK)	515
(AUSTRALIA)	512
(GERMANY)	512
(SLOVENIA)	509
(CYPRUS)	502
FRANCE	494
(CANADA)	485
(LATVIA)	485
SWITZERLAND	480
CZECH REPUBLIC	465
(AUSTRIA)	432
(UNITED STATES)	430
NONE	

INTERNATIONAL AVERAGE = 501

Heat

Nation	Average
NORWAY	[illegible]
(RUSSIAN FEDERATION)	530
SWEDEN	522
(SLOVENIA)	521
(AUSTRALIA)	517
(DENMARK)	512
SWITZERLAND	509
(CANADA)	508
FRANCE	491
(LATVIA)	504
(GERMANY)	[illegible]
CZECH REPUBLIC	[illegible]
GREECE	481
(UNITED STATES)	477
(CYPRUS)	476
(AUSTRIA)	445

INTERNATIONAL AVERAGE = 501

Wave Phenomena

Nation	Average
NORWAY	560
SWEDEN	560
(DENMARK)	537
(GERMANY)	530
(AUSTRALIA)	519
(RUSSIAN FEDERATION)	515
(SLOVENIA)	514
(CYPRUS)	507
SWITZERLAND	[illegible]
(LATVIA)	[illegible]
(CANADA)	[illegible]
(AUSTRIA)	[illegible]
FRANCE	463
GREECE	453
(UNITED STATES)	451
CZECH REPUBLIC	447
NONE	

INTERNATIONAL AVERAGE = 500

Modern Physics

Nation	Average
NORWAY	[illegible]
SWEDEN	560
(GERMANY)	545
(DENMARK)	544
(RUSSIAN FEDERATION)	542
(AUSTRALIA)	521
(SLOVENIA)	511
(CANADA)	494
SWITZERLAND	[illegible]
(AUSTRIA)	[illegible]
FRANCE	474
(LATVIA)	[illegible]
(UNITED STATES)	[illegible]
CZECH REPUBLIC	453
GREECE	447
(CYPRUS)	434

INTERNATIONAL AVERAGE = 501

Average significantly higher than U.S.

Average not significantly different from U.S.

Average significantly lower than U.S.

NOTE: Nations not meeting international sampling and other guidelines are shown in parentheses.

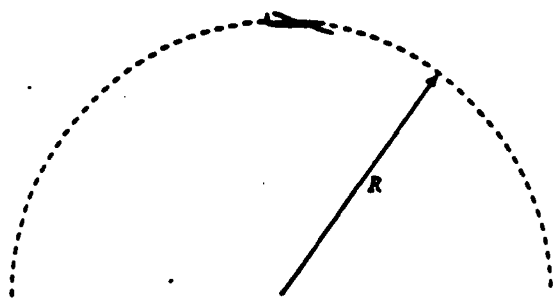
SOURCE: Mullis et al. (1998) *Mathematics and Science Achievement in the Final Year of Secondary School.* Table 9.1. Boston College: Chestnut Hill, MA.

WHAT ARE PHYSICS STUDENTS ASKED TO DO IN THE PHYSICS ASSESSMENT?

Figure 2-11 is an example of a Mechanics item. To solve this problem, students need to recall the properties of centrifugal force and gravitational force, and the dynamics of these properties in relation to each other. Moreover, students must recall the formulas associated with each of these forces in order to determine the speed, or velocity, of the aircraft at the top of the path. Twenty-five percent of U.S. physics students responded correctly to this item, while the international average was about 50 percent.

FIGURE 2-11: EXAMPLE OF MECHANICS ITEM

An aircraft flies in a vertical circular path of radius R at a constant speed. When the aircraft is at the top of the circular path the passengers feel "weightless". Acceleration due to gravity = g.



What is the speed of the aircraft at the top of the path?

A. gR

B. $\sqrt{gR}$

C. $\frac{g}{R}$

D. $\sqrt{\frac{g}{R}}$

E. $2gR$

Answer: B — U.S. Average: 25 percent — International Average: 50 percent

Figure 2-12 is an example of a Heat item. For this item, students first needed to recall that both oxygen and hydrogen are diatomic, or consist of two atoms each. With this knowledge, students should be able to discriminate amongst the four possible choices based on the fact that only average kinetic energy is affected by temperature and number of atoms, so that the values of the molecules are the same only for average kinetic energy. This item was moderately difficult, as the international average was 41 percent. Our students performed above the international average.

FIGURE 2-12: EXAMPLE OF HEAT ITEM

A jar of oxygen gas and a jar of hydrogen gas are the same temperature.

Which of the following has the same value for the molecules of both gases?

A. the average velocity
B. the average momentum
C. the average force
D. the average kinetic energy

Answer: D U.S. Average: 49 percent International Average: 41 percent

A third example of a physics item which requires students to apply scientific principles to develop explanations about wave phenomena is shown in Figure 2-13. While this was a difficult item for most students (the international average was 37 percent) it was even more difficult for our students. Twelve percent of U.S. physics students received at least partial credit for this item, 25 percentage points below the international average. Among the incorrect answers, one-fifth of our students answered that the frequency (or pitch or wave length) is continually changing as the car moves, e.g. "the nearer the car comes, the higher is the frequency".

FIGURE 2-13: EXAMPLE OF WAVE PHENOMENA ITEM

A car moving at constant speed with a siren sounding comes towards you and then passes by.
Describe how the frequency of the sound you hear changes.

Answer Examples
- *The pitch is higher as the car comes closer and lower after it goes by.*
- *When the car approaches, the wavelength of the sound is shorter than it is when the car moves away.*

U.S. Average: 12 percent International Average: 37 percent

IS THERE A GENDER GAP IN PHYSICS AT THE TWELFTH GRADE?

In the U.S., as in all other 16 TIMSS nations except in Latvia, 12th grade young men outperformed 12th grade young women in physics. In the U.S., this gender gap existed in all the content areas of physics included in the TIMSS assessment except Heat. More than three quarters of the countries had a significant gender gap in the content areas of Mechanics, Wave Phenomena, and Modern Physics. Only one third of the countries found a significant gender gap in the content area of Heat.

size of gap?

HOW DO U.S. STUDENTS DO IN PHYSICS COMPARED TO ADVANCED MATHEMATICS?

Unlike our performance on the literacy portion of the assessment, where students' performance was stronger in science than it was in mathematics, performance on physics assessment was poorer than the performance on the advanced mathematics assessment. Fourteen countries scored above us in the physics assessment, while, fewer countries (11 countries) outperformed us in advanced mathematics assessment.

The relationship might be more similar to the literacy assessment (with students performing better in science than in mathematics) if we had tested other content areas of science such as Life Science or Environmental Issues and the Nature of Science. Among the content areas of the science assessment given to eighth graders, our students performance was weakest in Physics and strongest in Life Science or in Environmental Issues and the Nature of Science

FIMS
SIMS for elite students?

CHAPTER THREE: THE CONTEXT OF LEARNING

KEY POINTS:

It is too early in the process of data analysis to provide strong evidence to suggest factors that may be related to the patterns of performance described here. No single factor or combination of factors emerges as particularly important.

The fact that other countries differ in the decisions they have made about the nature of secondary education does not mean it is inappropriate or unfair to compare the performance of U.S. students at the end of secondary school to those in other countries. TIMSS provides an opportunity to examine whether the choices countries have made about the nature of secondary education appear to be related to what students know at the end of their secondary schooling in mathematics and science.

— yuck

While secondary education in the U.S. differs from that in many of the other countries on important dimensions, none of those differences are clearly related to the relatively poor performance of our 12th graders on the TIMSS assessments.

The lives of U.S. graduating students do not differ from those of their peers in other countries on many of the factors examined. Where there are differences. few appear to be systematically related to the our performance in 12th grade compared to the other countries participating in TIMSS.

In general, preliminary analysis shed little light on factors that might account for the poor performance of U.S. 12th graders and why they did not compare as favorably with their international peers as U.S. 8th and 4th graders did. Further analyses are needed to provide more definitive insights on these subjects.

Chapters 1 and 2 have portrayed how U.S. high school students in the spring of their senior year perform in mathematics and science compared to their peers at the end of secondary school in many other countries. Generally, the performance of these U.S. students does not compare favorably with that of students in the other countries participating in TIMSS. The results from previous international assessments have tended to show that U.S. performance relative to other countries is lower at higher grade levels and a similar pattern has emerged in TIMSS, with the strongest U.S. performance in fourth grade and the poorest at the end of secondary schooling.

This chapter examines a number of factors that might contribute to the poor performance of U.S. 12th graders and for which there are data available from TIMSS or other sources. The first section examines factors related to differences among the education systems in the countries participating in TIMSS. Most of the factors examined in this section are ones that observers have postulated might be associated with differences in performance. The second section examines factors related to the students within each system, primarily focusing on their attitudes and how they spend their time. Most of these factors are ones that have been shown by previous research to be related to variation in performance within the U.S. There are three subsections within each of the two major sections: the first discusses the extent to which the U.S. is similar to or differs from the other countries on the factors being examined, the second examines whether there appears to be a relationship between those factors and the relative performance of U.S. graduating students in TIMSS, and the third briefly summarizes the findings within the section.

The focus of the chapter is to try to identify factors that might account for the relatively poor performance of U.S. students, rather than to look for ones that account for variation in performance across all the countries. Thus, we will be looking for factors that the countries who outperform the U.S. generally share in common and which the U.S. and those that perform similarly or less well than the U.S. do not share. On the literacy assessments, more countries outperformed the U.S. in mathematics than in science, and the focus will be primarily on the countries which outperformed the U.S. in mathematics. On the physics assessment, since the U.S. was outperformed by all the participating countries except one, it is unlikely that any patterns will be found that distinguish the U.S. (and Austria) from all the other countries, on average.

EDUCATION SYSTEMS AND PERFORMANCE IN TIMSS

The way in which countries structure and provide secondary education, or high school as it is called in the U.S., differs greatly around the world. Differences in the structure of secondary education grow out of different policy decisions nations have made, and different cultural beliefs about how best to develop students' potential. What students know at the end of secondary schooling represents the culmination of each country's attempt to prepare its students for adulthood.

Some have argued in the past that because the secondary education systems in many other countries are quite different from that in the U.S., it is inappropriate to compare the performance of U.S. students with those in other countries. However, understanding something about the differences between education systems provides important information for interpreting the findings about student performance. **The fact that other countries differ in the decisions they have made about the nature of secondary education does not mean it is inappropriate or unfair to compare the performance of U.S. students at the end of secondary school to those in other countries. TIMSS provides an opportunity to examine whether these differences in educational systems appear to be related to what students know at the end of their secondary schooling in mathematics and science.**

HOW DOES SECONDARY SCHOOLING IN THE OTHER TIMSS COUNTRIES RESEMBLE AND DIFFER FROM THAT IN THE UNITED STATES?

Structure of Secondary Education:

One major way in which the organization of schooling in the United States differs from that in many of the TIMSS countries is the amount of differentiation within secondary education. This differentiation can take at least two forms. One involves the **extent to which students are separated into different "tracks" or programs**, either within schools or between schools. The other is whether **the length of secondary schooling** is the same for all students, across all schools, programs, and regions of the country. **The U.S. is atypical among TIMSS countries is the lack of differentiation in secondary schooling on either dimension.** suggest: no tracking

The U.S. was one of five countries in TIMSS (the others are all former English colonies-- Australia, Canada, New Zealand, and South Africa) where most students attend comprehensive high schools, regardless of their ability, prior academic performance and career goals. Within those comprehensive high schools, students can choose from among a wide variety of curriculum options, creating their own program of studies from a variety of self-selected courses. Most of the students in the other TIMSS countries attend either specialized or mixed secondary schools. In specialized schools, students of different abilities or career goals attend separate types of schools. In mixed secondary schools, students of different abilities or career goals all attend the same school, but based on ability, or interest, students are divided into one of several pre-set programs of course work within the school.

In 7 of the TIMSS countries, including the U.S., secondary schooling ends at the same grade for all students. In the other 16 countries, the length of schooling varies. (See figure 3.1.) Generally, vocationally-oriented programs and credentials involve fewer years of secondary schooling than do those with an academic focus. For example, in the Czech Republic, there are three types of secondary schools -- gymnasium (academic), technical and vocational, and depending on the school or program, students complete secondary schooling at the end of grades 10, 11, 12, or 13. Students in technical schools and gymnasium usually complete their secondary education at grade 12, but a few at grade 13. In the vocational schools, the end of secondary education can occur between grades 10 and 13 depending on the type of vocation. In some countries, students after completing one secondary vocational program may enroll in a second such program in another field.

[FIGURE 3.1 GOES ABOUT HERE—TO COME] ?

In TIMSS, students were tested in the final year of secondary schooling for the various types of secondary schools in each nation's educational system, so that within the same country, students who took TIMSS varied in the number of years of schooling they had completed. Thus in the Czech Republic, when TIMSS tested students in the final year of secondary school in each type of school, there were Czech students taking TIMSS who were in grades 10 to 13. **Across all 21 countries participating in the literacy portion of TIMSS, students as low as grade 10 and as high as grade 14 were tested.** Like the U.S., every country assessed students in grade 12 (except the Russian Federation where it was only grade 11), but in the majority of countries students in at least one other grade also participated in TIMSS.

Reflecting the differences in the structure and organization of the education systems in the various countries, **the average age of the students in each country taking the literacy assessments** also varied across countries, from about 17 to 21. The average age of U.S. students was 18.1 years and the international average for all 21 countries was 18.7 years. Countries with relatively high average ages (19.0 or above) tended to be countries where primary school does not start until age 7 and/or where secondary schooling extends beyond grade 12. Most of these countries have much high proportions of 18-year-olds enrolled in secondary school than the U.S. and some have one-fourth to one-third of 20-year-olds still enrolled in secondary school (compared to 2 percent of 20-year-olds in the U.S.).

Secondary Enrollment and Completion:

One possible explanation for the poor performance of U.S. students could be that a much higher proportion of the U.S. population completes secondary education than in the countries that outperformed us on TIMSS. If that were the case, then the students participating in the TIMSS literacy assessment would represent an elite group within other countries while they would represent nearly all the population in the U.S. However, data gathered as part of TIMSS and by the Organization for Economic Cooperation and Development (OECD) on secondary enrollment and completion indicate that this is not the case.

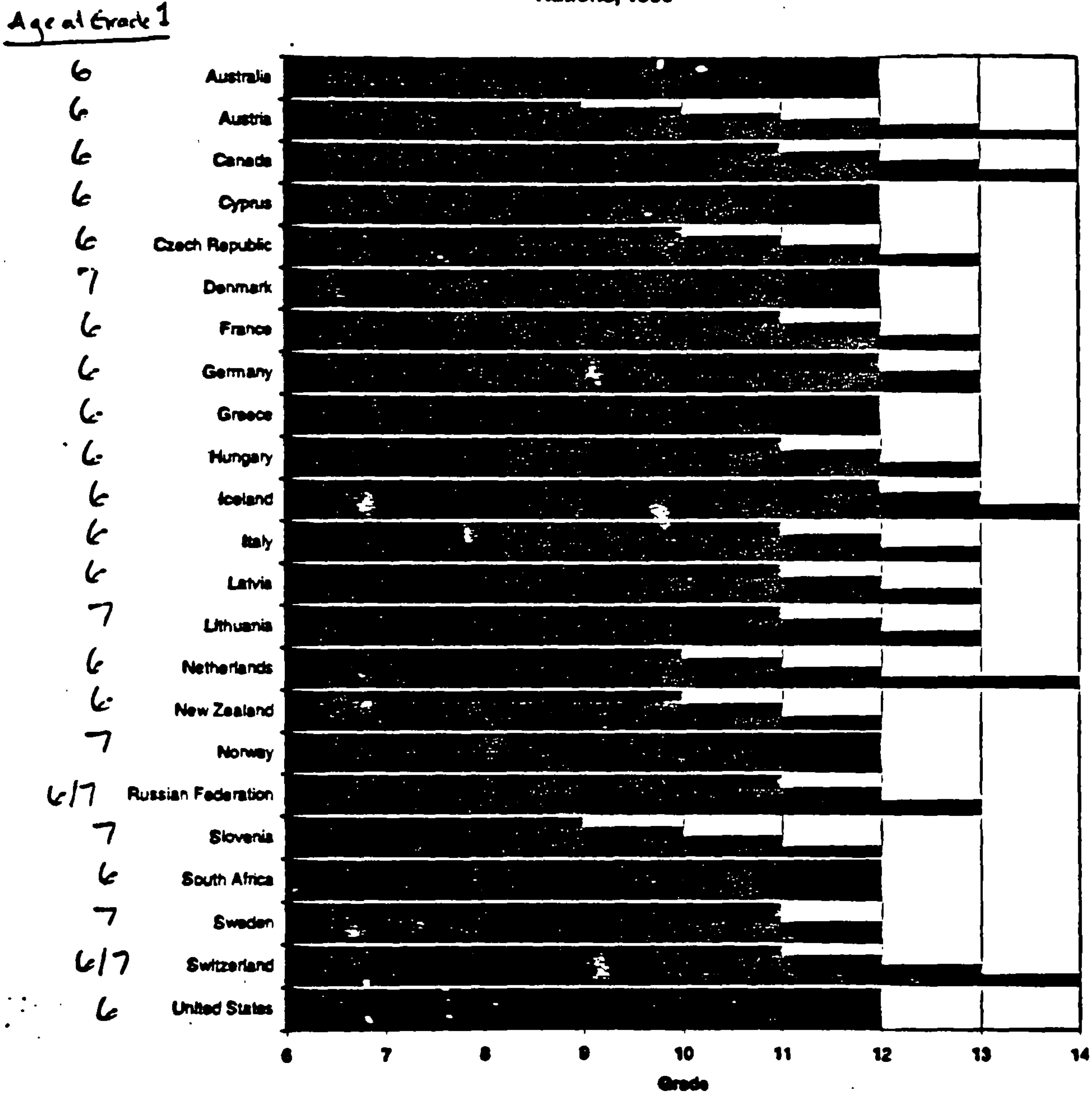
While in the past, it was true that the U.S. differed from many other countries in educating most of its young people through the end of secondary school, that was no longer true in the year TIMSS was conducted. **In the TIMSS countries as a whole, currently large proportions of the population attend and complete secondary school.** In 1995, enrollment in secondary education represented, ~~on average~~, over 90 percent of children of secondary school age among the 21 countries participating in the literacy portion of TIMSS and in the U.S.

This isn't so clear. Could there be a graph bar chart showing

90?

Figure 3-1

Age Begin Grade 1 and Grade(s) Marking End of Secondary School in TIMSS Nations, 1995



NOTE: The width of the segments of the bars do not indicate the proportion of the cohort that complete school at the end of the indicated grades.

SOURCE: Mullis et al. (1998) *Mathematics and Science Achievement in the Final Year of Secondary School.* Appendix A. Chestnut Hill, MA: Boston College.

why here?

While current secondary enrollment in the U.S. and the other TIMSS countries is similar, **the U.S. still has an edge in secondary completions among 25- to 34-year-olds**, reflecting differences in secondary enrollment in past years. Data collected by OECD reveal that in 1995 the average proportion of the population ages 25-34 who had completed high school, while relatively high (78 percent) for the 14 TIMSS countries for which the information was available, was somewhat lower than in the U.S. (87 percent).

Curriculum:

Although the literacy assessments were not designed to match secondary mathematics and science curricula, the content of the U.S. secondary curriculum relative to the other TIMSS countries might contribute to the poor U.S. performance. A comparison of the topics covered in the mathematics and science literacy assessments with the curriculum frameworks in the TIMSS countries did reveal that **both literacy assessments represented more advanced content in the U.S. than it did in most other countries.**[11]

The mathematics literacy assessment represented about a seventh grade level of curriculum for most TIMSS nations, but was most equivalent to the ninth grade curriculum in the U.S. The science literacy content was equivalent to ninth grade curriculum internationally, but was most equivalent to the eleventh grade curriculum in the U.S. The higher grade level equivalent of the assessments in the U.S. reflects the relatively late appearance in the U.S. curriculum compared to the other countries of algebra and many geometry topics in mathematics and chemistry and physics in science.

Another aspect of curriculum that differs among the TIMSS countries is the extent to which decision-making about curriculum is centralized. **In about half of the TIMSS countries, decisions about curriculum are centralized at the national level. In a few countries, those curriculum decisions are regionally centralized, and in the remaining countries, including the U.S., curriculum decisions are not centralized.**

Mathematics and Science Coursetaking:

One aspect of the curriculum is how much mathematics and science students take in secondary school and at what level. Research has shown in the U.S. that more years of science and mathematics coursetaking in high school is associated with higher levels of performance.[12] If a similar pattern holds in other countries and greater proportions of students in high achieving countries have studied mathematics and science for more years or have taken advanced courses than in the U.S., that could contribute to the relatively poor performance of U.S. students.

Because of the differences in the ways the curriculum is delivered in the various countries, it is difficult to construct comparable measures for the amount or the level of mathematics and science that students in different countries have studied. Students were asked whether they were currently taking mathematics and science at the time they participated in TIMSS, which at least indicates whether they were still studying these subjects in their final year of secondary school. Countries did vary considerably in the proportion of students reporting they were currently taking mathematics (from about half to all students) and science (from one-third to all students). **The proportion of graduating students currently taking mathematics was lower in the U.S. (66 percent) than the average in all the countries participating in the literacy assessments (84 percent). The same was also true for science (53 percent for the U.S. and 68 percent for all the TIMSS countries).**

** high priority

But prob w/ definition

One indicator of the extent of advanced mathematics ~~and science~~ study by secondary students can be found by looking at the advanced mathematics and physics assessments within TIMSS. Students taking those assessments were identified by their countries being their most advanced students in mathematics and science. **The proportions of U.S. students taking the advanced mathematics and the physics assessments were similar to the average in the other participating countries.** In the U.S., the participants in each of the two advanced assessments represented about 14 percent of the age cohort; the international average for the advanced mathematics assessment was 18 percent and for the physics assessment, 14 percent.

Support for Education:

One factor that may be associated with both educational system and student differences is the affluence of the countries, which may be translated into the level of resources available to schools and families. While the U.S. was one of the more affluent countries participating in this portion of TIMSS, with a GNP per capita of $25,860 compared to $17,305 for all 21 countries participating in the literacy portion of TIMSS. However, about one-third of the countries had GNP per capita similar to or higher than the U.S. ($23,500 to $37,000). Similarly, the U.S. had higher per capita public spending on elementary/secondary education than two-thirds of the other countries.

DO ANY OF THE FACETS OF SCHOOLING DESCRIBED ABOVE APPEAR TO CONTRIBUTE TO THE RELATIVELY POOR PERFORMANCE OF U.S. 12TH GRADERS IN TIMSS?

Most of the factors described above do not seem to account for U.S. students' relatively poor performance. This is the case for differentiation in curricular programs within or among schools, the grade level of the students participating in TIMSS, rates of secondary and postsecondary completion, and centralization of curricular decision-making. (See Appendix 5 for supporting materials.)

School Structure:

While the average age of the students participating in TIMSS in the countries outperforming the U.S. ranged 17.5 to 21.2, countries with an average age of 19.0 or above were somewhat more likely to outscore the U.S. than the countries in which the average age was less than 19.0.

Neither the grade level of the students being assessed nor the extent of differentiation within secondary schooling were related to whether a country outperformed the U.S.

Secondary Enrollment and Completion:

Rates of enrollment and completion of secondary education were not related to the likelihood of countries outperforming the U.S. The U.S. resembled the countries which outperformed us, so those countries were not assessing a smaller, and more elite, population than we did.

Curriculum:

The literacy assessments were more advanced in terms of grade-level of the curriculum for the U.S. than the for the TIMSS countries as a whole. However, estimates for the grade-level equivalents of the assessments for each of the other TIMSS countries are not currently available, so we cannot compare the curricular level of the assessments in the countries that outperformed the U.S. to that in the U.S. and countries that performed similarly or worse than we did.

Countries with centralized decision-making, either at the national or regional level, were not more likely to outscore the U.S. than the countries where the decision-making is not centralized.

Mathematics and Science Coursetaking:

The extent of mathematics and science coursetaking do not appear to be major factors in accounting for the poor performance of U.S. students. The countries which outperformed the U.S. in mathematics literacy did not have higher proportions of students in their last year of secondary schooling currently taking mathematics and science. Similarly, the countries outperforming the U.S. on the advanced mathematics and science assessments had similar proportions of their young people taking the assessments as did the U.S. but they diff. shift

Support for Education:.

The U.S. performance resembles, on average, the economically less affluent countries (those with lower GNPs and per capita expenditures on elementary education) participating in TIMSS at this grade level (and two of the less affluent countries, Hungary and Slovenia, also outperform the U.S.).

WHY DO U.S. STUDENTS PERFORM MORE POORLY RELATIVE TO THE INTERNATIONAL AVERAGE IN 12TH GRADE THAN IN 8TH GRADE?

The performance of all U.S. students was poorer in 12th grade than in 8th grade relative to the other countries which participated in TIMSS at both grade levels. Do any of the school organization and curriculum factors help explain the U.S.'s poorer performance at 12th grade? One factor that does seem to be associated with whether countries' relative position changed between the 8th grade and the end of secondary school is the difference in average age of the populations participating in the two assessments in each country.

There was considerable variation among countries in the differences in the average ages of the students in the two different assessments. Students participating in the end of secondary assessment were as much as 7.6 years older or as little as 2.9 years older than the students in the same country in the eighth grade assessment. (The international average was 4.4 years difference in age and for the U.S. it was 3.9 years.) This great variation reflects at least two factors: the age at which students begin primary education in each country, which affects what grade level was assessed at the middle school level, and how many years secondary education extends, which affects how old students are at the end of secondary school.

The population for the "8th grade" assessment was actually based on age, targeting the two grades in which most 13-year-olds were enrolled. In countries where primary education begins at age 7, most 13-year-olds are in grades 6 and 7 rather than in grades 7 and 8 as they are in countries where primary schooling begins at age 6. The middle school assessment was given to seventh and eighth graders (with eighth grade being the primary grade) in most countries, but in the 5 countries where all or most students start primary school at age 7, it was administered to 6th and 7th graders.

In other countries. secondary school ends before or extends beyond 12th grade for at least some students. Therefore, some students have fewer or more than 4 years of formal education between 8th grade and the end of secondary school.

The difference between the average age of the students participating in the middle-school assessment and those in the end-of-school assessments was related to whether a country's relative standing was higher, the same, or lower on the end-of-school than on the middle-school assessment. For both mathematics and science, countries whose performance relative to the international average was higher for the end-of school than the middle-school portion of TIMSS tended to have a larger age differential between the populations taking the two assessments than those whose relative standing did not change. Countries whose relative standing was lower at the older grade level tended to have a smaller differential in average age for the two groups of students. Countries whose standing in mathematics relative to the international average improved between 8th grade and the end of secondary schooling, had an average differential of 5.4 years compared to 4.6 for those whose relative standing did not change and 3.5 years for those, including the U.S., whose relative standing declined between 8th grade and the end of secondary school. (The numbers were very similar for science--5.3, 4.6, and 3.7.)

Countries where more students were taking mathematics in their final year of secondary school were not more likely to improve their relative standing from 8th to 12th grade than those that did not. In fact, for mathematics, countries whose relative standing declined had a higher proportion of students enrolled in mathematics in the final year of secondary schooling, on average, than did those whose relative standing declined, although this pattern did not hold for the U.S. The U.S. was the only country whose relative standing declined where the proportion of students currently taking mathematics was below the international average.

Summary

The United States differed from the international average for the TIMSS countries on several of the factors related to the organization of the educational system and the curriculum, including differentiation in the way secondary education is organized, the age of the students taking the assessment, the likelihood of starting and completing postsecondary education, the frequency of currently taking mathematics and science in the final year of secondary school, the curricular grade-level difficulty of the literacy assessments, and the extent of centralization in curricular decision-making. Yet few of these factors, with the possible exception of the difficulty of the test [in relation to the curricula] and the average age of the students taking the assessment, appear to be a major factor in explaining the relatively poor performance of U.S. high school seniors compared to graduating students in other TIMSS countries. However, some or all of these factors may contribute to our poor performance in some fashion. While none of them explain our students' performance relative to most of the countries which outperform us, some of them could an important factor relative to at least one of the countries. Furthermore, many of these factors are inter-related and this initial analysis looked at each factor separately. Further analysis which takes these interrelationships into account may reveal underlying patterns that are not apparent in these preliminary analyses.

STUDENTS' LIVES IN AND OUT OF SCHOOL AND PERFORMANCE IN TIMSS

As discussed in the first section of this chapter, we know that upper secondary education, or 'high school' as it is known in the U.S., varies greatly among the TIMSS nations. Students in one country may attend a school with a particular focus based on their abilities or career goals (as in France, for example), while students in another nation may be required to choose among several specialties as their "major" in a general school (as in Sweden, for example). In other countries, students may create their own program by choosing among a variety of courses (as in the United States, for example).

While we know much about the differences between school systems in the TIMSS nations, we know less about students' everyday lives in those schools, and, in particular, how aspects of their everyday lives may affect their performance. In order to learn more, TIMSS asked students about a number of factors that have been associated by policy-makers and educators with student performance within the United States and many other countries.

HOW DO U.S. TWELFTH-GRADE STUDENTS COMPARE INTERNATIONALLY ON FACTORS ASSOCIATED WITH THEIR LIVES INSIDE OF SCHOOL?

Based on students' reports, TIMSS finds the following concerning those students who took the mathematics literacy assessment.

Homework:

U.S. students reported spending fewer hours on homework and studying per day than the international average. Students in thirteen nations reported spending more hours, on average, studying or doing homework per day than their U.S. counterparts. Students in five nations reported a similar average number of hours as do U.S. twelfth-grade students, while students in only one nation, the Czech Republic, reported a lower average number of hours studying or doing homework per day.

Calculators:

Slightly more than half of U.S. twelfth-grade students reported using a calculator on a daily basis, which is similar to the international average. A significantly higher percentage of students in 10 nations reported using a calculator on a daily basis than do students in the U.S. A similar percentage of students as the U.S reported using a calculator daily in 6 nations, and a lower percentage in 3 nations.

In all nations, students were given the opportunity to use calculators during the TIMSS mathematics and science literacy assessment. **While a majority of U.S. students reported taking advantage of the opportunity to use calculators during the mathematics and science literacy assessment, fewer U.S. students did so than the international average.** More students took this advantage in 12 nations than did students in the U.S.

Computers:

Almost three quarters of U.S. twelfth-grade students reported using a computer at school, home, or elsewhere, which is higher than the international average. A higher percentage of students than the U.S. in 2 nations, and a similar percentage of students than the U.S. in 6 nations reported using a computer. A smaller percentage of students in 11 nations reported using a computer.

Attitudes Toward Mathematics and Science:

The percentage of U.S. twelfth graders who stated that they like mathematics "a lot," or who "like" or "like a lot" chemistry, earth science, and physics is also higher than the international average of students who reported a similar attitude. The percentage of U.S. students who stated that they "like" biology, or like it "a lot," is similar to the international average.

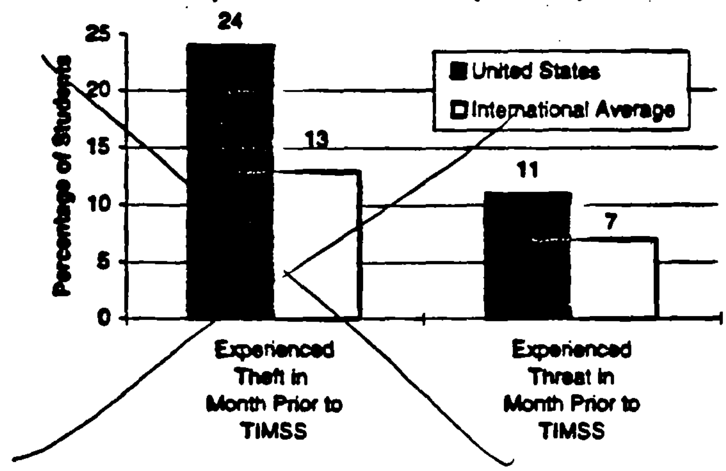
Personal Safety in School:

Almost one quarter of U.S. twelfth-graders have experienced theft of their property at school, which is higher than the international average (Figure 3-2). In only one nation, South Africa, did a higher percentage of students report having something stolen from them at school than U.S. students. A similar percentage of students in New Zealand reported experiencing theft at school as do students in the U.S. Theft was experienced by a smaller percentage of students in 15 nations.

~~While less common than theft in most nations around the world~~, **approximately one tenth of U.S. twelfth-grade students stated that they have been threatened by another student at school, which is higher than the international average (Figure 3-2).** In only one other nation, South Africa, did a larger percentage of students report similar occurrences of threats. A similar percentage of students in 6 nations reported having been threatened at school as do students in the U.S. Threats of violence at school were experienced by a smaller percentage of students in 10 nations.

Figure 3-2

Students' Reports on Their Negative Experiences at School (1994-95)



SOURCE: Mullis et al. (1998) *Mathematics and Science Achievement in the Final Year of Secondary School.* Table 4.21. Chestnut Hill, MA: Boston College.

We now turn our attention to examining advanced mathematics and physics students' responses to the TIMSS student questionnaire.

Advanced mathematics and physics students share many of the same experiences as the rest of their peers who have not taken or are not currently enrolled in advanced mathematics or physics courses. However, because many of the advanced mathematics and physics students continue to take mathematics and/or science courses in their final year of secondary school, we are provided the opportunity to learn additional information about their classroom experiences that we cannot learn from those who are no longer taking mathematics or science courses. Using this information, this section of the chapter explores advanced mathematics and physics students' everyday lives in school and in the classroom in order to learn more about how aspects of their everyday lives may affect their performance.

Because the vast majority of other nations that participated in the TIMSS advanced mathematics and physics assessments outperform the U.S., it is difficult to draw conclusions about the association between any of the factors described in this section and advanced mathematics or physics performance relative to the U.S. Examination of the distribution of nations on the factors described in this section shows that the many nations which outperform the U.S. are generally found to be above, similar to, or lower than the U.S. on the factors discussed here (Appendix 5).

Results from TIMSS indicate the following information about students who took the advanced mathematics and physics assessments.

Homework:

According to students' reports, **9 of every 10 U.S. twelfth-grade advanced mathematics students reported being assigned homework three or more times per week.** This is higher than the international average of approximately 2 out of 3 students. **Among U.S. twelfth-grade physics students, 1 of every 2 students reported being assigned physics homework three or more times a week.** This is higher than the international average of 4 of every 10 students who reported a similar frequency of physics homework.

Calculators:

A higher percentage of U.S. advanced mathematics and physics students reported using a calculator on a daily basis than was reported by their international counterparts. Approximately 80 percent of both U.S. advanced mathematics and physics students reported using a calculator on a daily basis.

As with the mathematics and science literacy assessments, students in all TIMSS nations were provided the opportunity to use calculators during the advanced mathematics and physics assessments. **More U.S. students who took the advanced mathematics assessment reported using a calculator during the assessment than the international average who reported doing so. Among U.S. students who took the physics assessment, a similar percentage of students reported using a calculator during the assessment as the international average.**

Hours of Instruction:

TIMSS asked advanced mathematics and physics students to report on the number of hours of mathematics or physics instruction they received each week. **Among U.S. twelfth-grade advanced mathematics students who were currently taking a mathematics course, a much lower percentage reported receiving five hours or more of instruction per week than the international average of students who reported this.**

In physics, the story is not quite the same as it was for advanced mathematics students. **A higher percentage of U.S. twelfth-grade physics students reported receiving five or more hours of physics instruction per week than the international average.**

Computers:

TIMSS queried students in advanced mathematics or physics courses how often they were asked to use computers to solve exercises or problems in their lessons. **Thirty-four percent of U.S. advanced mathematics and 42 percent of U.S. physics students reported being asked to use**

a computer to solve exercises or problems during lessons, which is higher than the international average for both groups.

Reasoning Tasks:

Among the many aspects of classroom instruction that experts have targeted for improvement is the use of reasoning tasks which require students to explain their reasoning behind an idea; represent and analyze relationships using tables, charts, or graphs; work on problems for which there is no immediately obvious method or solution; and write equations to represent relationships. **Forty-three percent of U.S. twelfth-grade advanced mathematics students reported that they were asked to do reasoning tasks in "every mathematics lesson."** This is higher than the international average of 32 percent of students who reported similar experiences. **Among U.S. physics students, half reported that they were asked to do reasoning tasks in "every physics lesson."** This is also higher than the international average of approximately 43 percent of students who reported similar experiences.

Laboratory Experiments:

Another area of education which has received much attention is in the use of experiments to enhance students' learning of concepts and knowledge in science. **When queried whether they are asked to conduct laboratory experiments during physics lessons, 96 percent of U.S. physics students replied affirmatively, which is higher than the international average.** More U.S. physics students stated that they were asked to conduct laboratory experiments than students in 10 of the 15 other TIMSS nations that participated in the physics assessment.

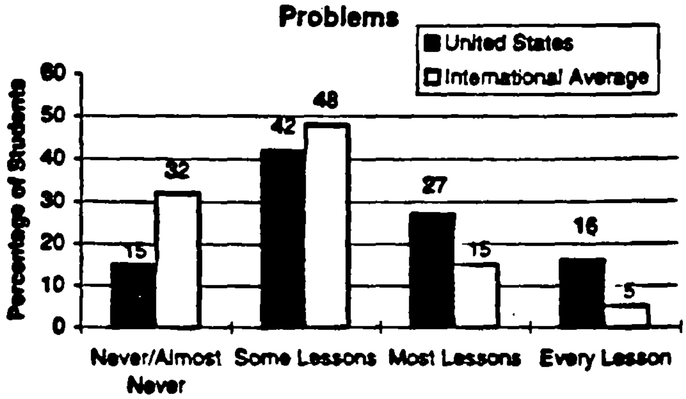
add dichotomy

Connecting Mathematics to Everyday Problems:

While laboratory experiments are often viewed as a way of helping students to make concrete connections with the physical properties they are meant to demonstrate, some experts believe that a way to improve students' interest in mathematics is to make it connect to everyday, real-world problems rather than just to abstract, artificial problems. **Approximately 8 of every 10 U.S. advanced mathematics students responded that they were asked to connect mathematics to everyday problems, which is higher than the international average of approximately 7 of every 10 students (Figure 3-3).** More U.S. advanced mathematics students reported that they were asked to apply mathematics to everyday problems in their mathematics lessons than students in 13 of the 15 other nations which participated in the advanced mathematics assessment.

Figure 3-3

Advanced Mathematics Students' Reports on Connecting Mathematics to Everyday Problems



SOURCE: Mullis et al. (1998) *Mathematics and Science Achievement in the Final Year of Secondary School.* Table 7.4. Chestnut Hill, MA: Boston College.

ARE ANY OF THE AVERAGE STUDENT CHARACTERISTICS REPORTED ABOVE ASSOCIATED WITH PERFORMANCE?

With respect to country averages, there does not seem to be a relationship between student performance in mathematics literacy and most of these factors (Appendix 5). However, the situation appears to be different for calculator usage among those students who took the mathematics literacy assessment. According to TIMSS data, 8 of 10 nations in which a higher percentage of students used a calculator on a daily basis than the U.S. performed higher in mathematics literacy than the U.S. Countries in which students were as likely or less likely to use a calculator daily than students in the U.S. are fairly evenly divided between high mathematics performance relative to the U.S. and similar or lower performance. **Thus, nations in which a higher percentage of students used a calculator daily than the U.S. appear to have been more likely to outperform the U.S. in mathematics literacy than nations with a similar or lower percentage of daily calculator use.**

In addition, average calculator use during the TIMSS assessment also appears to be related to performance. Eleven of the 12 countries with higher student calculator use during the TIMSS assessment than the U.S. performed better than the U.S. in mathematics literacy. Moreover, 5 of the 8 countries with similar or lower student calculator use during the assessment than the U.S. performed similar to or lower than the U.S. in mathematics literacy. **Thus, countries in which a higher percentage of students used a calculator on the TIMSS mathematics literacy assessment appear to have been more likely to outperform the U.S. than countries with a similar or lower percentage of student calculator use on the mathematics literacy assessment.**

How did they do at 4th & 8th grade in computer

With respect to country averages, there does not appear to be a relationship between student performance in advanced mathematics or physics and most factors among the TIMSS nations either. However, one factor does appear to be related to advanced mathematics performance: number of hours of mathematics instruction per week.

According to TIMSS data, all 6 nations which reported a higher percentage of students receiving 5 or more hours of mathematics instruction per week outperformed the U.S. in advanced mathematics. Among the 6 nations which reported a similar or lower percentage of students receiving 5 or more hours of mathematics instruction per week, 3 performed similar to or lower than the U.S. in advanced mathematics. **Thus, nations in which a higher percentage of students received 5 or more hours of mathematics instruction per week than** In **the U.S. appear to have been more likely to perform above the U.S. in advanced mathematics than nations in which a similar or smaller percentage of students received 5 or more hours of mathematics instruction per week than the U.S.**

HOW DO U.S. TWELFTH-GRADE STUDENTS COMPARE INTERNATIONALLY ON FACTORS ASSOCIATED WITH THEIR LIVES OUTSIDE OF SCHOOL?

Students' lives outside of school can be occupied with any number of activities and demands. For example, students may spend time with family and friends, participate in sports or other leisure time activities, or work at a job. The different ways in which students' lives are structured outside of school can provide support or prove to be an obstacle to their learning in school. Some believe that activities not directly related to improving learning, such as television watching or holding a part-time job, can have a negative impact on performance. TIMSS asked students about a number of factors associated with their activities outside of school that policy-makers and educators have argued are associated with performance within the U.S. and in other nations. Results from TIMSS show the following.

Television and Video Watching:

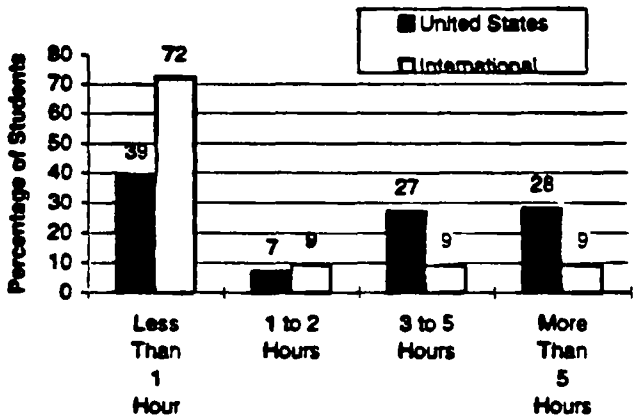
U.S. twelfth graders spent, on average, a similar amount of time watching television or videos as the international average. U.S. students watched an average of 1.7 hours of television or videos per day, which is a similar amount of time as reported by students in 8 other nations. Students in 6 nations spent more time watching television or videos, on average, than U.S. students, while students in 5 nations spent fewer hours watching television, on average, than U.S. students.

Working at a Paid Job:

More U.S. twelfth-grade students reported that they worked at a paid job, and worked longer hours, than did students in any other TIMSS nation (Figure 3-4 and Appendix 5). A little more than half of U.S. students said that they worked 3 or more hours per day at a paid job compared with the international average of less than one-fifth of all graduating students who reported this. Moreover, U.S. students reported that they worked an average of 3.1 hours per day, which represented a longer average workday than for students in any other TIMSS nation.

Figure 3-4

Students' Reports on the Hours Per Day Spent Working at a Paid Job (1994-95)



SOURCE: Mullis et al. (1998) *Mathematics and Science Achievement in the Final Year of Secondary School.* Table 4.21. Chestnut Hill, MA: Boston College.

ARE THE AVERAGE STUDENT CHARACTERISTICS REPORTED ABOVE ASSOCIATED WITH PERFORMANCE?

Again, with respect to country averages, **there does not appear to be a relationship between student performance and average number of hours watching television or videos, or working at a paid job** (Appendix 5).

Summary

We have examined the early evidence from the TIMSS student questionnaires about how various factors many experts believe to be related to educational performance differ from the international average. When appropriate, we have also examined whether or not these differences are associated with performance on the TIMSS assessments at this grade level. **Initial evidence concerning why the international standing of U.S. twelfth-grade students is relatively poor in mathematics and science literacy, in advanced mathematics, and in physics does not definitively point to any single factor, or group of factors, which would explain U.S. students' performance in comparison with their international peers.** We did note, however, that among those students who completed the mathematics literacy assessment, two factors—percentage of students who reported using a calculator on a daily basis and percentage of students who reported using a calculator during the TIMSS assessment—appear to be associated with their performance in mathematics literacy. In addition, one factor appears to be associated with performance in advanced mathematics—number of hours of mathematics instruction per week. For all other factors examined in this section, there does not appear to be a relationship with performance.

It is important to note that factors may be related to performance for individual students and at the same time, not be related to average performance at the country level. For example, individual student performance in mathematics and science literacy is associated with hours spent doing homework in many countries. Yet when comparing the U.S. with other countries, there is no relationship between average hours spent doing homework and average mathematics and science literacy. The same is true for hours spent watching television.[13]

Similarly the existence of a relationship at the aggregate level--e.g. average use of calculators on the TIMSS test and average performance (relative to the U.S.)--does not imply within individual countries, that students who used calculators on the TIMSS ASSESSMENT performed better than those who did not use calculators on the TIMSS assessment.

Additional analyses are needed to understand more fully the interrelationships among individual and country-level factors.

CONCLUSIONS

This report has presented highlights from the initial analyses of the academic performance of the U.S. twelfth graders in comparison with performance of students from other countries at the end of secondary education. The performance of United States' students in mathematics and science at the end of secondary school is among the lowest of those countries participating in TIMSS. This is true for all students as well as for advanced students in mathematics and physics.

The report has also presented the evidence available from early analyses concerning why U.S. students performance is one of the lowest in the participating TIMSS countries. TIMSS does not suggest any single factor or combination of factors that can explain why our performance is so low. From our preliminary analyses, it also appears that some factors commonly thought to influence the individual student performance are not strongly related to performance when comparing average student performance across countries.

TIMSS provides a rich source of information about student performance in mathematics and science and about education in other countries. These early findings suggest that to use the study most effectively, we need to continue to pursue the data beyond this initial report, taking the opportunity and time to look at interrelationships among factors in greater depth.

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APPENDICES

APPENDIX 1
SUMMARY OF INTERNATIONAL STUDY GUIDELINES AND DEFINITION OF ELIGIBLE STUDENTS

Twenty-three nations participated in the study. Twenty-one participated in literacy, while two other nations (Greece and Latvia) only participated in one or both of the advanced tests.

To identify comparable groups across countries for the three assessments, TIMSS countries were asked to identify eligible students in terms common definitions, after adapting the definitions to country-specific situations. Students in the mathematics and science literacy assessment were to be in their final year of secondary school. For the advanced mathematics assessment, eligibility was based on participation in advanced mathematics courses. For the physics assessment students were to have taken a physics course. For each assessment, international guidelines specified that the sample was to be representative of at least 90 percent of students in the total population eligible for the study.

The guidelines also specified the following sampling standards:

- the school participation rate without the use of replacement: schools must be at least 50 percent, **and**
- the combined participation rate (the product of school and student participation rates after replacements) must be at least 75 percent, **or** school and student participation rates must each be 85 percent.

Countries were also required to submit a sampling plan for approval by the TIMSS International Study Center.

Most of the TIMSS countries experienced some deviation from international guidelines for execution of the study, in one or more of the tests. All deviations from these guidelines are **bolded** in the tables below.

Table A1.1
Mathematics and Science Literacy Test

Country	Population and exclusion rates	Sampling standards
(Australia)	Students in Grade 12, in government, Catholic, and independent schools Exclusion rate: 6%	**Participation rate before replacement: 49%,** **Combined participation rate: 52%**
(Austria)	Students in their final year of academic schools, (Grade 12), their final year of higher technical and vocational school, (Grade 13), their final year of medium technical and vocational school (Grades 10,11, 12 depending on the vocational program of the student), and students in their final year of apprenticeship. **Exclusion rate: 18 %**, (Students enrolled in teacher training colleges and courses lasting less than three years)	**Participation rate before replacement: 36%,** **Combined participation rate: 72%**
(Canada)	Students in Grade 12 in all provinces except Quebec where Students in the Grades 13 and 14 (depending on program) were tested. In Ontario, students completing the OAC in Grade 13 also were tested. **Exclusion rate: 22 %**, (Ontario students graduating in December excluded)	Participation rate before replacement: 82% **Combined participation rate: 68%**
(Cyprus)	Students in Grade 12 of lycea and the technical schools. Vocational students in technical schools were not tested. Students in the private and vocational schools were note included. **Exclusion rate: 22%**, (private and vocational schools excluded)	Participation rate before replacement: 100% Combined participation rate: 98%
Czech Republic	Students in their final year of each type of school. In technical schools and gymnasia, student sin Grades 12 and 13 were tested. In vocational schools students in Grades 10, 11, 12 and 13 were tested, depending on their vocation. Exclusion rate: 0 %	Participation rate before replacement: 100% Combined participation rate: 92%
(Denmark)	Students in Grade 12 of the general secondary and vocational schools, however students finishing their formal schooling after *folkeskole* (Grade 9) were not tested. Exclusion rate: 2 %	**Did not follow sampling procedures** Participation rate before replacement: 55% **Combined participation rate: 49%**
(France)	Students in their final year of preparation for all types of the *baccalaureat* which includes students in Grade 12 or Grade 13 (depending on the type of exam). Also tested were students in the final year of preparation for the *Brevet d'etudes professionnelles* or the *Certificat d'aptitude professionnelle* who will not continue towards a *baccalaureat.* Exclusion rate: 1 %	Participation rate before replacement: 80% **Combined participation rate: 69%**

(Germany)	Students in their final year in the gymnasium and the vocational education programs. This corresponded to Grade 13 in the Laender of the former West Germany and to Grade 12 in the Laender of the former East Germany. Exclusion rate: 9%	**Did not follow sampling procedures** Participation rate before replacement: 89% Combined participation rate: 80%
Hungary	Students in their final year of academic secondary and vocational schools (Grade 12) and students in their final in-school year of trade school (Grade 10). Exclusion rate: 0%	Participation rate before replacement: 100% Combined participation rate: 98%
(Iceland)	Primarily students in Grade 14, and also students Grades 12 and 13 depending on school program Exclusion rate: 0%	Participation rate before replacement: 100% **Combined participation rate: 74%**
(Italy)	The final grade of school depended on their focus of study within the school type, ranging from Grade 11 to Grade 13. Students in private schools were not tested. **Exclusion rate: 30%** (Four regions of 20 were excluded)	Participation rate before replacement: 60% Combined participation rate: 62%
(Lithuania)	Students in Grade 12 in vocational, gymnasia, and secondary schools where Lithuanian is the language of instruction. Schools not under the authority of the Ministry of Education or the Ministry of Science were excluded. **Exclusion rate: 16%** (non-Lithuanian-speaking students excluded).	Participation rate before replacement: 97% Combined participation rate: 85%
(Netherlands)	Students in Grade 12 of pre-university, students in Grade 11, in senior general secondary, and students in the second year of the two to four year senior secondary vocational program. Students in the apprenticeship program were not tested. **Exclusion rate: 21%** , (short senior vocational and apprenticeship programs excluded)	**Did not follow sampling procedures** **Participation rate before replacement: 36%** **Combined participation rate: 49%**
New Zealand	Students in Grade 12 and Students in Grade 11 who were returning to school for Grade 12. Exclusion rate: 9%	Participation rate before replacement: 87% Combined participation rate: 81%
(Norway)	Students in the Grade 12 in general academic and vocational programs. Exclusion rate: 0%	Participation rate before replacement: 74% **Combined participation rate: 71%**
(Russian Federation)	Students in Grade 11, of general secondary schools. **Exclusion rate: 43%** , (vocational schools and non-Russian speaking students excluded)	Participation rate before replacement: 93% Combined participation rate: 90%
(Slovenia)	Students in Grade 12 in gymnasia and in technical secondary schools, and Students in Grade 11 in vocational schools. Students finishing vocational school in Grades 9 and 10 were not tested. Exclusion rate: 0%	**Did not follow sampling procedures** **Participation rate before replacement: 46%** **Combined participation rate: 42%**

(South Africa)	Students in Grade 12 Exclusion rate: 0%	**Did not follow sampling procedures** **Participation rate before replacement: 36%** **Combined participation rate: 72%**
Sweden	In schools where the new three-year upper-secondary system was implemented, students in Grade 12. In the former two- or three-year system, students in the final year, Grade 11 or 12, respectively Exclusion rate: 0%	Participation rate before replacement: 95% Combined participation rate: 82%
Switzerland	Students in Grade 11 or 12 in gymnasium (final year depending on canton); Grade 12 in the general track; Grade 12 of the teacher-training track, and Grade 11, 12, or 13 in vocational track (final year varies by occupation). Exclusion rate: 2%	Participation rate before replacement: 87% Combined participation rate: 85%
(United States)	Students in Grade 12. Exclusion rate: 1%	Participation rate before replacement: 77% **Combined participation rate: 63%**

NOTE: Nations not meeting international sampling guidelines are shown in parentheses.

SOURCE: Mullis et al. (1998) *Mathematics and Science Achievement in the Final Year of Secondary School.* Boston College: Chestnut Hill, MA.

Table A1.2
Advanced Mathematics Test

Country	Population and exclusion rates	Sampling standards
(Australia)	Students in Grade 12, enrolled in mathematics courses (varies across states) preparing them for the post-secondary study, and students in Grade 12 who took such mathematics courses during Grade 11	**Participation rate before replacement: 47%,** **Combined participation rate: 55%**
(Austria)	Students in their final year of the academic or higher technical track, taking courses in advanced mathematics **Exclusion rate: 18 %**, (Students enrolled in teacher training colleges and courses lasting less than three years)	**Participation rate before replacement: 37%,** Combined participation rate: 81%
(Canada)	Students in mathematics courses preparing them for post-secondary study (varies by province), except in Quebec where students in the two-year science program were tested **Exclusion rate: 22 %**, (Ontario students graduating in December excluded)	Participation rate before replacement: 85%, Combined participation rate: 77%
(Cyprus)	Students in mathematics/science program study at the lyceum **Exclusion rate: 22%**, (private and vocational schools excluded)	Participation rate before replacement: 100% Combined participation rate: 96%
Czech Republic	Gymnasia students in their final year of study, Grade 12 or 13	Participation rate before replacement: 100% Combined participation rate: 92%
(Denmark)	Mathematics and physics students in the gymnasium and mathematics students in their final year, Grade 12, of the technical or higher preparation tracks	**Did not follow sampling procedures** Participation rate before replacement: 55%, **Combined participation rate: 50%**
France	Students in the scientific track, Grade 12, preparing the *baccalaureat general*	Participation rate before replacement: 90%, Combined participation rate: 77%
(Germany)	Students in Grade 12 or 13 depending on the Laender, in advanced mathematics courses (3 to 5 periods per week)	Participation rate before replacement: 77%, Combined participation rate: 77%
Greece	Students in Grade 12 of the general (academic) *Lyceum* taking advanced courses in mathematics and/or science in preparation for university disciplines requiring mathematics	Participation rate before replacement: 76%, Combined participation rate: 87%
(Italy)	Students in *Liceo Scientifico* (classical schools), Grade 11, 12, or 13, depending on the student's program of study, and *Instituti Technici* (technical schools), Grade 13 **Exclusion rate: 30%** (Four regions of 20 were excluded)	Participation rate before replacement: 70%, **Combined participation rate: 68%**

(Lithuania)	Students in Grade 12, of the mathematics and science gymnasia and students in secondary schools offering enhanced curriculum in mathematics **Exclusion rate: 16%** (non-Lithuanian-speaking students excluded).	Participation rate before replacement: 100% Combined participation rate: 92%
(Russian Federation)	Students in Grade 11, in general secondary schools in advanced mathematics courses or advanced mathematics and physics courses **Exclusion rate: 43%**, (vocational schools and non-Russian speaking students excluded)	Participation rate before replacement: 98% Combined participation rate: 96%
(Slovenia)	Students in their final year of gymnasia and technical and professional schools, Grade 12, who were taking advanced mathematics courses	**Did not follow sampling procedures** **Participation rate before replacement: 46%,** **Combined participation rate: 42%**
Sweden	Students in Grade 12 of the Natural Science or Technology lines	Participation rate before replacement: 95%, Combined participation rate: 87%
Switzerland	Students in Grade 12 or 13 of the scientific track of the *Maturitatsschule* and the scientific track of the general education track	Participation rate before replacement: 99%, Combined participation rate: 87%
(United States)	Students in Grade 12 who had taken Advanced Placement Calculus, Calculus, or Pre-Calculus	Participation rate before replacement: 76%, **Combined participation rate: 67%**

NOTE: Nations not meeting international sampling guidelines are shown in parentheses.

SOURCE: Mullis et al. (1998) *Mathematics and Science Achievement in the Final Year of Secondary School.* Boston College: Chestnut Hill, MA.

Table A1.3
Physics Test

Country	Population and exclusion rates	Sampling standards
(Australia)	Students in Grade 12, enrolled in Year 12 physics	Participation rate before replacement: 63%, **Combined participation rate: 54%**
(Austria)	Students in their final year of the academic or higher technical track, taking courses in physics **Exclusion rate: 18 %** , (Students enrolled in teacher training colleges and courses lasting less than three years)	**Participation rate before replacement: 37%,** Combined participation rate: 81%
(Canada)	Students in physics courses preparing them for post-secondary study (varies by province), except in Quebec where student sin the two-year science program were tested. **Exclusion rate: 22 %** , (Ontario students graduating in December excluded)	Participation rate before replacement: 80%, **Combined participation rate: 73%**
(Cyprus)	Students in their final year of the mathematics/science program of study at the lyceum **Exclusion rate: 22%** , (private and vocational schools excluded)	Participation rate before replacement: 100%, Combined participation rate: 96%
Czech Republic	Gymnasia students in their final year of study, Grade 12 or 13	Participation rate before replacement: 100%, Combined participation rate: 92%
(Denmark)	Mathematics and physics students in the gymnasium and physics students in their final year, Grade 12, of the technical or higher preparation tracks	**Did not follow sampling procedures** Participation rate before replacement: 55%, **Combined participation rate: 47%**
France	Students in the scientific track, Grade 12, preparing the *baccalaureat general*	Participation rate before replacement: 90%, Combined participation rate: 77%
(Germany)	Students in Grade 12 or 13 depending on the Laender, in physics courses (3 to 5 periods per week)	Participation rate before replacement: 77%, Combined participation rate: 82%
Greece	Students in Grade 12 of the general (academic) *Lyceum* taking advanced courses in mathematics and/or science in preparation for university disciplines requiring physics.	Participation rate before replacement: 76%, Combined participation rate: 87%
(Latvia)	Students in Grade 12, enrolled in advanced physics courses, in Latvian-speaking academic secondary schools. **Exclusion rate: 50%** , (non-Latvian speaking students excluded)	Participation rate before replacement: 84%, Combined participation rate: 77%
Norway	Students in Grade 12, of the three-year physics course in the general academic branch	Participation rate before replacement: 78%, Combined participation rate: 83%

(Russian Federation)	Students in Grade 11, in general secondary schools in advanced physics courses or advanced mathematics and physics courses. **Exclusion rate: 43%**, (vocational schools and non-Russian speaking students excluded)	Participation rate before replacement: 98%, Combined participation rate: 95%
(Slovenia)	Students in their final year of gymnasia, Grade 12, taking the physics *matura* examination	**Did not follow sampling procedures** **Participation rate before replacement: 46%,** Combined participation rate: 43%
Sweden	Students in Grade 12, of the Natural Science or Technology lines	Participation rate before replacement: 95%, Combined participation rate: 89%
Switzerland	Students in Grade 12 or 13, of the scientific track of the *Maturitatsschule* and the scientific track of the general education track	Participation rate before replacement: 99%, Combined participation rate: 87%
(United States)	Students in Grade 12 who had taken Advanced Placement Physics, or Physics	Participation rate before replacement: 77%, **Combined participation rate: 68%**

NOTE: Nations not meeting international sampling guidelines are shown in parentheses.

SOURCE: Mullis et al. (1998) Mathematics and Science Achievement in the Final year of Secondary School. Boston College: Chestnut Hill, MA.

APPENDIX 2
NATIONAL AVERAGE SCORES AND STANDARD ERRORS

Table A2.1
Mathematics and Science Literacy

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

NATION	MATHEMATICS LITERACY		SCIENCE LITERACY	
NATION	AVERAGE	STANDARD ERROR	AVERAGE	STANDARD ERROR
(Australia)	522	9.3	527	9.8
(Austria)	518	5.3	520	5.6
(Canada)	519	2.8	532	2.6
Czech Republic	466	12.3	487	8.8
(Denmark)	547	3.3	509	3.6
(France)	523	5.1	487	5.1
(Germany)	495	5.9	497	5.1
(Lithuania)	469	6.1	461	5.7
(Cyprus)	446	2.5	448	3.0
Hungary	483	3.2	471	3.0
(Iceland)	534	2.0	549	1.5
(Italy)	476	5.5	475	5.3
(Netherlands)	560	4.7	558	5.3
New Zealand	522	4.5	529	5.2
(Norway)	528	4.1	544	4.1
(Russian Federation)	471	6.2	481	5.7
(Slovenia)	512	8.3	517	8.2
Sweden	552	4.3	559	4.4
Switzerland	540	5.8	523	5.3
(South Africa)	356	8.3	349	10.5
(United States)	461	3.2	480	3.3

MATHEMATICS INTERNATIONAL AVERAGE = 500

SCIENCE INTERNATIONAL AVERAGE = 500

NOTE: Nations not meeting international sampling guidelines are shown in parentheses.

SOURCE: Mullis et al. (1998) *Mathematics and Science Achievement in the Final Year of Secondary School.* Tables 1.1. and 1.2. Boston College: Chestnut Hill, MA.

Table A2.2
Advanced Mathematics and Physics

NATION	ADVANCED MATHEMATICS		PHYSICS	
NATION	AVERAGE	STANDARD ERROR	AVERAGE	STANDARD ERROR
(Australia)	525	11.6	518	6.2
(Austria)	436	7.2	435	6.4
(Canada)	509	4.3	485	3.3
Czech Republic	469	11.2	451	6.2
(Cyprus)	518	4.3	494	5.8
(Denmark)	522	3.4	534	4.2
France	557	3.9	466	3.8
(Germany)	465	5.6	522	11.9
Greece	513	6.0	486	5.6
(Italy)	474	9.6		
(Latvia)			488	21.5
(Lithuania)	516	2.6		
Norway			581	6.5
(Russian Federation)	533	10.5	532	15.0
(Slovenia)	475	9.2	523	15.5
Sweden	512	4.4	573	3.9
Switzerland	533	5.0	488	3.5
(United States)	442	5.9	423	3.3

MATHEMATICS INTERNATIONAL AVERAGE = 500

SCIENCE INTERNATIONAL AVERAGE = 500

NOTE: Nations not meeting international sampling guidelines are shown in parentheses.

SOURCE: Mullis et al. (1998) *Mathematics and Science Achievement in the Final Year of Secondary School.* Tables 1.1. and 1.2. Boston College: Chestnut Hill, MA.

APPENDIX 3

Table A3.1
PERFORMANCE PER COUNTRY ON TEST ITEM EXAMPLES

Country	Percentage of students responding correctly			Country	Percentage of students responding correctly		
	Mathematics Literacy Items				Science Literacy Items		
	1-2	1-3	1-4		1-7	1-8	1-9
(Australia)	82.7	88.4	47.2	(Australia)	68.9	71.8	35.3
(Austria)	91.7	84.4	50.9	(Austria)	68.5	59.8	30.1
(Canada)	82.2	79.6	47.4	(Canada)	69.0	42.1	37.2
(Cyprus)	77.1	53.8	35.2	(Cyprus)	57.7	42.1	52.1
Czech Republic	90.3	65.8	37.7	Czech Republic	50.2	55.9	24.6
(Denmark)	91.2	78.0	65.1	(Denmark)	64.4	52.6	33.9
(France)	89.5	71.3	56.8	(France)	47.8	68.2	22.4
(Germany)	86.2	74.3	51.0	(Germany)	65.3	51.9	31.2
Hungary	74.0	55.8	50.4	Hungary	67.2	48.7	(NA)
(Iceland)	91.3	73.8	57.6	(Iceland)	78.1	75.4	35.6
(Italy)	85.5	61.9	44.7	(Italy)	53.6	68.3	23.3
(Lithuania)	84.7	61.2	51.5	(Lithuania)	45.3	53.7	41.2
(Netherlands)	95.8	91.4	63.2	(Netherlands)	77.9	54.5	57.3
New Zealand	86.0	91.1	44.5	New Zealand	67.6	69.8	44.1
(Norway)	90.0	77.8	48.9	(Norway)	71.8	57.4	52.6
(Russian Federation)	87.0	61.7	53.8	(Russian Federation)	53.0	48.8	35.4
(Slovenia)	92.1	79.9	65.0	(Slovenia)	72.1	45.4	25.8
(South Africa)	25.7	59.6	12.2	(South Africa)	18.9	34.5	8.3
Sweden	93.3	84.6	58.3	Sweden	71.8	69.9	53.8
Switzerland	88.3	74.7	69.0	Switzerland	70.3	74.5	33.6
(United States)	61.5	84.5	24.6	(United States)	41.7	74.5	23.4
International Average	**83.2**	**74.0**	**49.3**	**International Average**	**61.0**	**58.1**	**35.0**

NOTE: Nations not meeting international sampling guidelines are shown in parentheses.

SOURCE: TIMSS International Study Center, *P-Value Almanac for Achievement Items, Population 3 - Literacy.* Boston College: Chestnut Hill, MA.

Table A3.1 (Continued)

Country	Percentage of students responding correctly			Country	Percentage of students responding correctly		
	Advanced Mathematics Items				Physics Items		
	2-5	2-6	2-7		2-11	2-12	2-13
(Australia)	60.0	76.1	34.5	(Australia)	47.1	60.5	53.3
(Austria)	22.9	36.6	19.0	(Austria)	17.8	47.9	50.6
(Canada)	55.4	60.9	28.4	(Canada)	50.4	45.1	22.0
(Cyprus)	62.9	35.1	51.2	(Cyprus)	69.2	33.0	67.9
Czech Republic	44.2	42.9	24.6	Czech Republic	37.4	29.4	3.5
(Denmark)	39.9	66.9	38.7	(Denmark)	50.5	33.7	40.9
France	64.5	61.9	38.6	France	46.6	16.9	17.9
(Germany)	31.1	46.0	26.5	(Germany)	37.8	42.6	59.6
Greece	65.5	29.1	32.0	Greece	72.3	52.8	40.1
(Italy)	45.5	33.7	41.8	(Latvia)	43.4	39.3	42.9
(Lithuania)	48.1	48.9	31.1	Norway	72.2	44.4	44.5
(Russian Federation)	58.9	34.5	42.2	(Russian Federation)	69.3	41.4	27.8
(Slovenia)	39.8	39.9	25.2	(Slovenia)	65.9	49.1	53.8
Sweden	50.0	64.4	48.0	Sweden	62.7	31.5	19.8
Switzerland	62.9	62.5	43.6	Switzerland	38.7	43.2	29.7
(United States)	18.9	62.4	27.4	(United States)	25.2	49.0	12.0
International Average	**48.2**	**50.1**	**34.6**	**International Average**	**50.4**	**41.2**	**36.6**

NOTE: Nations not meeting international sampling guidelines are shown in parentheses.

SOURCES: TIMSS International Study Center, *P-Value Almanac for Achievement Items, Population 3 - Advanced Mathematics*. Boston College: Chestnut Hill, MA; TIMSS International Study Center, *P-Value Almanac for Achievement Items, Population 3 - Physics*. Boston College: Chestnut Hill, MA.

APPENDIX 4

SUB-SCALE SCORES AND STANDARD ERRORS FOR U.S. ADVANCED MATHEMATICS AND PHYSICS STUDENTS

Table A4.1
Advanced Mathematics Sub-scale Scores (1994-95)

	CALCULUS STUDENTS		AP CALCULUS STUDENTS	
	Average	Standard Error	Average	Standard Error
Numbers and Equations	459	7.9	520	5.2
Calculus	455	6.8	523	7.2
Geometry	421	8.2	484	5.3

SOURCE: Third International Mathematics and Science Study, unpublished tabulations

Table A4.2
Physics Sub-scale Scores (1994-95)

	PHYSICS STUDENTS		AP PHYSICS STUDENTS	
	Average	Standard Error	Average	Standard Error
Mechanics	417	2.6	460	8.4
Electricity / Magnetism	416	3.0	463	8.9
Heat	474	3.0	507	7.1
Wave Phenomena	448	2.3	487	6.1
Modern Physics	453	2.2	497	10.4

SOURCE: Third International Mathematics and Science Study, unpublished tabulations

APPENDIX 5

TABLE A5.1

Mathematics Performance at 4th and 12th Grades Compared with the International Averages

	12th grade: Above the international average	12th grade: Same as the international average	12th grade: Below the international average
4th Grade: Above the international average	(Netherlands)	(Slovenia) (Australia) (Australia) Czech Republic	Hungary (United States)
4th Grade: Same as the international average		(Canada)	
4th Grade: Below the international average	(Iceland)	New Zealand (Norway)	(Cyprus)

Table A5.2

Science Performance at 4th and 12th Grades Compared with the International Averages

	12th grade: above the international average	12th grade: same as the international average	12th grade: below the international average
4th Grade: Above the international average	(Netherlands)	(Australia) (Austria) Czech Republic	(United States)
4th Grade: Same as the international average	(Norway) (Canada)	(Slovenia) New Zealand	Hungary
4th Grade: Below the international average	(Iceland)		(Cyprus)

NOTE: Nations not meeting international sampling guidelines in the end of secondary school assessment shown in parentheses.

SOURCE: Mullis et al. (1998) *Mathematics and Science Achievement in the Final Year of Secondary School.* Boston College: Chestnut Hill, MA.

Table A5.3
Extent of Differentiation in Secondary Education and Performance on TIMSS Literacy Assessments Relative to the United States: 1995

Differentiation within and between schools in programs for students with differing abilities	Differentiation in length of secondary education	
	Yes	No
Yes (Specialized and mixed secondary schools)	**(Austria)** Czech Republic ***(France)*** ***(Germany)*** ***Hungary*** **(Iceland)** (Italy) (Lithuania) **(Netherlands)** (Russian Federation) **(Slovenia)** **Switzerland** **Sweden**	*(Cyprus)* **(Denmark)** **(Norway)**
No (Comprehensive secondary schools)	**New Zealand** (Canada)	**(Australia)** *(South Africa)*

United States: Comprehensive high schools and uniform length of secondary schooling.
Greece: Specialized/mixed schools and uniform length of secondary schooling.
Latvia: Specialized/mixed schools and varying lengths of secondary schooling.

NOTES:
1) Nations not meeting international sampling guidelines are shown in parentheses.
2) **bold**: nations which perform above the U.S. in both mathematics and science literacy
bold italic: nations which perform above the U.S. in mathematics literacy only
regular: nations which perform similar to the U.S. in both mathematics and science literacy
italic: nations which perform below the U.S. in mathematics and science literacy

SOURCE: Mullis et al. (1998) *Mathematics and Science Achievement in the Final Year of Secondary School.* Appendix A, pp.A-1 to A-26. Boston College: Chestnut Hill, MA.

TABLE A5.4

Average Age of Students Assessed and Grades Included in Literacy Assessments Compared to Performance on Mathematics Literacy Assessment Relative to the United States

Country and Performance Relative to the U.S. in Mathematics Literacy	Average Age of Students Participating in Literacy Assessment	End of Secondary Grades Assessed in Literacy Assessment					
		10	11	12	13	14	
Performance Above the United States							
(Netherlands)	18.5		X	X			(11-12)
Sweden	18.9		X	X			(11-12)
(Iceland)	21.2			X	X	X	(12-14)
(Norway)	19.5			X			(12)
Switzerland	19.8		X	X	X		(11-13)
(Denmark)	19.1			X			(12)
(Canada)	18.6			X	X	X	(12-14)
New Zealand	17.6		X	X			(11-12)
(Australia)	17.7			X			(12)
(Austria)	19.1	X	X	X	X	X	(10-14)
(Slovenia)	18.8		X	X			(11-12)
(France)	19.5		X	X	X		(11-13)
(Germany)	19.5			X	X		(12-13)
Hungary	17.5	X		X			(10, 12)
Average	**18.9**						
Performance Same as the United States							
Czech Republic	17.8	X	X	X	X		(10-13)
(Russian Federation)	16.9		X				(11)
(Italy)	18.7		X	X	X		(11-13)
(Lithuania)	18.1			X			(12)
Performance Below the United States							
(Cyprus)	17.7			X			(12)
(South Africa)	20.1			X			(12)
Average (Same & Below)	**18.2**						
(United States)	18.1			X			(12)
International Average	18.7						

NOTE:
1) Nations not meeting international sampling guidelines are shown in parentheses.
2) International average is the average of the national figures.

SOURCE: Beaton et al. (1998) *Mathematics and Science Achievement in the Final Year of Secondary School.* Table 1.1., Figure 2.1, and Appendix A, pp. A1-A26. Boston College: Chestnut Hill, MA.

TABLE A5.5
SECONDARY ENROLLMENT AND COMPLETION COMPARED TO THE UNITED STATES

Country and Performance Relative to the US in Mathematics	Percentage in Secondary School	Percentage of 25-34-Year-Olds Completing Secondary Education	Percentage Enrolled in Secondary Education by Age			
			17	18	19	20
Performed Above the U.S.						
(Netherlands)	93	70	91	69	47	32
Sweden	99	88	96	87	24	12
(Iceland)	103	—	77	65	63	33
(Norway)	116	88	90	83	33	19
Switzerland	91	88	82	75	52	23
(Denmark)	114	69	82	71	52	31
(Canada)	88	84	69	34	10	—
New Zealand	104	64	74	33	17	13
(Australia)	84	57	77	32	20	17
(Austria)	107	81	88	56	22	8
(Slovenia)	85	—	—	—	—	—
(France)	106	86	91	60	34	15
(Germany)	101	89	93	82	57	31
Hungary	81	—	71	39	17	11
Average	**98**	**79**	**83**	**60**	**34**	**20**
Performed Same as U.S.						
Czech Republic	86	91	72	30	6	3
(Russian Federation)	88	—	—	—	—	—
(Italy)	81	49	—	—	—	—
(Lithuania)	78	—	—	—	—	—
Performed Below the U.S.						
(Cyprus)	95		—	—	—	—
(South Africa)	77		—	—	—	—
Average (Same & Below)	**84**	—	—	—	—	—
(United States).	97	87	75	22	4	2
International Average	94	78	82	56	31	18

NOTES:
1) — not available.
2) Nations not meeting international sampling guidelines are shown in parentheses.
3) Percentage in secondary school represents gross enrollment of all ages at the secondary level as a percentage of school-age children as defined by each country. This may be reported in excess of 100% if some pupils are younger or older than the country's standard range of secondary school age.
4) International average is the average of the national figures

SOURCES: Mullis et al. (1998) *Mathematics and Science Achievement in the Final Year of Secondary School*. Table 4 and Figure 2.1. Boston College: Chestnut Hill, MA; Organisation for Economic Co-operation and Development. (1997) *Education at a Glance: OECD Indicators*. Tables A2.2a and C3.3, pp.39 and 158. Paris: OECD.

TABLE A5.6

MATHEMATICS AND SCIENCE COURSETAKING COMPARED TO PERFORMANCE ON MATHEMATICS AND SCIENCE LITERACY ASSESSMENTS RELATIVE TO THE UNITED STATES

Comparison to the United States	Percentage of Students Currently Taking Mathematics	Percentage of Students Currently Taking Science
Countries above the United States	**(Australia)** *(Cyprus)* Czech Republic **(Denmark)** **France** **Hungary** (Italy) (Lithuania) (Russian Federation) **(Slovenia)**	**(Australia)** **(Austria)** *(Cyprus)* France Hungary **(Iceland)** (Italy) (Lithuania) **New Zealand** (Russian Federation) **(Slovenia)** *(South Africa)*
Countries same as the United States	**(Austria)** **(Iceland)** **(Netherlands)** **New Zealand** (Norway) *(South Africa)* **Sweden** **Switzerland**	**(Canada)** **(Netherlands)** **Switzerland**
Countries below the United States	**(Canada)**	Czech Republic **(Denmark)** **(Norway)** **Sweden**
(United States)	★66%	★53%
International Average	84	68
Countries Missing	**(Germany)**	(Germany)

NOTES:
1) Nations not meeting international sampling guidelines are shown in parentheses.
2) **bold**: Nations which perform above the U.S. in the subject.
Regular: Nations which perform similar to the U.S. in the subject.
Italic: Nations which perform below the U.S. in the subject.
★ U.S. average is significantly different from the international average.

SOURCE: Mullis et al. (1998) *Mathematics and Science Achievement in the Final Year of Secondary School.* Tables 4.2 and 4.4. and Figures 2.1 and 2.2 . Boston College: Chestnut Hill, MA.

TABLE A5.7

CENTRALIZATION OF DECISION-MAKING ABOUT CURRICULUM SYLLABI AND PERFORMANCE ON MATHEMATICS AND SCIENCE LITERACY RELATIVE TO THE UNITED STATES

Nationally Centralized	**(Austria)** *(Cyprus)* Czech Republic ***(France)*** (Italy) (Lithuania) **New Zealand** **(Norway)** **(Slovenia)** *(South Africa)* **Sweden**
Regionally Centralized	**(Canada)** ***(Germany)*** **Switzerland**
Not centralized	**(Australia)** **(Denmark)** ***Hungary*** **(Iceland)** **(Netherlands)** (Russian Federation) (United States)

NOTES:

1) Nations not meeting international sampling guidelines are shown in parentheses.

2) **bold**:	Nations which perform above the U.S. in both mathematics and science literacy
bold Italic	Nations which perform above the U.S. in mathematics literacy only
regular	Nations which perform similar to the U.S. in both mathematics and science literacy
italic	Nations which perform below the U.S. in both mathematics and science literacy

SOURCE: Mullis et al. (1998) *Mathematics and Science Achievement in the Final Year of Secondary School.* Figure 1. Boston College: Chestnut Hill, MA.

TABLE A5.8

STUDENTS TAKING ADVANCED MATHEMATICS AND PHYSICS ASSESSMENTS AS PROPORTION OF AGE COHORT AND PERFORMANCE ON ADVANCED MATHEMATICS AND PHYSICS ASSESSMENTS RELATIVE TO THE U.S.

Advanced Mathematics		Physics	
Country and Performance Relative to the United States	**Percentage of Age Cohort Represented**	**Country and Performance Relative to the United States**	**Percentage of Age Cohort Represented**
Performed Above the U.S.			
France	20	Norway	8
(Russian Federation)	2	Sweden	16
Switzerland	14	(Russian Federation)	2
(Australia)	16	(Denmark)	3
(Denmark)	21	(Slovenia)	39
(Cyprus)	9	(Germany)	—
(Lithuania)	3	(Australia)	13
Greece	10	(Cyprus)	9
Sweden	16	(Latvia)	3
(Canada)	16	Greece	6
(Slovenia)	75	Switzerland	14
		(Canada)	14
		France	20
		Czech Republic	11
Average	18		13
Performed Same as the U.S.			
(Italy)	14	(Austria)	33
Czech Republic	11		
(Germany)	—		
(Austria)	33		
Average	19		
(United States)	14		14
International Average	18		14

Notes:
1) — data not available.
2) Nations not meeting international sampling guidelines are shown in parentheses.
3) International average is the average of the national figures.

SOURCE: Mullis et. al. (1998) *Mathematics and Science Achievement in the Final Year of Secondary School.* Figures 5.1 and 8.1, Tables 5.1 and 8.1. Boston College: Chestnut Hill, MA.

TABLE A5.9

Gross National Product and Public Expenditure on Elementary and Secondary Education of TIMSS Countries Compared to Performance on Mathematics Assessment Relative to the United States

Country and Performance Relative to the Unites States in Mathematics Literacy	GNP Per Capita (United States$)	Public Expenditure on Elementary/ Secondary Education as Percent of GNP	Public Expenditure on Elementary/ Secondary Education Per Capita (U.S. $)
Performed Above the United States			
(Netherlands)	$21,970	3.30	$ 725
Sweden	23,630	4.92	1,163
(Iceland)	24,590	4.77	1,173
(Norway)	26,480	5.26	1,393
Switzerland	37,180	3.72	1,383
(Denmark)	28,110	4.80	1,349
(Canada)	19,570	4.62	904
New Zealand	13,190	3.15	415
(Australia)	17,980	3.69	663
(Austria)	24,950	4.24	1,058
(Slovenia)	7,140	4.20	300
(France)	23,470	3.61	847
(Germany)	25,580	2.43	622
Hungary	3,840	4.31	166
Average	**21,263**	**4.07**	**869**
Performed Same as the United States			
Czech Republic	3,210	3.75	120
(Russian Federation)	2,650	---	---
(Italy)	19,270	2.89	557
(Lithuania)	1,350	2.18	29
Below the United States			
(Cyprus)	10,380	3.60	374
(South Africa)	3,010	5.12	154
Average (Same and Below)	**6.645**	**3.51**	**247**
(United States)	25,860	4.02	1,040
International Average	17,305	3.93	722

NOTES: 1) Nations not meeting international sampling guidelines are shown in parentheses.
2) --- data is not available.
3) International average is the average of national figures.

SOURCE: Mullis et. al. (1998) *Mathematics and Science Achievement in the Final Year of Secondary School.* Table 5 and Figure 2.1, Boston College: Chestnut Hill, MA.

TABLE A5.10

Differential in Average Age of TIMSS Participants in 8th Grade Assessment and 12th Grade Assessment and Change in Standing Relative to the International Average in the Assessment

		Differential in Average Age, 8th to 12th Grade Participants in TIMSS[1]			
		Mathematics		Science	
Change in Nation's Standing Relative to the International Average from 8th to 12th Grades	Improve Standing	Sweden	5.0	Switzerland	5.6
		New Zealand	3.6	New Zealand	3.6
		(Denmark)	5.2	(Iceland)	7.6
		(Norway)	5.6	(France)	4.5
		(Iceland)	7.6	(Denmark)	5.2
		Average	**5.4**		**5.3**
	Standing Unchanged	Switzerland	5.6	(Netherlands)	4.5
		(Netherlands)	4.2	Sweden	5.0
		(Austria)	5.8	(Norway)	5.6
		(France)	4.5	(Austria)	4.8
		(Canada)	4.5	(Canada)	4.5
		(Germany)	4.7	(Lithuania)	3.8
		(Lithuania)	3.8	(Cyprus)	4.0
		(Cyprus)	4.0	(South Africa)	4.7
		(South Africa)	4.7		
		Average	**4.6**		**4.6**
	Decrease Standing	(Slovenia)	4.0	(Slovenia)	4.0
		(Australia)	3.5	(Australia)	3.5
		Czech Republic	3.4	Czech Republic	3.4
		Hungary	3.2	(Germany)	4.7
		(Russian Federation)	2.9	Hungary	3.2
		(United States)	3.9	(Russian Federation)	2.9
				(United States)	3.9
		Average	**3.5**		**3.7**
		Average without U.S.	**(3.4)**		**(3.6)**
		(United States)	3.9		3.9
	International Average		4.4		4.4

NOTES:

1) Calculated by subtracting the average age of 8th grade participants from the average age of 12th grade participants in the mathematics and science literacy assessments.

2) Nations not meeting international sampling guidelines are shown in parentheses.

3) International average is the average of national figures.

SOURCES: Mullis et al. (1998) *Mathematics and Science Achievement in the Final Year of Secondary School.* Table 1.1, Figures 2.3, 2.4. Boston College: Chestnut Hill, MA; Beaton et al. (1996) *Mathematics Achievement in the Middle School Years.* Table 1.1. Boston College: Chestnut Hill, MA.

TABLE A5.11

MATHEMATICS AND SCIENCE COURSETAKING AND CHANGE IN STANDING RELATIVE TO THE INTERNATIONAL AVERAGE BETWEEN 8TH AND 12TH GRADES

Comparison to the United States	Percentage of Students Currently Taking Mathematics	Percentage of Students Currently Taking Science
Countries above the United States	*(Australia)* (Cyprus) *Czech Republic* **(Denmark)** (France) *Hungary* (Lithuania) *(Russian Federation)* *(Slovenia)*	*(Australia)* **(Austria)** (Cyprus) **(France)** *Hungary* **(Iceland)** (Lithuania) **New Zealand** *(Russian Federation)* *(Slovenia)* (South Africa)
Countries same as the United States	(Austria) **(Iceland)** (Netherlands) **New Zealand** **(Norway)** (South Africa) **Sweden** Switzerland	(Canada) (Netherlands) **Switzerland**
Countries below the United States	(Canada)	*Czech Republic* **(Denmark)** (Norway) Sweden
(United States)	★66%	★53%
International Average	84	68
Countries Missing	(Germany)	*(Germany)*

NOTES:
1) Nations not meeting international sampling guidelines are shown in parentheses.
2) **bold**: Nations which improve in relative standing between 8th and 12th grades in that subject.
regular: Nations which undergo no change in relative standing between 8th and 12th grades in that subject.
italic: Nations which decrease in relative standing between 8th and 12th grades in that subject.
★: U.S. average is significantly different from the international average.
3) International average is the average of the national figures.
SOURCE: Mullis et al. (1998) *Mathematics and Science Achievement in the Final Year of Secondary School.* Tables 4.2 and 4.4. and Figures 2.3 and 2.4. Boston College: Chestnut Hill, MA.

Table A5.12
STUDENTS' RESPONSES TO SELECT TIMSS STUDENT QUESTIONNAIRE ITEMS (1994-95)
Mathematics Science and Literacy Students' Responses

	Average hours of TV watching per school day	Average hours of homework per day	Average hours at a paid job per day	Percentage who like mathematics "a lot"
Above U.S.	Czech Republic ***Hungary*** (Lithuania) **(Netherlands)** **New Zealand** (Russian Federation)	**(Australia)** **(Canada)** (*Cyprus*) **(Denmark)** ***(France)*** ***Hungary*** **(Iceland)** (Italy) (Lithuania) **New Zealand** (Russian Federation) (*South Africa*) **Switzerland**	none	**(Denmark)** (*South Africa*)
Same as U.S.	**(Australia)** **(Austria)** **(Canada)** (*Cyprus*) **(Denmark)** **(Iceland)** **(Norway)** **Sweden**	**(Austria)** **(Netherlands)** **(Norway)** **(Slovenia)** **Sweden**	none	(*Cyprus*) **(Iceland)** (Italy) **Switzerland**
Below U.S.	***(France)*** (Italy) **(Slovenia)** (*South Africa*) **Switzerland**	Czech Republic	**(Australia)** **(Austria)** **(Canada)** (*Cyprus*) Czech Republic **(Denmark)** ***(France)*** **(Iceland)** (Italy) (Lithuania) **(Netherlands)** **New Zealand** **(Norway)** (Russian Federation) **(Slovenia)** (*South Africa*) **Sweden** **Switzerland**	**(Australia)** **(Austria)** **(Canada)** Czech Republic ***(France)*** ***Hungary*** (Lithuania) **New Zealand** **(Norway)** (Russian Federation) **(Slovenia)** **Sweden**
United States	1.7 hrs.	1.87 hrs	3.1 hrs.	21%
International average	1.73 hrs	2.69 hrs.	1.17 hrs.	14.75%
No data available	***(Germany)***	***(Germany)***	***(Germany)*** ***Hungary***	***(Germany)*** (Netherlands)

NOTES: Nations not meeting international sampling guidelines are shown in parentheses.
SOURCE: Beaton et al. (1998) *Mathematics and Science Achievement in the Final Year of Secondary School.* Boston College: Chestnut Hill, MA.

Mathematics and Science Literacy Students' Responses—Continued

	Percentage who use a calculator "daily"	Percentage who used a calculator in the TIMSS test	Percentage who use a computer at school, home, or elsewhere	Percentage who have been threatened at school
Above U.S.	**(Australia)** **(Canada)** (*Cyprus*) **(Denmark)** ***(France)*** ***Hungary*** **(Iceland)** **(Netherlands)** **New Zealand** (*South Africa*)	**(Australia)** **(Austria)** **(Canada)** Czech Republic **(Denmark)** ***(France)*** ***(Germany)*** ***Hungary*** **(Netherlands)** **New Zealand** **Sweden** **Switzerland**	**(Denmark)** **(Iceland)**	(*South Africa*)
Same as U.S.	**(Austria)** (Italy) (Lithuania) **(Norway)** **(Slovenia)** **Switzerland**	(*Cyprus*) **(Iceland)** (Italy) **(Norway)** **(Slovenia)**	**(Australia)** **(Austria)** **(Canada)** **(Netherlands)** **New Zealand** **Sweden**	**(Australia)** (*Cyprus*) Czech Republic **(Denmark)** **New Zealand**
Below U.S.	Czech Republic (Russian Federation) **Sweden**	(Lithuania) (Russian Federation) (*South Africa*)	(*Cyprus*) Czech Republic ***(France)*** ***Hungary*** (Italy) (Lithuania) **(Norway)** (Russian Federation) **(Slovenia)** (*South Africa*) **Switzerland**	**(Austria)** **(Canada)** **(Iceland)** (Italy) (Lithuania) **(Norway)** (Russian Federation) **(Slovenia)** **Sweden** **Switzerland**
United States	52%	71%★	73%★	11%★
International average	55.2%	78.81%	57.4%	7.3%
No data available	***(Germany)***		***(Germany)***	***(France)*** ***(Germany)*** ***Hungary*** **(Netherlands)**

Mathematics and Science Literacy Students' Responses—Continued

	Percentage who have had something stolen at school	Percentage who "like" or like "a lot" Biology	Percentage who "like" or like "a lot" Chemistry
Above U.S.	(*South Africa*)	**(Iceland)** (Russian Federation) (*South Africa*)	**(Iceland)** (*South Africa*)
Same as U.S.	**New Zealand**	**(Australia)** **(Austria)** **(Canada)** (*Cyprus*) **(Denmark)** ***(France)*** ***Hungary*** (Italy) (Lithuania) **New Zealand** **Sweden** **Switzerland**	**(Canada)** (*Cyprus*) ***(France)*** (Italy) **(Norway)** (Russian Federation) **Sweden** **Switzerland**
Below U.S.	**(Australia)** **(Austria)** **(Canada)** (*Cyprus*) Czech Republic **(Denmark)** ***Hungary*** **(Iceland)** (Italy) (Lithuania) **(Norway)** (Russian Federation) **(Slovenia)** **Sweden** **Switzerland**	Czech Republic **(Norway)** **(Slovenia)**	**(Australia)** **(Austria)** Czech Republic **(Denmark)** ***Hungary*** (Lithuania) **New Zealand** **(Slovenia)**
United States	24%★	67%	49%★
International average	12.9%	66.53%	42.00%
No data available	***(France)*** ***(Germany)*** **(Netherlands)**	***(Germany)*** **(Netherlands)**	***(Germany)*** **(Netherlands)**

Mathematics and Science Literacy Students' Responses—Continued

	Percentage who "like" or like "a lot" Earth Science	Percentage who "like" or like "a lot" Physics
Above U.S.	(Lithuania)	(*South Africa*)
Same as U.S.	**(Austria)** **(Canada)** Czech Republic **(Iceland)** (Italy) (Russian Federation) **(Slovenia)** (*South Africa*) **Sweden** **Switzerland**	**(Canada)** (*Cyprus*) **(Denmark)** ***(France)*** **(Iceland)** (Italy) **(Norway)** (Russian Federation) **Sweden** **Switzerland**
Below U.S.	**(Australia)** (*Cyprus*) **(Denmark)** ***(France)*** ***Hungary*** **New Zealand** **(Norway)**	**(Australia)** **(Austria)** Czech Republic ***Hungary*** (Lithuania) **New Zealand** **(Slovenia)**
United States	68%★	47%★
International average	63.11%	42.37%
No data available	***(Germany)*** **(Netherlands)**	***(Germany)*** **(Netherlands)**

NOTES:

1)

bold: nations which perform above the U.S. in both mathematics and science literacy
bold italic: nations which perform above the U.S. in mathematics literacy only
regular: nations which perform similar to the U.S. in mathematics and science literacy
italic: nations which perform below the U.S. in mathematics and science literacy
★ U.S. average is significantly different from the international average

2) International average is the average of the national figures.

SOURCE: Mullis et al. (1998) *Mathematics and Science Achievement in the Final Year of Secondary School.* Boston College: Chestnut Hill, MA.

Table A5.13
Advanced Mathematics Students' Responses

	Percentage who receive 5 hours or more of mathematics instruction per week	Percentage who are assigned mathematics homework 3 or more times per week	Percentage who are asked to do reasoning tasks in "every mathematics lesson"	Percentage who are asked to apply mathematics to everyday problems in their mathematics lessons
Above U.S.	**(Australia)** **(Canada)** **(Cyprus)** **Greece** **(Lithuania)** **(Russian Federation)**	**(Cyprus)**	**(Cyprus)** **Greece**	none
Same as U.S.	(Austria) **Switzerland**	**(Australia)** **(Canada)** **Greece** **(Russian Federation)**	**(Australia)** Czech Republic (Italy) **Sweden**	**(Australia)** **(Canada)**
Below U.S.	Czech Republic (Italy) **(Slovenia)** **Sweden**	(Austria) Czech Republic **(Denmark)** (Italy) **(Lithuania)** **(Slovenia)** **Sweden** **Switzerland**	(Austria) **(Canada)** **(Denmark)** **France** (Germany) **(Lithuania)** **(Russian Federation)** **(Slovenia)** **Switzerland**	(Austria) **(Cyprus)** Czech Republic **(Denmark)** **France** (Germany) **Greece** (Italy) **(Lithuania)** **(Russian Federation)** **(Slovenia)** **Sweden** **Switzerland**
United States	12%★	90%★	43%★	85%★
International average	34.8%	65.4%	32.38%	67.56%
No data available	**(Denmark)** **France** (Germany)	**France** (Germany)		

Advanced Mathematics Students' Responses—Continued

	Percentage who are asked to use computers to solve mathematics exercises or problems	Percentage who use a calculator at school, home or anywhere else "daily"	Percentage who used a calculator in the TIMSS test
Above U.S.	**(Cyprus)** (Italy) **(Slovenia)**	**(Australia)** **(Denmark)** **Sweden**	**(Canada)** **(Denmark)** **Sweden** **Switzerland**
Same as U.S.	**(Australia)** **(Denmark)** **Greece**	**(Canada)** **(Cyprus)** **France**	**(Australia)** (Austria) Czech Republic **France** (Germany)
Below U.S.	(Austria) **(Canada)** Czech Republic **France** (Germany) **(Lithuania)** **(Russian Federation)** **Sweden** **Switzerland**	(Austria) Czech Rep. (Germany) **Greece** (Italy) **(Lithuania)** **(Russian Federation)** **(Slovenia)** **Switzerland**	**(Cyprus)** **Greece** (Italy) **(Lithuania)** **(Russian Federation)** **(Slovenia)**
United States	34%★	82%★	86%★
International average	27.87%	70.06%	76.31%
No data available			

NOTES:
1) Nations not meeting international sampling guidelines are shown in parentheses.
2)
   bold: nations which perform above the U.S. advanced mathematics students on the advanced mathematics assessment
   regular: nations which perform similar to the U.S. advanced mathematics students on the advanced mathematics assessment
   ★ U.S. average is significantly different from the international average
3) International average is the average of national figures.

SOURCE: Beaton et al. (1998) *Mathematics and Science Achievement in the Final Year of Secondary School.* Boston College: Chestnut Hill, MA.

Table A5.14

Physics Students' Responses

	Percentage who currently receive 5 hours or more of physics instruction per week	Percentage who receive physics homework 3 or more times per week	Percentage who are asked to do reasoning tasks in "every physics lesson"	Percentage who are asked to conduct laboratory experiments during physics lessons
Above U.S.	**(Canada)**	**(Canada)** **(Cyprus)** **Greece** **Norway** **(Russian Federation)**	**(Denmark)** **Sweden**	none
Same as U.S.	**(Australia)** **(Latvia)** **(Russian Federation)**	**(Australia)** **(Denmark)**	**(Australia)** **(Canada)** **(Cyprus)** **Czech Republic** **France** **(Germany)** **Greece** **Norway** **(Russian Federation)** **(Slovenia)** **Switzerland**	**(Cyprus)** **(Denmark)** **France** **Norway** **Sweden**
Below U.S.	**(Cyprus)** **Czech Republic** **(Denmark)** **(Germany)** **Greece** **Norway** **(Slovenia)** **Sweden** **Switzerland**	(Austria) **Czech Republic** **(Germany)** **(Latvia)** **(Slovenia)** **Sweden** **Switzerland**	(Austria) **(Latvia)**	**(Australia)** (Austria) **(Canada)** **Czech Republic** **(Germany)** **Greece** **(Latvia)** **(Russian Federation)** **(Slovenia)** **Switzerland**
United States	17%★	51%★	50%★	96%★
International average	8.14%	39.9%	42.59%	78.56%
No data available	(Austria) **France**	**France**		

Physics Students' Responses—Continued

	Percentage who are asked to use computers to solve physics exercises or problems	Percentage who use a calculator at school, home or anywhere else "daily"	Percentage who used a calculator in the TIMSS test
Above U.S.	**(Slovenia)**	**(Australia)** **(Canada)** **(Cyprus)** **(Denmark)** **Norway** **Sweden**	**(Australia)** **(Canada)** **(Denmark)** **Norway** **Sweden** **Switzerland**
Same as U.S.	**(Canada)** **(Cyprus)** **(Denmark)** **France** **Greece**	**France** **(Germany)** **(Slovenia)** **Switzerland**	**(Cyprus)** **Czech Republic** **France** **(Germany)** **(Slovenia)**
Below U.S.	**(Australia)** (Austria) **Czech Republic** **(Germany)** **(Latvia)** **Norway** **(Russian Federation)** **Sweden** **Switzerland**	(Austria) **Czech Republic** **Greece** **(Latvia)** **(Russian Federation)**	(Austria) **Greece** **(Latvia)** **(Russian Federation)**
United States	42%★	79%★	81%
International average	29.25%	72.94%	78.5%
No data available			

NOTES:

1) Nations not meeting international sampling guidelines are shown in parentheses.
bold: nations which perform above the U.S. physics students on the physics assessment
regular: nations which perform similar to the U.S. physics students on the physics assessment
★ U.S. average is significantly different from the international average
2) International average is the average of national figures.

SOURCE: Beaton et al. (1998) *Mathematics and Science Achievement in the Final Year of Secondary School.* Boston College: Chestnut Hill, MA.

APPENDIX 6
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APPENDIX 7
ADDITIONAL TIMSS REPORTS

Full contact information for each of the following publications is located at the end of this appendix.

HOW CAN EDUCATORS, PRACTITIONERS, POLICYMAKERS, AND CONCERNED CITIZENS REFLECT UPON THEIR OWN LOCAL PRACTICES IN LIGHT OF TIMSS FINDINGS?

***Attaining Excellence: A TIMSS Resource Kit*, September 1997 - This comprehensive package includes four modules which contain the following items: reports on the TIMSS findings; videotapes of classroom teaching in the United States, Japan, and Germany; guides for discussion leaders; presentation overheads with talking points for speakers; checklists, leaflets, and flyers. Note that the Kit's twelve publications and two videos include several items which are available individually elsewhere on this list. Those publications are denoted by an asterix in the margin. $94. GPO Stock #065-000-01013-5.**
To order, contact: Superintendent of Documents

WHERE CAN I FIND A GOOD SUMMARY OF TIMSS FINDINGS THAT PUTS U.S. EDUCATION IN COMPARATIVE PERSPECTIVE?

***Pursuing Excellence: A Study of U.S. Fourth-Grade Mathematics and Science Achievement in International Context*, June 1997 - This report summarizes the most important findings concerning U.S. achievement and schooling in the fourth grade, Paperback, 68 pp. $4.75. GPO Stock #065-000-01018-6.**
To order, contact: Superintendent of Documents. Also may be downloaded from: http://nces.ed.gov/timss

***Pursuing Excellence: A Study of U.S. Eighth-Grade Mathematics and Science Teaching, Learning, Curriculum, and Achievement in International Context*, Nov. '96 - This report draws from the assessments, surveys, video, and case studies of TIMSS to summarize the most important findings concerning U.S. achievement and schooling in the eighth grade. Paperback, 80 pp. $9.50. GPO Stock #065-000-00959-5.**
To order, contact: Superintendent of Documents. Also may be downloaded from http://nces.ed.gov/timss

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WHERE CAN I FIND A DETAILED INTERNATIONAL COMPARISON OF FOURTH-GRADE STUDENTS?

***Mathematics Achievement in the Primary School Years: IEA's Third International Mathematics and Science Study (TIMSS)*, June '97 - This report focuses on third and fourth grade mathematics achievement in 26 countries, including background information about students and teachers. Paperback, 184 pp. + 52 pp. Appendix. $20.00 (+ $7.00 shipping & handling, if international).**

To order, contact: TIMSS International Study Center. Also may be downloaded from: http://wwwcsteep.bc.edu/TIMSS1/TIMSSPublications.html#International

Science Achievement in the Primary School Years: IEA's Third International Mathematics and Science Study (TIMSS), **June '97 - This report focuses on third and fourth grade science achievement in 26 countries, including background information about students and teachers. Paperback, 148 pp. + 52 pp. Appendix. $20.00 (+ $7.00 shipping & handling, if international).**

To order, contact: TIMSS International Study Center. Also may be downloaded from: http://wwwcsteep.bc.edu/TIMSS1/TIMSSPublications.html#International

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WHERE CAN I FIND A DETAILED INTERNATIONAL COMPARISON OF EIGHTH-GRADE STUDENTS?

Mathematics Achievement in the Middle School Years: IEA's Third International Mathematics and Science Study (TIMSS), **Nov. '96 - This report focuses on seventh and eighth grade mathematics achievement in 41 countries, including background information about students and teachers. Paperback, 176 pp. + 60 pp. Appendix. $30. GPO Stock #065-000-01023-2.**

To order, contact: TIMSS International Study Center or Superintendent of Documents. Also may be downloaded from: http://wwwcsteep.bc.edu/TIMSS1/TIMSSPublications.html#International

Science Achievement in the Middle School Years: IEA's Third International Mathematics and Science Study (TIMSS), **Nov. '96 - This report focuses on seventh and eighth grade science achievement in 41 countries, including background information about students and teachers. Paperback, 168 pp. + 62 pp. Appendix. $30. GPO Stock #065-000-01023-2.**

To order, contact: TIMSS International Study Center or Superintendent of Documents. Also may be downloaded from: http://wwwcsteep.bc.edu/TIMSS1/TIMSSPublications.html#International

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WHERE CAN I FIND A DETAILED INTERNATIONAL COMPARISON OF TWELFTH-GRADE STUDENTS?

Mathematics Achievement in Secondary School: IEA's Third International Mathematics and Science Study (TIMSS) **??? - This report focuses on mathematics achievement in ?? countries at the end of secondary school, including background information about students and teachers. Paperback, ??? pp. + ?? pp. Appendix. $30.**

To order, contact: TIMSS International Study Center. Also may be downloaded from: http://wwwcsteep.bc.edu/TIMSS1/TIMSSPublications.html#International

Science Achievement in Secondary School: IEA's Third International Mathematics and Science Study (TIMSS), **??? - This report focuses on science achievement in ?? countries at the end of secondary school, including background information about students and teachers. Paperback, ??? pp. + ?? pp. Appendix. $30.**

To order, contact: TIMSS International Study Center. Also may be downloaded from: http://wwwcsteep.bc.edu/TIMSS1/TIMSSPublications.html#International

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WHERE CAN I OBTAIN THE COMPLETE TIMSS INTERNATIONAL DATABASE IN ORDER TO PERFORM SECONDARY ANALYSIS?

TIMSS International Database **- The database contains achievement scores in mathematics and science for those countries that participated in TIMSS at the third- and fourth-grades (Population 1) and the seventh- and eighth-grades (Population 2), and questionnaire results for students, teachers, and principals. The database can be used with either SASS or SPSS software. Accompanied by User Guidebook.**

The TIMSS International Database is available on CD-ROM from the IEA Secretariat. It is provided in ASCII format and may also be downloaded from: http://wwwcsteep.bc.edu/timss1/database.html

The Population 3 Database and User Guide will be available in June 1998.

WHERE CAN I COMPARE STUDENTS' PERFORMANCE ON A SERIES OF PRACTICAL TASKS IN BOTH MATH AND SCIENCE?

Performance Assessment in IEA's Third International Mathematics and Science Study**, 1997 - The regular TIMSS assessments were supplemented by hands-on performance assessments which measured 4th and 8th-grade students' content and procedural knowledge, as well as their ability to use that knowledge in reasoning and problem solving. Students in 21 countries participated, making it the largest international performance assessment yet conducted. This report includes findings from the 21 countries and descriptions of the performance tasks. Paperback, 128 pp. + 45 pp. Appendix.**

To order, contact: TIMSS International Study Center. Also may be downloaded from http://wwwcsteep.bc.edu/TIMSS1/PAreport.html

HOW CAN I GET A FIRST-HAND GLIMPSE OF ACTUAL CLASSROOM LESSONS IN THE U.S., GERMANY, AND JAPAN?

Eighth-Grade Mathematics Lessons: United States, Japan, and Germany **- An 80-minute VHS tape with abbreviated versions of six eighth-grade mathematics lessons: one algebra and one geometry lesson each from the United States, Japan, and Germany, GPO Stock #065-000-01025-9, $20.**

To order, contact: Superintendent of Documents

CD-ROM Video Examples from the TIMSS Videotape Classroom Study: Eighth-Grade Mathematics in Germany, Japan, and the United States **- Actual footage of eighth-grade mathematics classes lets viewers see first hand an abbreviated geometry and algebra lesson in each of three countries: Germany, Japan, and the U.S.**

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IBM ® PC or 100% compatible, MS Windows ® (Windows 95 ® recommended), Pentium ® 90, 16 mb of RAM, 256 color SVGA or better, Double-speed or higher CD-ROM drive, Sound Card, or

Macintosh ® PowerPC 100 ® or 100% compatible System 7.5.3, 16 mb of RAM, 256-color or better, Netscape Navigator ® 3.0 with MPG plug-in Double-speed or higher CD-ROM drive

To order, contact: National Education Data Resource Center

WHERE CAN I FIND OUT WHAT TIMSS HAS LEARNED ABOUT CURRICULUM?

A Splintered Vision: An Investigation of U.S. Science and Mathematics Education, 1997 - This book enunciates the argument that math and science curricula in U.S. schools suffer from a lack of focus. The authors contend that in their effort to canvas as many topics as possible, both teachers and textbook publishers fail to delve into the most important subjects with sufficient depth. 176 pp. Hardback ISBN: 0-7923-4440-5, $87; Paperback ISBN: 0-7923-4441-3, $49.
To order, contact: Kluwer Academic Publishers Group

Many Visions, Many Aims: Volume 1, A Cross-National Exploration of Curricular Intentions in School Mathematics, 1997 - An analysis of mathematics curriculum guides and textbooks in 50 countries. This report looks at the sequence and the topics covered from kindergarten through the end of secondary school, analyzed in a comparative framework. 286 pp. Hardback ISBN: 0-7923-4436-7, $120; Paperback ISBN: 0-7923-4437-5, $55.
To order, contact: Kluwer Academic Publishers Group

Characterizing Pedagogical Flow: An Investigation of Mathematics and Science Teaching in Six Countries, 1996 - Describes the results of the Study of Mathematics and Science Opportunity (SMSO) survey, which investigated curriculum content and instructional methods in France, Japan, Norway, Spain, Switzerland, and the United States, using case studies in each participating country. 229 pp. Hardback ISBN: 07923-42720, $110; Paperback ISBN: 07923-42739, $49.
To order, contact: Kluwer Academic Publishers Group

TIMSS Monograph Series No. 3 Mathematics Textbooks: A Comparative Study of Grade 8 Texts, 1995 - An examination of eight mathematics textbooks for 13-year-olds for their pedagogical and philosophical similarities and differences. Texts are from the United States, the Netherlands, the United Kingdom, Norway, Spain, France, Switzerland, and Japan. Paperback, 96 pp. ISBN: 1-895766-03-6. $16.95.
To order, contact: Pacific Educational Press

WHERE CAN I FIND OUT MORE ABOUT THE METHODOLOGY OF TIMSS?

Third International Mathematics and Science Study: Quality Assurance in Data Collection, 1996 - A report on the quality assurance program which ensured the comparability of results across participating countries. The program emphasized instrument translation and adaptation, sampling response rates, test administration and data collection, the reliability of the coding process, and the integrity of the database. Paperback, 93 pp. + 91 pp. Appendix.

To order, contact: TIMSS International Study Center. Also may be downloaded from: http://wwwcsteep.bc.edu/TIMSS1/TIMSSPublications.html#International

Third International Mathematics and Science Study: Technical Report, Volume 1 Design and Development, **1996 - This report describes the study, design, and the development of TIMSS up to, but not including, the operational stage of main data collection. Paperback, 149 pp. + 40 pp. Appendix.**
To order, contact: TIMSS International Study Center. Also may be downloaded from: http://wwwcsteep.bc.edu/TIMSS1/TIMSSPublications.html#International

TIMSS Monograph Series No. 1 Curriculum Frameworks for Mathematics and Science, **1993 - This monograph explains the study's foci and its key first step - the development of the curriculum frameworks that served as the guide for designing the study's achievement tests. The frameworks are included in the appendices. Paperback, 102 pp. ISBN: 0-88865-090-6. $16.95.**
To order, contact: Pacific Educational Press

TIMSS Monograph Series No. 2 Research Questions and Study Design, **1996 - This monograph presents the study's research objectives along with discussions that include: the impact of prior studies on the design of TIMSS; how the research questions were derived from TIMSS' conceptual framework; and how the research questions and test items were tailored to meet the contexts of the participating countries. Paperback, 112 pp. ISBN: 1-895766-02-8. $17.95.**
To order, contact: Pacific Educational Press

WHERE CAN I READ THE ACTUAL TEST ITEMS GIVEN TO STUDENTS?

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